United States
Department of
Agriculture

**Forest
service**

Forest
Products
Laboratory

General
Technical
Report
FPL-GTR-80

Literature Review on Use of Nonwood Plant Fibers for Building Materials and Panels

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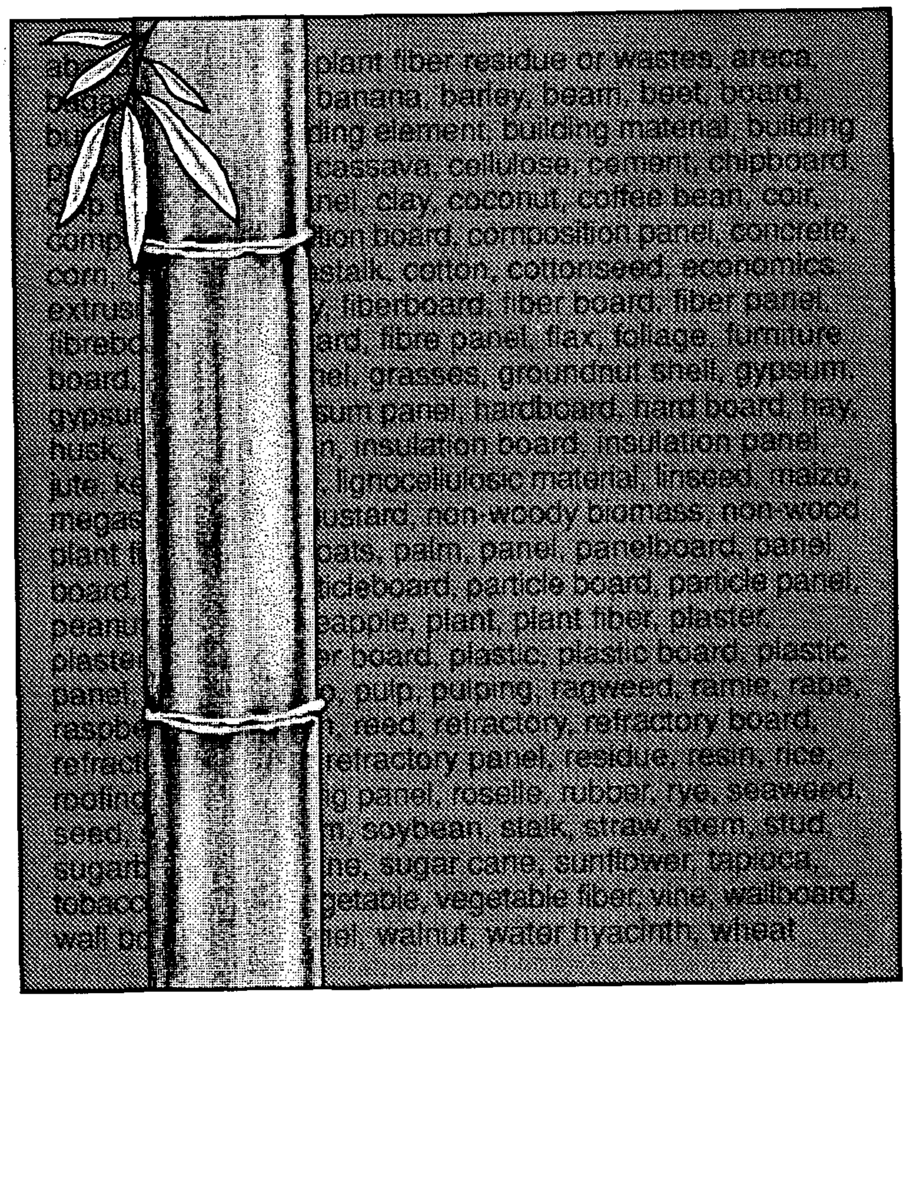

Abstract

The research studies included in this review focus on the use of nonwood plant fibers for building materials and panels. Studies address (1) methods for efficiently producing building materials and panels from nonwood plant fibers; (2) treatment of fibers prior to board production; (3) process variables, such as press time and temperature, press pressure, and type of equipment; (4) mechanical and physical properties of products made from nonwood plant materials; (5) methods used to store nonwood plant materials; (6) use of nonwood plant fibers as stiffening agents in cementitious materials and as refractory fillers; and (7) cost-effectiveness of using nonwood plant materials.

Keywords: Nonwood plant fiber, panel, building material

Acknowledgments

This comprehensive bibliography would not have been possible without the assistance of many individuals. Particular thanks are given to Dr. Roger Meimban, Research Associate, Department of Forestry, University of Illinois, Urbana-Champaign, for reference search, help in locating original sources, and review.

Thanks are also due to the American Hardboard Association (AHA), Palatine, Illinois, for the partial funding that enabled the authors to undertake this study. Thanks are due to Louis E. Wagner, Technical Director of the AHA, and Michael Hoag, Technical Director of the National Particleboard Association (NPA), for their critical review of the publication.

This study was funded by the U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin, and the Illinois Agricultural Experiment Station, University of Illinois, Urbana, Illinois.

July 1994

Youngquist, John A.; English, Brent E.; Scharmer, Roger C.; Chow, Poo; Shook, Steven R. 1994. Literature review on use of nonwood plant fibers for building materials and panels. Gen. Tech. Rep. FPL-GTR-80. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 146 p.

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Introduction

The literature references in this report are the results of a search carried out by the Forest Products Laboratory of the USDA Forest Service and the Department of Forestry at the University of Illinois, Urbana-Champaign. The 1,165 publications were authored by many research scientists and organizations over an 80-year period-from 1913 to 1993. Over half the citations were published after 1975; less than 10 percent were published prior to 1951. Table 1 lists the number of reports by year of publication.

Citations included in this report were gleaned from industry trade journals, scholarly journals, university publications and holdings, and patent gazettes. As a result of the unavailability of many original publications, the literature search was primarily based on research published in English or containing English abstracts.

Scope of Research

The bibliography includes studies on many different kinds of nonwood plant materials (Table 2). Over 30 percent of the studies address the use of bagasse and rice as raw materials in building elements. Other materials widely studied include bamboo (10 percent of studies), coconut and coir (7 percent), flax (6 percent), and straw (6 percent).

Virtually all studies failed to examine the durability of the product. Of the few studies that did investigate durability, most focused on cement and concrete roofing panels and sheets. This literature review indicates that additional research is needed to obtain information on long-term durability and the influence of weathering on the performance of materials. Moreover, research in the future needs to focus on comparing the product against product standards,

Table l-Number of references by publication year

Year	Reference (no.)	Year	Reference (no.)
1913	1	1953	6
1914	1	1954	9
1915	0	1955	15
1916	0	1956	6
1917	0	1957	12
1918	0	1958	15
1919	0	1959	11
1920	0	1960	13
1921	0	1961	24
1922	0	1962	33
1923	0	1963	21
1924	3	1964	21
1925	1	1965	15
1926	0	1966	13
1927	0	1967	13
1928	2	1968	24
1929	2	1969	17
1930	7	1970	32
1931	2	1971	19
1932	5	1972	20
1933	2	1973	21
1934	5	1974	25
1935	3	1975	44
1936	5	1976	40
1937	4	1977	36
1938	2	1978	40
1939	3	1979	32
1940	3	1980	33
1941	2	1981	41
1942	2	1982	30
1943	8	1983	39
1944	5	1984	33
1945	6	1985	27
1946	6	1986	44
1947	4	1987	30
1948	9	1988	45
1949	6	1989	22
1950	9	1990	48
1951	10	1991	36
1952	8	1992	26
		1993	5

Table 2—Number of references by raw material, including cross-references

Raw material	Reference (no.)		Reference (no.)
Abaca	5	Pecan	5
Areca	14	Pineapple	5
Bagasse/ sugarcane	255	Plant/ vegetable fiber	87
Bamboo	154	Poppy	4
Banana	12	Potato	1
Barley	6	Ragweed	1
Beet	1	Ramie	4
Cashew nut	5	Rape	14
Cassava/tapioca	5	Raspberry	1
Cellulose	6	Red onion	1
Coconut/coir	101	Reed	33
Coffee bean	7	Rice	219
Corn/Maize	62	Rye	4
cotton	41	Scrub palmetto	1
Flax/linseed	90	Seaweed	2
Foliage	5	Sisal	56
Grasses	13	Sorghum	12
Groundnut shell	20	Soybean	2
Hemp	19	Straw	87
Jute	23	Sunflower	11
Kenaf	17	Tobacco	5
Megass	1	Tomato	1
Mustard	3	Vine	2
Oats	4	Walnut	1
Palm	15	Water hyacinth	1
Papyrus	8	Wheat	39
Peanut	20	Total[a]	,507

[a]Total includes references that are cross-referenced to other sections in the report.

Table 3—Number of references by heading and subheading, excluding cross-references

Section	Reference (no.) Heading	Subheading
Panel board	734	—
Particleboard		228
Fiberboard/Hardboard		168
Insulation board		112
Cement /Gypsum/Plaster board		64
Plastic/Plastic-bonded board		35
Roofing board		13
Unknown board		114
Cement/Clay/Gypsum/ Plaster materials	189	189
Molded masses	97	—
Plastics		23
Refractory materials		40
Resins/Binders		26
Rubbers		8
Miscellaneous	122	—
Economics		3
Loose insulation		4
Material preparation/ Pulping/Storage methods		33
General information/Reviews		82
Material used in natural state	23	23
Total	1,165	1,165

such as American Standard for Testing and Materials (ASTM), German Standard Institute (DIN), International Standard Organization (ISO), American National Standards (ANSI), and the U.S. Department of Commerce standards.

Organization of Literature Review

The references are grouped, by type of raw material, into five major sections: panel boards, cement/clay/gypsum/plaster materials, molded masses, miscellaneous, and material used in natural state. Molded masses are defined as those elements produced by extrusion or pouring processes. The major sections are subdivided as shown in Table 3. Under panel boards, insulation board includes acoustical and thermal materials but not refractory materials. Plaster board pertains to board made with inorganic binder. Cement/clay/gypsum/ plaster materials do not include panel boards. Under molded masses, the refractory materials include boards.

In this review, the full entry for each reference appears only once-under the heading and/or subheading that pertains to the primary emphasis of the study. If the publication also addresses other topics, it is cross-referenced to the appropriate section or sections. The annotations summarize important research methods and results.

Method of Literature Search

A comprehensive literature search was conducted by Roger C. Scharmer of the Forest Products Laboratory. The following databases were accessed from the DIALOG search service: AGRICOLA, AGRIS INTERNATIONAL, CA SEARCH, CAB ABSTRACTS, CLAIMS/US. PATENT ABSTRACTS, COMPENDEX PLUS, DISSERTATION ABSTRACTS ONLINE, NTIS, TRADE AND INDUSTRY INDEX, PAPERCHEM, AND DERWENT WORLD PATENT INDEX.[1] These databases include records through December 1992. DISSERTATION ABSTRACTS goes back to 1861, the patent databases to 1950 and 1963, and the other

[1]The use of trade, firm, or corporate names in this publication is for the information and convenience of the user. Such use does not constitute an official endorsement or approval of any product or services by the authors or the U.S. Department of Agriculture to the exclusion of others which may be suitable. Registration of chemicals and preservatives is under constant review by the U.S. Environmental Protection Agency (EPA) and Department of Agriculture; therefore, a responsible State or Federal agency should be consulted as to the current status of chemical or preservative use and its proper disposal.

databases to about 1967. Citations were also obtained from the Forest Products Society FOREST database and from the Forest Service FS INFO database. Another literature search was conducted by Steven R. Shook at the University of Illinois for references that may have been missed by the DIALOG, FOREST, and FS INFO searches. The strategy of this search included electronically examining the three largest university library collections in the United States, namely Harvard, the University of Illinois, and Yale. Additionally, several libraries at land grant colleges with large agricultural programs were electronically searched. These searches yielded many unpublished master's degree theses, old out-of-print titles, and old unabstracted agricultural experiment station reports and trade journal articles. The references in many publications were used to obtain more references for this literature review.

The keywords used in the search included the following words, their combinations, and variants thereof: abaca, agricultural plant fiber residue or wastes, areca, bagasse, bamboo, banana, barley, beam, beet, board, building board, building element, building material, building panel, cashew nut, cassava, cellulose, cement, chipboard, chip board, chip panel, clay, coconut, coffee bean, coir, composite, composition board, composition panel, concrete, corn, corncob, cornstalk, cotton, cottonseed, economics, extrusion, feasibility, fiberboard, fiber board, fiber panel, fibreboard, fibre board, fibre panel, flax, foliage, furniture board, furniture panel, grasses, groundnut shell, gypsum, gypsum board, gypsum panel, hardboard, hard board, hay, hemp, husk, hull, insulation, insulation board, insulation panel, jute, kenaf, laminate, lignocellulosic material, linseed, maize, megass, molded, mustard, non-woody biomass, non-wood plant fiber wastes, oats, palm, panel, panelboard, panel board, papyrus, particleboard, particle board, particle panel, peanut, pecan, pineapple, plant, plant fiber, plaster, plasterboard, plaster board, plastic, plastic board, plastic panel, poppy, potato, pulp, pulping, ragweed, ramie, rape, raspberry, red onion, reed, refractory, refractory board, refractory molding, refractory panel, residue, resin, rice, roofing board, roofing panel, roselle, rubber, rye, seaweed, seed, sisal, sorghum, soybean, stalk, straw, stem, stud, sugarbeet, sugarcane, sugar cane, sunflower, tapioca, tobacco, tomato, vegetable, vegetable fiber, vine, wallboard, wall board, wall panel, walnut, water hyacinth, and wheat.

Abaca

Panel Board

Particleboard

(See references 53 and 83.)

Fiberboard/Hardboard

1. Tobias, B.C. 1990. Fabrication and performance of natural fiber-reinforced composite materials. International SAMPE Symposium and Exhibition. 35(1): 970-978.

Summary: Short abaca fiber-reinforced composite materials were fabricated at room conditions using a combination of Araldite resin, Thiokol, and hardener. The tensile strength, tensile modulus, and impact strength were dependent on the fiber length and fiber volume fraction. Fiber length greater than critical length coupled with a strong interfacial bond between fiber and matrix yielded better tensile strength, whereas short fiber and weak interfacial bonding yielded better impact strength. Both tensile and impact strength increased as the fiber volume fraction increased to approximately 70 percent.

2. Tobias, B.C. 1991. Stress rupture behavior of natural fiber-reinforced composite materials. International SAMPE Symposium and Exhibition. 36(2): 1816-1822.

Summary: Composite lamina containing polysulfide rubber-modified epoxy resin with short fiber volume fractions of 30 and 40 percent were used in the experimental investigation-which was carried out to establish the influence of fiber volume fraction on the stress rupture life. An increase in the sustained constant stress reduced the life of the abaca fiber-reinforced composite materials, but the rupture strength of the material increased significantly as the fiber volume fraction increased. The rate of degradation under sustained constant stress was higher in material with lower fiber volume fraction. Fabrication of the composite was by a conventional manual lay-up method.

Unknown Board

3. Augustin, H. 1973. Annotated bibliography on the utilization of agricultural residues and non-wood fibrous material for the production of panels. United Nations Industrial Development Organization (UNIDO) Document ID/WG.83/16.95 p.

Summary: This report is an excellent review of publications on nonwood plant fiber materials used in panel board production. The review contains 444 references, including cross-references. Plant-fiber materials included are abaca, areca-nut, bagasse, bamboo, banana, cassava stalks, coffee husks, coconut and coir, cornstalk and corncob, cotton stalk and cotton seed hulls, flax, groundnut shells, hemp, jute, kenaf, mustard stalk, papyrus, peanut shell, pineapple, poppy straw, ramie, rape straw, reed, rice husks and straw, palm, sisal, sorghum, straw, sunflower husks, and tobacco.

Areca-Nut and Areca Palm Stem

Panel Board

Particleboard

4. Narayanamurti, D.; Gupta, R.C.; Ratra, Y.S. 1962. Utilization of areca palm stems. Research and Industry. 7: 340-343.

Summary: The production of particleboard, fiberboard, and plastic board from areca palm stems was studied and reported.

5. Narayanamurti, D.; Gupta, R.C.; Singh, J. 1962. Measurements of swelling pressure in wood-particle boards. Holz als Roh- und Werkstoff. 20(3): 89-90. [German].

Summary: Thermodyne boards and thermally plasticized particleboards made from two tropical woods, areca-nut husk, and bamboo (*Bambusa polymorpha*) were examined with a Cope tensiorheometer. The results indicated that the measurement of the swelling pressure by this method gave a good criterion for evaluating the swelling resistance and dimensional stability of wood-based products.

6. Narayanamurti, D. 1960. Fibre boards from Indian timbers. Indian Forester. 86(1): 5-15.

Summary: Hardboards and insulation boards with satisfactory properties can be produced from indigenous Indian raw material, namely, areca-nut husk, bagasse, bamboo, tapioca stems, and the wood and bark of various conifers and hardwoods. The properties of the boards obtained by the Asplund process or by a mild chemical cook (0.5 to 1 percent NaOH at 100°C) are tabulated.

7. Narayanamurti, D.; Ranganathan, V.; George, J. 1947. Studies on building boards. Part I. Utilization of areca-nut husk waste. Forest Research Institute, Dehra Dun, Indian Forest Leaflet 112. 9 p.

Summary: Data are given on the chemical composition of areca-nut husks. Satisfactory building boards can be made by pulping the husks by the Asplund process or a hydrolytic treatment with dilute acid or alkali, and then pressing the pulp to boards in the usual manner.

8. Narayanamurti, D.; Singh, H. 1954. Studies on building boards. VII. Building boards from tannin-containing ligno-cellulosic materials. Composite Wood. 1(5): 121-124.

Summary: Building boards were prepared experimentally from indigenous tannin-containing waste, namely, areca-nut husk, spent tea leaves, and sal bark. Furfural and formaldehyde were added to the powdered material. Tea

leaves yielded the poorest results. Areca-nut husk board had good strength only when high pressures were applied. Sal bark board had good strength, but the addition of sawdust further improved the strength.

9. Narayanamurti, D.; Singh, H. 1955. Studies on building boards. VIII. Production of building boards from various woods and barks by defibration. Composite Wood. 2(1): 6-15.

Summary: Asplund pulps were prepared from indigenous Indian raw materials, such as areca-nut husk, bamboo shavings, tannin-extracted sal bark, and different wood species, and then wet pressed into insulating boards and hardboards. The effect of operating conditions on board properties was studied in detail. The outer portion of bamboo, containing waxes and resinous materials, gave products with higher moisture resistance and better strengths than the inner portion. Moisture absorption and swelling of boards made from areca-nut husk could be reduced by treating the pulp with alkali prior to forming into boards. Data on chemical composition of the pulps and the physical properties of the resulting boards are given in tables.

10. Narayanamurti, D.; Singh, J. [n.d.] Final report on the utilisation of areca-nut husk. Calicut: Indian Central Arecanut Committee. 44 p.

Summary: The possibilities of producing insulating wools, fiberboards, and plastics from areca-nut husk by various processes are described and detailed in tables.

11. Vimal, O.P. 1976. Arecanut husk. Yojana. 19(23): 11-13.

Summary: A brief discussion of the chemical composition of the areca-nut husk and its possible use in manufacturing hardboard, paper, insulation wool, and plastic materials is provided.

(Also see references 4 and 12.)

Insulation Board

12. Anonymous. 1952. Valuable materials from arecanut husk. Indian Central Arecanut Committee. ICAC Monographs Bull. 1(10): 5-7.

Summary: Use of areca-nut husk as insulating wool, insulation board, and hardboard is described.

(Also see reference 6.)

Plastic/Plastic-Bonded Board

(See reference 4.)

Unknown Board

13. Bavappa, K.V.A.; Murthy, K.N. 1961. The many things they make from areca. Indian Farming. 10(10): 19, 40.

Summary: Alternative uses of areca palm for making stationary articles such as rulers, paper cutters, and book shelfs are covered and detailed.

(Also see reference 3.)

Molded Masses

Plastics

(See references 10 and 11.)

Miscellaneous

Loose Insulation

(See references 10, 11, and 12.)

Material Preparation/Pulping/Storage Methods

14. Subramanyan, V.; Siddappa, G.S.; Govindarajan, V.S.; Iyengar, N.V.R. 1963. Utilization of cellulosic agricultural waste: pulp from banana pseudostem and areca husk. Indian Pulp and Paper. 17(9): 1-4.
(no abstract available)

General Information/Reviews

15. Bavappa, K.V.A.; Murthy, K.N. 1959. Potentialities of arecanut stem and leaves. Arecanut Journal. 10: 61-64.
(no abstract available)

16. Joshi, Y.; Reddy, N.R. 1982. Arecanut Palm (Area *catechu* Linn.) an annotated bibliography up to 1981. Central Plantation Crops Research Institute. Bangalore, India: INSDOC Regional Centre: 116 p.

Summary: The book contains 665 references on the areca-nut palm and nut. References concerning the use of areca-nut for building material are also included.

Bagasse, Guar, Sugarcane

Panel Board

Particleboard

17. Anonymous. 1966. New particle board from crushed sugarcane fibre. Board Manufacture. 9(10): 172-173.

Summary: A commercial procedure for producing bagasse particleboard is detailed. The press, at a temperature of 130°C to 150°C and a pressure between 343.2 kPa to 6.9 MPa, is closed for 5 to 30 min depending on the thickness of the board.

18. Anonymous. 1968. Bagasse panels bonded with urea-formaldehyde resin. Assignee: Societe Anon. Verkor. Patent, P.N.: GB 1127700, I.D.: 680918.

Summary: Bagasse panels bonded with urea-formaldehyde resin had mechanical properties comparable to high-quality wood-particle panels. Extensive production data are given. Boards were tested to DIN standards to give, for the nonfermented bagasse, 0.52 to 0.63 g/cm^3 density, 12 to 20 mm thickness, 16.7 to 25.5 MPa bending strength, and 1.4 to 2.0 GPa modulus of elasticity compared with 0.52 to 0.63 g/cm^3 density, 12 to 20 mm thickness, 11.8 to 13.7 MPa bending strength, and 1.0 to 1.2 GPa modulus of elasticity for the control (fermented bagasse).

19. Borlando, L.A. 1964. Panels of sugar cane bagasse and synthetic resin. Plast. Resinas. 6(29): 4-7, 10-20. [Spanish].

Summary: Particleboards were manufactured from sugarcane bagasse agglomerated with urea-formaldehyde resin. Experimental results of the study are reported.

20. Carvajal, O. 1980. Particle boards. In: Los Derivados de la Cana de Azucar. GALVEZ, ICIDCA. La Habana, Cuba. p. 204-224. [Spanish].
(no abstract available)

21. Chen, J. 1988. Review on the bagasse particleboard production technology in China. Consultation on the food-processing industry with emphasis on sugar-cane processing; 1988 September 26-30; Havana, Cuba. 16 p.
(no abstract available)

22. Cherkasov, M.; Lodos, J. 1969. Use of furfural-urea resin for production of particle board from bagasse. Sobre Derivados de la Cana de Azucar. 3(2): 13-17. [Spanish].

Summary: Urea-furfural resins were prepared, combined with bagasse, and cured in the presence of various acid catalysts to yield particleboard with excellent rupture modulus and low water absorption and thickness swelling. The physical properties of the boards were superior to those obtained by using urea-formaldehyde resin binder only.

23. Clark, J. 1955. A new process multi-ply board. Forest Products Journal. 5(4): 209.
(no abstract available)

24. Dalen, H. 1980. Utilization of bagasse as raw material for particleboard production in the future. In: Proceedings of the TAPPI pulping conference; 1980 November 16-19; Atlanta, GA. Atlanta, GA: TAPPI Press: 307-309.

Summary: This paper presents a general overview on the use of bagasse in the production of particleboard. A compact plant layout is shown and the ease of operation discussed. A comparison of costs for wood and bagasse fibers and how these influence the production costs is given.

25. Esnouf, C.; Orliac, F. 1981. Use of bagasse surpluses in the French Antilles (particleboard, paper pulp, composts, livestock feed, energy source). Bulletin d'information du Centre national d'etudes et d'experimentation de machinisme agricole (CNEEMA). 278/279: 19-30. [French].
(no abstract available)

26. Frers, S. 1974. Particleboard from bagasse. Sugar Y Azucar. 69(5): 65-68.
(no abstract available)

27. Fuentes, F.J.; Silva, J.A.; Rodriguez, R.; Bravo, L.R.; Valdes, J.L. 1991. Particleboard from nontraditional raw materials. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 25(3): 50-54. [Spanish; English summary].

Summary: This report is a review (with 14 references) on manufacturing particleboard from agricultural residues, bagasse, and other sources of lignocellulosic materials and natural fibers.

28. Grozdits, G.A.; Bibal, J.N. 1983. Surface-activated wood bonding systems: accelerated aging of coated and uncoated composite boards. Holzforschung. 37(4): 167-172.

Summary: The performance of coated and uncoated flakeboard and fiberboard, made from HNO_3-activated, lignin-bonded fir flakes and bagasse, respectively, and phenolic resin-bonded fir flakeboard during accelerated aging was evaluated in this study. H_2O-based acrylic and latex primers showed equal, or slightly better, performance on flakeboard and fiberboard made from HNO_3-activated, lignin-bonded fir flakes and bagasse, respectively, as compared to phenolic resin-bonded fir flakeboard. The slightly better performance of flakeboard and fiberboard made from HNO_3-activated, lignin-bonded fir flakes and bagasse, respectively, during the early stages of weathering, after 80 and 160 h of exposure, was explained in part by the HNO_3 treatment of the fir flakes and bagasse. After the 80 and 160 h of exposure, the coatings on flakeboard and fiberboard made from HNO_3-activated, lignin-bonded fir flakes and bagasse, respectively, were more effective in reducing swelling than those on phenolic resin-bonded fir flakeboard. However, after 1,024 h of exposure this difference diminished. The paint durability was best when 1 percent fines were incorporated into the boards to improve bonding and board texture.

29. Hamid, S.H.; Maadhah, A.G.; Usmani, A.M. 1983. Bagasse-based building materials. Polymer-Plastics Technology and Engineering. 21(2): 173-208.

Summary: Product properties, composition, and processes were described and reviewed in detail for bagasse-phenolic, bagasse-rubber, bagasse-thermoplastic, oriented bagasse-phenolic, random bagasse-phenolic, and bagasse in-situ generated composites.

30. Herryman, M.; Alonso, G. 1990. International aspects of the industrial utilization of bagasse. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 24(23): 33-42. [Spanish; English summary].

Summary: This report is a review with seven references on the uses of sugarcane bagasse in the manufacture of pulp and paper, particleboard, and furfural, worldwide.

31. Hesch, R. 1967. Particle board from bagasse. I. Bagasse as a raw material for particle board. Holz-Zentralblatt. 93(83): 1335. [German].

Summary: A review of the morphological and chemical characteristics of bagasse used in particleboard manufacture was given in detail.

32. Hesch, R. 1967. Particle board from bagasse. II. Manufacture of bagasse particle board on the Island of Reunion. Holz-Zentralblatt. 93(85): 1367. [German].

Summary: The manufacture of bagasse particleboard as practiced at a new board plant on the island of Reunion is described in detail. The properties of bagasse boards are compared with those of boards made from other annual plants and wood, showing that bagasse is a most suitable raw material for particleboard. Some applications of bagasse particleboard were outlined.

33. Hesch, R. 1967. Particle board from sugar cane-a fully integrated production plant. Board Manufacture. 10(42): 39-45.

Summary: The process and equipment used at the Bagapan plant on the Island of Reunion for the manufacture of particleboard from bagasse are described. Bagasse is depithed in a special machine in two stages, dried, mixed with a binder, and hot pressed in the same way as boards made from wood particles. The boards produced ranged in thickness from 8 to 35 mm, and in density from 0.30 to 0.75 g/cm^3. Strength properties are comparable to those of similar boards made of jute sticks, hemp shives, flax shives, and various wood species. Bagasse particleboards can be used as flooring, wall partitions, ceilings, roofings, and furniture.

34. Hesch, R. 1968. Annual plants as raw material for the particle board industry. Holz als Roh- und Werkstoff. 26(4): 129-140. [German].

Summary: A general review is of present and future important raw materials for particleboard other than wood; namely, bagasse, flax, hemp, and jute. Both the economic and technology of their use are discussed in some detail.

35. Hesch, R. 1968. Bagasse–particleboard additional income for sugar industry. Sugar News. 44(11): 634, 636, 638, 640, 642, 644, 646, 648-654, 656-657.
(no abstract available)

36. Hesch, R. 1970. Prospects and economics of utilizing bagasse for particleboard manufacture. Sugar Y Azucar. 65(1): 23-26, 28, 34. [English and Spanish].
(no abstract available)

37. Hesch, R. 1971. New bagasse particle board plant being erected in Trinidad. Sugar Y Azucar. 66(10): 86-88. [English and Spanish].
(no abstract available)

38. Hesch, R. 1973. Producing particleboard from sugar mill. bagasse. World Wood. 14(8): 16-18.
(no abstract available)

39. Hesch, R. 1975. Physical properties of bagasse particleboard. Sugar Y Azucar. 70(5): 23-24. [English and Spanish].
(no abstract available)

40. Hsieh, W.; Chen, M. 1972. Preparation of phenolic resin bagasse particle board. Tai-Wan Tang Yeh Shih Yen So Yen Chiu Hui Pao. 57: 95-107. [Chinese].

Summary: Phenol-formaldehyde resin, phenol-m-cresol-formaldehyde resin, and phenol-resorcinol-formaldehyde resin were prepared, mixed with bagasse particles, and press cured for about 15 min at roughly 145°C to 150°C at 1.2 MPa to give particleboards that met WCPA specifications. Their resistance to weathering was tested. All boards had good weathering resistance. In accelerated aging tests (ASTM D 1037-64), flexural strength was 70 to 85 percent of the original strength. Phenol-resorcinol-formaldehyde resin had the best overall physical properties.

41. Huang, H.C. 1966. Quality improvement of bagasse particle board with low-resin cost. Taiwan Sugar. 13(5): 23-25, 29.

Summary: A study was made of the effect of urea-formaldehyde resin content and resin extender on the quality of bagasse particleboard. The results can be summarized as follows: resin spraying conditions had no effect on board quality; reducing the resin content to less than 6 percent resulted in an abrupt decrease in board strength; and neither wheat flour nor sodium silicate were suitable resin extenders. Sulfur acted as an extender, but the long hot-pressing time required makes it uneconomical to use. Good results were obtained when using asphalt as an extender. Board containing 6 percent resin, 2 percent asphalt, and 1 percent paraffin wax had a water absorption of 8.6 percent and a thickness swell of 11.8 percent after 24 h of immersion. Strength properties of the board were satisfactory.

42. Huang, H.C. 1974. A study of changes in bagasse during storage and the effect on the quality of bagasse particle boards. In: Proceedings of the 15th congress of the International Society of Sugar Cane Technology. 3: 1840-1850.
(no abstract available)

43. Hugot, E.; Langreney, F. 1968. The Bagapan particle board. In: Proceedings of the 13th congress of the International Society of Sugar Cane Technologists; Taiwan. Amsterdam, The Netherlands: Elsevier Science Publishing Co.: 1891-1899.
(no abstract available)

44. Kehr, E.; Schölzel, S. 1962. Bagasse and other residues of annual plants as raw material for particle board. Holztechnologie. 3(3): 225-232. [German].

Summary: The suitability of bagasse and other lignocellulosic residues, such as flax shives, rape straw, reed, sunflower seed husks, and groundnut shells, as raw material for particleboard was studied. The physical properties of the boards prepared from various residues on a laboratory scale were tabulated. While the utilization of annuals other than bagasse were only touched on, the manufacture of bagasse particleboard is given in detail. Single-layer, as well as three-layer, boards were prepared using 5 to 12 percent urea-formaldehyde resin as a binder. Satisfactory products were obtained by pressing the material at 170°C and 1.5 MPa for 6 to 10 min.

45. Khaleyan, V.P.; Bagdasaryan, A.B.; Khaleyan, G.V.; Kazirelov, G.K. 1981. Composition for producing structural articles. Assignee: Shinanyut Erevan Experimental Plant. Patent, P.N.: SU 885206, I.D.: 811130. [Russian].

Summary: The bulk density of structural articles is decreased and the strength indexes are increased by adding 28 to 32 percent by weight cane stems to the composition containing 40 to 43 percent by weight phenol-formaldehyde resin, 0.7 to 1 percent by weight blowing agent, 5 to 5.2 percent by weight urotropine, 10 to 13.4 percent by weight expanded perlite, and 8 to 10 percent by weight ground straw.

46. Kolejàk, M.; Rajkovic, E. 1961. Particle board from bagasse and bamboo. Drevarsky Vyskum. 2: 103-116. [Slovakian].

Summary: Various types of experimental particleboards (single- and three-layer construction boards, boards overlayed with resin-impregnated paper, thick insulation boards, and 5-mm-thick boards) were manufactured from depithed bagasse and bamboo chips. The two materials were found to be suitable for all types of boards. The mechanical properties and water absorption of the boards obtained are tabulated.

47. Laurie, C.K. 1978. Separation-a process for producing high-quality sugar cane fibers for pulping and for use in composition panels. In: TAPPI Nonwood plant fiber pulping progress report 9. Atlanta, GA: TAPPI Press: 83-89.

Summary: The Tilby separation process removed the rind from the split sugarcane stalk by milling away the soft pithy interior and then machining off the epidermal layer and wax on the outside of the rind. The rind, which is 18 to 20 percent of the weight of the cane stalk, contained some 46 percent bagasse fiber on a wet basis. The fibers are substantially free of pith and may be washed free of hot-water solubles and used in the production of corrugating medium and particleboard.

48. Mahanta, D.; Chaliha, B.P.; Lodh, S.B.; Iyengar, MS. 1970. Binderless process for obtaining waterproof boards from bagasse. Indian Pulp and Paper conference (IPPTA); 7: 58-62.

Summary: Bagasse was powdered to a specific size with a predetermined moisture content and blended with a suitable dehydrating agent. Boards were prepared on a laboratory scale using a hot press that is described fully. The effects of particle size, temperature of the hot press, applied pressure, and time of pressing on board properties were noted and results shown in a series of graphs.

49. Maku, T.; Sasaki, H.; Ishihara, S.; Kimoto, K.; Kamo, H. 1972. On some properties of composite panels. Wood Research (Kyoto). 44: 21-52. [Japanese].

Summary: Composites building panels were evaluated for thermal conductivity, warping as a function of moisture content, bending strength, modulus of elasticity, and flame resistance. Materials used as laminate plies included decorative veneer, plywood, wood fiber insulation board, wood particleboard, bagasse particleboard, paper honeycomb, and various mineral boards. Results are shown in tables and graphs.

50. Maldas, D.; Kokta, B.V. 1990. Studies on the preparation and properties of particleboards made from bagasse and PVC. I: Effects of operating conditions. Journal of Vinyl Technology. 12(1): 13-19.

Summary: The mechanical properties of particleboards prepared from ground sugarcane bagasse, polyvinyl chloride (PVC), and polymethylene polyphenylene isocyanate and the effects of different parameters-such as mixing temperature, molding conditions, particle size of the bagasse, concentration of PVC and polymethylenepolyphenylene isocyanate, as well as dilution of polymethylene polyphenylene isocyanate, on the mechanical properties of particleboards were investigated. The properties of phenol formaldehyde particleboards changed with the variation of mixing and molding conditions. A mixing temperature of 79.4°C and molding conditions (platen temperature, 87.8°C; time, 10 min; and pressure, 3.8 MPa) were optimal conditions for producing particleboards. Both the mechanical properties and the density of particleboards of bagasse with a 60-mesh size improved up to 20 percent by weight of PVC and 10 percent by weight of polymethylene polyphenylene isocyanate.

51. Maldas, D.; Kokta, B.V. 1991. Studies on the preparation and properties of particle boards made from bagasse and PVC: II. Influence of the addition of coupling agents. Bioresource Technology. 35(3): 251-261.

Summary: This study concerned the effect of thermoplastics (polyvinyl chloride and polystyrene), as well as the coupling agent polymethylene polyphenyl isocyanate (PMPPIC) and bagasse lignin, on the mechanical properties of particleboards of sugarcane bagasse. The mechanical properties of the bagasse particleboards were compared to those of hardwood aspen fiber particleboards, as well as those of composites made from bagasse, polymers, and coupling agents. Bagasse particleboards comprised of both thermoplastics and a coupling agent offered superior properties compared to boards made only of thermoplastic or a coupling agent.

52. Martinez, O.; Serantes, M.; Morales, A.; Puig, J.; Almarales, G.; Sosa, P.; Rodriguez, M.E. 1991. Comparative study of urea-formaldehyde and urea-polyformaldehyde resin in bagasse particleboard production. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 25(3): 7-10. [Spanish; English summary]. (no abstract available)

53. Mestdagh, M.; Verkor, S.A.; Lawe, N.V. 1970. Particle board from annual plant wastes. United Nations Industrial Development Organization Document UNIDO) ID/WG.S3/5. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 45 p.

Summary: A review is given of the manufacture of particleboard from agricultural residues, especially from bagasse and flax shives. The physical properties of phenolic bonded flaxboards and bagasse boards are reported. Other fibrous materials considered were: hemp, jute, cotton stalk, rice hulls, groundnut shells, cereal straw, cornstalks, sisal, abaca, coconut fiber, bamboo, reed, palm leaves, and palm trunks.

54. Mobarak, F.; Fahmy, Y.A.; Augustin, H. 1982. Binderless lignocellulose composite from bagasse and mechanism of self-bonding. Holzforschung. 36(3): 131-135.

Summary: The self-bonding of air-dry bagasse and bagasse pith exhibited during hot pressing in a closely fitting mold was studied under varying conditions. It was shown that the ability of the particles to pack up closely was most important to self-bonding. The pith fraction gave a highly densified, plastic-like product superior to those from whole or depithed bagasse. This was attributed to the high lumen to cell wall ratio which favors the formation of interparticle bonds. Bending strength of up to 130 MPa and water absorption as low as 10 percent were obtained at 25.5 MPa molding pressure and 175°C.

55. Nagaty, A.; Mustafa, A.B.; Mansour, O.Y. 1979. Lignocellulose-polymer composite. Journal of Applied Polymer Science. 23(11): 3263-3269.

Summary: The properties of lignocellulose-poly (Me methacrylate) graft copolymer composites, prepared by grafting Me methacrylate onto bagasse ground to different mesh sizes in the presence of $NaHSO_3$ and soda lime glass system, depended on the polymer load and mesh size of the ground bagasse. Grafting without soda lime glass was also successful, although the properties of the composites produced from these samples differed greatly from those containing glass. Composites from impregnated ground bagasse of 40-mesh size exhibited deteriorated properties such as increased percent deformation, compressibility, and H_2O uptake, and decreased compression strength, compression strength to percent deformation ratio, and hardness compared to samples from crude graftings.

56. Nakasone, H.; Oda, K. 1976. Studies of bagasse storage. I. Deterioration of bagasse during storage and quality of bagasse particle boards. Wood Industry. 31(3): 104-107. [Japanese summary].
(no abstract available)

57. Narayanamurti, D. 1957. The influence of resin supply in the development of a particle board industry in underdeveloped countries. Composite Wood. 4(5): 79-88.

Summary: The establishment of a particleboard industry in India was investigated. Lignocellulosic wastes, such as bagasse, jute sticks, and wood waste, are plentiful in India. Particleboard adhesives would have to be imported, but could be substituted with native adhesives prepared from cashew shell oil or bark tannins. The properties of boards made from native materials are described.

58. Paturau, J.M. 1989. By-products of the sugar cane industry: an introduction to their industrial utilization. 3d ed. Amsterdam, The Netherlands: Elsevier Science Publishers V.B. 435 p.

Summary: This report provided thorough coverage on the industrial utilization of sugarcane, including well-cited references at the end of each chapter.

59. Paul, B.B. 1970. Prospects and economics of utilization of bagasse as raw material for pulp and paper industries in India. Indian Pulp and Paper conference (IPPTA); 7: 43-48.

Summary: The economics of bagasse purchase, collection, storage, preservation, and depithing, and the cost of bagasse particleboard manufacture were discussed. The evaluation of bagasse fuel value (as compared with oil) was also covered. Strength properties of bagasse particleboards were compared with those of corresponding boards made from wood, flax, jute, and hemp.

60. Pizzi, A.; Cameron, F.; Van der Klashorst, G.H. 1989. Soda bagasse lignin adhesives for particleboard: preliminary results. In: American Chemical Society symposium series 385. Washington, DC: The American Chemical Society, Books and Journals Division: 82-95.

Summary: The development and application of low-cost adhesives for interior-grade particleboard and for exterior-grade structural glulam derived from soda bagasse lignin are very advanced. Laboratory results and optimum conditions of application of these adhesives for particleboard manufacture were evaluated in this study. The results satisfy the requirements of the relevant standard specifications.

61. Rakszawski, J.F.; Schroeder, H.F. 1970. Process for single stage addition of resin in the preparation of multi-layer bagasse boards. Assignee: Esso Research and Engineering Co. Utility, P.N.: US 3493528, I.D.: 700203.

Summary: A structural board is formed from bagasse by fractionating the bagasse into a fiber fraction and a pith-and-fines fraction, adding resin to each fraction, and forming multi-layered board in which each layer is made of one of the fractions. The ratio of resin in the pith-and-fines fraction to that in the fiber fraction is 1.8 to 3.5.

62. Rengel, F.; Bartolucci, L.A. 1968. Panel boards from sugarcane bagasse and formaldehyde quebracho tannin resins. Industria Quimica. 26(3): 178-182. [Spanish; English summary].

Summary: Sugarcane bagasse, comminuted to small particles, was used for board manufacture; the sugar was removed to improve the mechanical resistance of the finished board. For fiber bonding, the material was mixed with a resin obtained from 50 percent sulfited quebracho tannin solution, formaldehyde, and hexamethylenetetramine. The best gelling time was 270 s at 100°C and 9 percent hexamethylenetetramine concentration (based on tannin extract). After sheet formation, the material was pressed at 140°C to 150°C, yielding boards with satisfactory strength and water resistance.

63. Roman, C. 1951. Artificial wood product. Patent, P.N.: US 2578489, I.D.: unknown.

Summary: An artificial wood product is produced using bagasse, a thermosetting resin binder, and cereal flour.

64. Salyer, I.O.; Usmani, A.M. 1982. Utilization of bagasse in new composite building material. Industrial and Engineering Chemistry, Product Research and Development. 21(1): 17-23.

Summary: A description is given of two composite building material systems and processes that utilize major percentages of bagasse filler and minor amounts of phenolic binder. Building materials developed are defined in the paper as bagasse-phenolic and oriented bagasse-phenolic. Applications for these composites are wall panels, ceiling, roofing, flooring, counter tops, fences, siding, acoustical panels, sinks, furniture, doors, and shutters.

65. Serantes, M.; Martinez, O.; Almarales, G.; Morales, A. 1989. Free formaldehyde resins for the production of bagasse particleboard. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 23(2): 26-29. [Spanish; English summary].

Summary: The effects of urea with a formaldehyde ratio in the range of 1:0.9 to 1:1.5 in the resin on the physical and mechanical properties of bagasse particleboard were tested. Data on density, moisture content, bending and tensile strengths, and 24 h swelling are tabulated and graphed. Regression equations are given for the graphs. Boards in which the ratio was 1:1.1 had good properties.

66. Serantes, M.; Morales, A.; Almarales, G. 1990. Sealer based on urea-formaldehyde resin for bagasse particleboards. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 24(1): 24-28. [Spanish; English summary].
(no abstract available)

67. Serantes, M.; Sedliacik, M.; Morales, A. 1985. Phenol-formaldehyde adhesive for bonding of particleboard from bagasse. Zb. Ref.—Semin. "Pokroky Vyrobe Pouziti Lepidiel Drevopriem." 7: 130-148. [Spanish].

Summary: Phenol-formaldehyde resin was prepared and used to manufacture bagasse-based particleboards with properties similar to those of wood-based particleboard. Using the special phenol-formaldehyde resin developed in the laboratory, particleboard samples were manufactured (160°C, 1 percent paraffin emulsion) at varying resin levels (8 to 12 percent) and pressing cycle times (6 to 10 min), and the density, moisture content, and water absorption were determined. Bagasse particleboards with properties comparable to wood particleboard were obtained at a resin level of 11 percent and a pressing cycle time of 7 min.

68. Serantes, M.; Sedliacik, M.; Morales, A.; Puig, J.; Almarales, G. 1990. Phenol-formaldehyde resin catalysts for the production of bagasse particle boards. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 23(2): 37-42. [Spanish; English summary].

Summary: Formamide, hexamethylene tetramine, and potassium carbonate catalysts used with phenol-formaldehyde resin in the manufacture of bagasse-based particleboard were studied to assess their effects on resin hardening time (RHT) and particleboard press time (PBPT). The best results were obtained with 1 to 2 percent formamide, which reduced RHT by 35 percent and PBPT by 6 to 7 min and produced the greatest improvement in the board's physical and mechanical properties.

69. Serantes, M.; Sedliacik, M.; Morales, A.; Puig, J.; Almarales, G.; Sosa, P. 1990. Hardeners in phenol-formaldehyde resin for production of bagasse particleboards. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 24(2/3): 37-42. [Spanish; English summary].
(no abstract available)

70. Shen, K.C. 1984. Composite products from lignocellulosic materials. Patent, P.N.: SA 8308301, I.D.: 840725.

Summary: Hot pressing of comminuted sugar-containing lignocellulosic materials, such as bagasse, sorghum, corn, sunflower, and flax stalks, without using adhesives, gave composites with good strength properties and dimensional stability. Bagasse containing 3.8 percent moisture and 4.7 percent reducing sugar was hammermilled, formed into a three-layer mat, and pressed to a density of 0.72 g/cm^3 for 12 min at 235°C and 2.8 MPa pressure to give a board containing 0.7 percent reducing sugar with 16.3 and

8.6 MPa dry and wet modulus of rupture, respectively, and 3.8 GPa dry modulus of elasticity.

71. Shukla, K.S.; Prasad, J. 1985. Building boards from bagasse: Part I. PF bonded particleboards. Journal of the Timber Development Association of India. 31(4): 20-27.

Summary: The addition of 8 percent phenol formaldehyde copolymer on the basis of dry fiber weight to bagasse fibers and pressing at 60°C to 62.8°C gave particleboard physico-mechanical properties that met the requirement of Indian Standards. However, the color of the boards was not as attractive as that of boards from lumber.

72. Stofko, J. 1982. Steam bonding of solid lignocellulosic material. Assignee: John Jansky. Patent, P.N.: EP 63404, I.D.: 821027.

Summary: Steaming the mat from wood particles treated with sugar, starch, and lignin in a sealed press and compaction by pressure gave particleboard with bond strength comparable to that produced by conventional adhesives. Wood particles were sprayed with an aqueous suspension containing 17.5 percent sugarcane molasses and 35 percent wheat flour or sugar and bark extract or lignosulfonate, deposited into a press, and heated to 172°C for 6 mm. The resulting boards had a density of 0.70 to 0.75 g/cm^3, a modulus of rupture of 10 to 14.5 MPa, an internal bond strength of 592.9 to 861.8 kPa, and thickness swelling of 10 to 14.5 percent after 24 h of soaking in water.

73. TAPPI Nonwood Plant Fibers Committee. 1976. Nonwood plant fiber pulping. Progress report 7 (featuring utilization of nonwood plant fibers for manufacture of composition panel boards). TAPPI C.A. Rep. 67. Atlanta, GA: TAPPI Press. 111 p.

Summary: Ten technical papers presented at a conference, held in Dallas in September 1976, are included in this volume. Most papers deal with the manufacture of particleboards and related building panels from bagasse, kenaf, and other nonwood fibrous raw materials.

74. Tilby, S.E. 1977. Sugarcane rind fibreboard forming apparatus-has horizontal compacting plunger followed by vertical extrusion plunger. Patent, P.N.: US 4025278, I.D.: 770524.

Summary: The first stage plunger works horizontally across a collection zone to compress the fibers against a vertical face. The second stage plunger works vertically, aided by gravity, to further compress and pack the material downward through an extrusion die. The die contains a heating/cooling device with heating stage to melt natural resinous binder substances in the material. The cooling section hardens binder. Boards are delivered in a way which facilitates subsequent sizing and stacking. Fiber pattern and strength of finished boards are about the same as those of wooden lumber. Board can be utilized structurally or made similar to plywood.

75. Tropical Products Institute. 1963. Examination of a sample of bagasse from the West Indies for particle board production. Rep. 14/63. London, England Tropical Products Institute (TPI). 7 p.

Summary: Sample preparation, manufacture, and testing of bagasse particleboards are described, and the disadvantages of bagasse as a raw material for particleboard are discussed. Both single- and three-layer boards were produced. Although the boards had satisfactory density, they did not meet the specifications required by British Standard 2604.

76. Trujillo, M.; Carvajal, O.; Puig, J. 1988. The use of diammonium phosphate as a fireproofing agent for particleboards. Institute Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 22(2): 58-62. [Spanish; English summary].

Summary: The fire resistance of particleboards manufactured with bagasse and urea-formaldehyde resin containing approximately 4 percent $(NH_4)2HPO_4$ solution as the fireproofing agent was acceptable and the physical and mechanical properties of the boards met Cuban quality standards. The combustion time of the boards decreased as the fireproofing agent concentration increased.

77. Tu, CC. 1973. Studies on improving the quantity and quality of bagasse particle board. Taiwan Sugar. 20(2): 48-55.
(no abstract available)

78. Turreda, L.D. 1983. Bagasse, wood, and wood-bagasse particleboards bonded with urea-formaldehyde and polyvinyl acetate/isocyanate adhesives. NSTA Technology Journal. 8(3): 66-78.

Summary: Chips of bagasse and/or plywood residue were bonded with urea formaldehyde or polyvinyl acetate/polyurethane adhesives (8, 10, 12 percent resin) and made into single-ply, 10-mm particleboards with relative densities of 0.5, 0.65, and 0.75 g/cm^3. Property evaluations indicate that partially depithed bagasse, by itself, could serve for internal-use particleboards and that urea-formaldehyde resin was more compatible as a binder for bagasse than was polyvinyl acetate/polyurethane. Boards produced from bagasse met Japanese standards for modulus of rupture and internal bond, but boards of bagasse/wood-particle mixtures had better properties.

79. Turreda, L.D. 1985. Cornstarch adhesive as bonding agent for particleboard. NSTA Technology Journal. 10(2): 56-66.

Summary: In the manufacture of particleboard from bagasse and wood, the resin binder type had a significant effect on the properties of the board. Cornstarch adhesive containing Millionate MR 100 was more compatible with bagasse than with wood particles. Boards containing 8 percent cornstarch-Millionate MR 100 adhesive met the JIS specifications for modulus of rupture and internal bond strength properties at board density 0.50 g/cm^3 and 0.65 g/cm^3; bagasse particleboard bonded with cornstarch-Millionate MR 100 adhesive produced better internal bond strength than particleboard bonded with resin adhesive.

80. Ulbricht, H.J. 1957. The possibility of using bagasse and straw as raw materials for particle board manufacture. Food and Agriculture Organization of the United Nations Document (FAO) FAO/ECE/BOARD CONS/Paper 4.17. Fiberboard and Particle Board. Report of an international consultation on insulation board, hardboard, and particle board; Geneva, Switzerland. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

Summary: Experiments indicated promising possibilities for the manufacture of particleboard from bagasse. Urea-formaldehyde resin (8 percent) was added as binder. The strength properties of the bagasse particleboards were comparable to those of similar boards made from pine shavings or flax shives.

81. Valdes, J.L.; Mendez, J.; Rodriguez, M.E.; Sosa, P. 1989. Quality of Cuban particle boards made from bagasse. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 23(1): 44-47. [Spanish; English summary].

Summary: The physical and mechanical properties of bagasse particleboards produced at Cuba's three main factories in 1987 were evaluated. Results indicated that the quality of these boards improved significantly over that of boards manufactured in previous years, particularly with regard to modulus of rupture, swelling, and bending strength.

82. Valdes, J.L.; Rodriguez, M.E.; Sosa, P. 1991. Bagasse particle boards: qualitative and use aspects. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 25(1/2): 22-26. [Spanish; English summary].

Summary: Cuban, British, and ISO standards were utilized to evaluate bagasse particleboards. The properties evaluated included density, moisture content, bending strength, surface solidity, modulus of rupture, modulus of elasticity, and surface smoothness. Cuban-manufactured boards were found to be of a quality suitable for the international market.

83. Verbestel, J.B. 1968. Some experiences with and possibilities for the manufacture of particle boards from nonwood fibrous raw materials. Food and Agriculture Organization of the United Nations Document (FAO) WPP/68/4.5. Food and Agriculture Organization of the United Nations (FAO) Committee on wood-based panel products, 2d session; 1968 November 6-8; Rome, Italy. 23 p. [French].

Summary: Large-scale commercial production of particleboard from nonwood fibrous raw materials is limited to bagasse, flax, hemp, jute sticks, and cotton stalks. The board making processes used are described briefly and the properties of the boards tabulated. Other agricultural wastes that have been tested but are not used industrially include bamboo, abaca, ramie, sisal, kenaf, coconut tree, palm leaves and stems, and groundnut shells. Density and strength properties of boards made experimentally from these materials are reported.

84. Wang, U. 1975. Scale-up production of bagasse plastic combinations using gamma radiation. Ho Tzu K'o Hsueh. 12(1): 12-22.

Summary: The impregnation of bagasse boards with vinyl acetate-vinyl chloride mixtures, Me methacrylate, unsaturated polyester-Me methacrylate mixtures, or styrene dissolved in EtOH, followed by irradiation with a Co^{60} source, gave plastic-bonded structural boards with greater mechanical strength, better resistance to weather, and higher resistance to insect damage than untreated bagasse boards. The boards containing 48 to 53 percent polymeric binder had 1.2 to 2.5 times greater tensile strength, 6 times greater hardness, and 1/10 of the water absorption of the untreated control boards.

85. Ye, Q.; Ye, L. 1987. Bagasse cellulose boards production-using cane molasses adhesive formed as by-product of sucrose production. Assignee: (YEQQ/) Ye Qinze. Patent, P.N.: CN 85106931, I.D.: 870311. [Chinese].

Summary: Molasses is mixed with slaked lime, sodium silicate, and water to prepare adhesives for bonding plant fibers such as crushed wood, shavings, sawdust, rice straw, wheat straw, and bagasse to prepare boards.

86. Young, M.A. 1968. Use of furfuryl alcohol in binder resin for bagasse particle boards. I. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 2(1): 48-54. [Spanish].

Summary: Particleboard with excellent water resistance and modulus of rupture was prepared by impregnating bagasse fibers with 12 to 14 percent furfural alcohol and 7.5 to 10 percent maleic acid or toluenesulfonic acid catalyst (based on furfural alcohol), forming the material into a mat, and pressing the mat at 160°C to 180°C to polymerize the furfural.

(See references 229, 236, 238, 239, 240, 254, 660, 678, and 1075.)

Fiberboard/Hardboard

87. Anonymous. 1963. Bagasse panelboard. Industrial Woodworking. 15(2): 12-13.

Summary: The manufacture and uses of bagasse fiberboard, as manufactured by the National Bagasse Products Corporation, are discussed. Such boards (Fibron™) are said to offer good finishing and painting surfaces, and high density properties for machining and fastening for heavy industrial applications.

88. Anonymous. 1984. Flame-resistant organic fiber products. Assignee: Osaka Soda Co., Ltd. Patent, P.N.: JP 59029551, I.D.: 840721. [Japanese].

Summary: Aqueous slurries are prepared from 100 waste organic fibers and 1 to 100 weight by parts waste paper, mixed with hardening agents, shaped, impregnated with aqueous silicates, and hot pressed to give flame-resistant organic fiber products. A ratio of 3:1 (by weight) of bagasse and waste papers, respectively, were used to make an aqueous slurry, mixed with acidic China clay (4 percent), $Al(OH)_3$ (4 percent), and $AlPO_4$ (2 percent) by weight, shaped, dried at 105°C, impregnated with an aqueous sodium silicate containing 0.2 percent sodium naphthalenesulfonate, dried, and pressed at 160°C and 196.1 kPa to obtain a flame-resistant, water-resistant board with bending strength 6.6 MPa.

89. Bargava, M.P.; Nayer, A.N. 1943. Manufacture of insulation and pressed board, etc., from bagasse. International Sugar Journal. 45: 95-97.

Summary: The processing of bagasse into boards using the Asplund defibrator for preparation of the stock is described in detail. The methods of moisture- and fire-proofing and preservation of the boards are reviewed. Estimates of production costs and profits are given.

90. Batlle, C.E. 1973. Characterization of the process of fiberboard manufacture from sugarcane bagassi by the wet-dry method. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 7(1): 3-12. [Spanish; English summary].
(no abstract available)

91. Batlle, E.; Rodriguez, N.; Suarez, J. 1974. Influence of storage methods on the properties of bagasse fiberboards. (1). Effect of storage time on chemical composition and morphology of bagasse bales. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 8(3): 9-15. [Spanish; English summary].

Summary: Variations in the chemical composition and morphology of bagasse stored for 12 months are analyzed. Under ideal storage conditions, the chemical composition was slightly altered, but the bagasse became a stable material within the storage period. The α-cellulose, holocellulose, and lignin contents increased in the first 7 months, then decreased slightly. Besides storage time, depithing seemed to affect the length of elemental fibers; fiber length varied with the equipment used and the humidity at which depithing occurred.

92. Batlle, E.; Rodriguez, N.; Suarez, J. 1975. Influence of storage methods on the properties of bagasse fiberboards. (2). Influence of bale storage time on the properties of hard fiberboards made by the wet-dry process. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 9(1): 56-68. [Spanish; English summary].

Summary: It was found that the rupture modulus value tended to rise in the first 7 months of storage and then decreased sharply until it was less than the initial value for fresh bagasse. Such behavior appeared to be correlated to the chemical composition rather than to the degree of depithing or the granulometric composition of the pulp. Granulometric composition of the bagasse samples used is tabulated. It is suggested that depithing is intimately related to the ultimate board properties. In commercial practice, similar behavior can be expected as a result of storage time, as well as cooking parameters.

93. Batlle, E.; Suarez, J.; Rodriguez, N. 1973. Characterization of the process of fiberboard manufacture from sugarcane bagasse by the wet-dry method. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 7(1): 3-12. [Spanish; English summary].
(no abstract available)

94. Cao, Z.; Xing, Z.; Guan, Z.; Wu, Q.; Bai, G. 1986. Bagasse fibreboard dry manufacturing process by hot pressing using waterproof agent and binder, e.g. phenol resin or urea-formaldehyde resin. Assignee: (CAOZ/) Cao Zhengxiang. Patent, P.N.: CN 85109469, I.D.: 860723. [Chinese].
(no abstract available)

95. Cao, Z.; Xing, Z.; Guan, Z.; Wu, Q.; Bai, G. 1986. Dry method of manufacturing bagasse fiberboards. Patent, P.N.: CN 109469/85, I.D.: 860723. [Chinese].

Summary: Bagasse fiberboard with high bending strength and improved water absorption resistance comprises PhOH-modified urea-formaldehyde copolymer and paraffin wax. Bagasse fiber containing 5.24 percent PhOH-modified urea-formaldehyde copolymer and 1.5 percent paraffin wax was molded at 170°C and 2.5 to 7.8 MPa to give a 4.29-mm-thick sample exhibiting bending strength of 58.5 MPa and water absorption of 11.3 percent. This compares to 43.8 MPa and 34.7 percent for 11 percent urea-formaldehyde copolymer instead of PhOH-modified urea-formaldehyde copolymer.

96. Carvajal, O.; Puig, J.; Leal, J.A.; Rodriguez, M.E. 1985. Effect of pith content on quality of bagasse-based particle boards. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 19(3): 19-24. [Spanish; English summary].

Summary: Test samples contained 0, 5, 10, 15, 25, and 30 percent pith added to the center and surface layers of bagasse-based particleboard. Results showed that the addition of up to 15 percent pith will produce good quality board; this is comparable to 61 percent fiber in the center layer and approximately 50 percent fiber in the surface layers. Traction perpendicular to the plane decreases with the addition of pith, whereas wood improves this property through the addition of fines. The pith's sponginess allows for the penetration of resin, thereby adversely affecting this

property. Modulus of rupture, expansion, water absorption, and surface quality are similar to those of wood-based particleboards, except that expansion and absorption are better in the thickest wood particles. Industrial results confirm the experimental data obtained in this study.

97. Carvajal, O.; Rodriguez, M.E.; Almarales, G. 1984. Bagasse-based particle boards treated with fire retardants. Instituto Cubano de htvestigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). Supplement 3. 9 p. [Spanish].

Summary: The most suitable amount of fire retardant to be used on bagasse-based particleboard was determined, together with the effects of the fire retardants on both the properties of the resins used in manufacturing particleboard and the board itself. Under the test conditions used, 4 percent fire retardant gave the best results with regard to resin properties and the physical and mechanical properties of the particleboards. Weight loss was 12 ± 2 percent. Fire retardant was added to other chemicals used in particleboard manufacture with satisfactory results.

98. Cherkasov, M.; Lodos, J. 1971. Use of furfural-urea resins in the manufacture of bagasse boards. Annual memorial conference of the Association Tec. Azucar Cuba. 38: 689-697. [Spanish].

Summary: Low density, low water absorption, deformation-resistant fiberboards were prepared from dry bagasse impregnated with a 10 percent alcohol solution of furfural-urea copolymer. Urea was refluxed with furfural in a 1:2 molar ratio for 3 h at pH of 7.5 to 8.0 and 2 h at pH of 5.5. Bagasse containing 10 percent water was impregnated 10 percent by weight in an alcohol solution, dried, and formed at 180°C and 9 MPa for 15 min to give a board with a density of 0.81 to 0.85 g/cm^3, water absorption of 14 to 15 percent after 24 h, deformation of 8 to 10 percent in water, and dry breaking strength of 22.6 to 26.5 MPa. Boards prepared from a liquid resin, not prepared and dissolved in alcohol, had lower densities and strengths.

99. Christensen, F.J.; Christensen, M.L. 1955. The production of hardboard from bagasse and a cresol resin. Victoria, Australia: Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Forest Products. 18 p.

Summary: The possibility of producing a high grade hardboard by the dry process from bagasse bonded with cresol formaldehyde resin was investigated. An examination was made of the effects of resin content, moisture content, and pressing time and temperature on the material pressed at 3.4 MPa. The resin content was varied from 2 to 10 percent, moisture content from 0 to 17 percent, and pressing temperature from 188°C to 210°C. The resin content greatly influenced water resistance and modulus of rupture. Attempts to produce a satisfactory board with a resin content of 2 percent were unsuccessful.

100. Cunningham, W.A. 1942. Strong plaster for paperless wallboard. Rock Products. 45(4): 50-53.

Summary: The manufacture of bagasse fiberboard having a tensile strength of 2.3 MPa and a compressive strength of 6.9 MPa is described in detail.

101. De la Vega, E.; De Armas, E.; Canete, R.; Sabadi, R. 1988. Increase of energy efficiency by use of vapor thermocompression in manufacture of sugarcane byproducts. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 22(3): 56-60. [Spanish; English summary].

Summary: The energy balance in an integrated sugar mill-bagasse/furfural fiberboard manufacturing facility can be improved if secondary steam from the mill-bagasse/furfural production plant is used as carrier fluid in a thermo-compressor; the resulting steam can then be used in the thermal fiber removal units in the board plant. Thermo-compression is carried out by mixing two steam streams in a jet ejector: one of the streams is the high pressure working fluid and the other is low pressure carrier fluid; the thermodynamic characteristics of the resulting steam are determined by the mixing streams. The theoretical energy balance calculations are outlined; the estimated fuel oil savings are approximately 6,381,200 kg/year.

102. De Lumen, B.O.; Villanueva, L.J.; Bawagan, P. 1962. Properties of hardboard from sugar cane bagasse. Philippine Agriculturist. 46(9): 717-728.

Summary: Undepithed and depithed bagasse was pulped by the cold soda process, passed through an 20.32-cm attrition mill, and formed into circular pulp mats approximately 21.59 cm in diameter. The mats, without sizing, were pressed to hardboard by using an initial maximum pressure of 4.9 MPa for 1 min at 177°C. The hardboards from depithed bagasse were superior in load capacity, stiffness, and water resistance, and showed higher values of rupture modulus and elasticity than undepithed boards. Water absorption was lower after 15 min pressing time than after a 10 to 12 min pressing treatment.

103. Friedrich, K. 1941. The behavior of fiberboard toward wood-destroying fungi. Holz als Roh- und Werkstoff. 4(7): 241-248. [German].

Summary: The attack of wood-destroying fungi on fiberboard (insulation board, medium density board, and hardboard) prepared from bagasse, coniferous wood, or straw was studied. Samples of both untreated and treated with fungicides (arsenic and barium compounds, chlorinated hydrocarbons, dinitrocresol), bitumen, and natural and synthetic resins were tested. All agents were ineffective, with the exception of arsenic. Boards prepared from bagasse and straw were particularly sensitive to fungus attack.

104. Gaddi, V.Q.; Samaniego, R.L.; Semana, J.A. 1984. Starch and some derivatives as binder in the production of hardboard from sugarcane bagasse. Technical Information Digest. 4345: 1-12.

Summary: Starch and two of its derivatives were used as binders in the production of hardboards from sugarcane bagasse. The derivatives used were the acid-modified starch made by treating the starch suspensions with an alkaline hypochlorite solution. The addition of starch and two of its derivatives improved static bending, or modulus of rupture, of the boards. The highest value obtained with 4 percent addition of hypochlorite-oxidized starch was 16.6 MPa. Other properties evaluated were moisture content, percent thickness swell, and density.

105. Galvez Taupier, L.O. 1988. Fibreboards. In: Manual de los Derivados de la Cana de Azucar. Mexico: ICIDCA-GEPLACEA-PNUD: 111-116. [Spanish].
(no abstract available)

106. Gemmell, M.J.; Mann, P.E. 1972. Fibrous boards. Assignee: Tate and Lyle Ltd. Patent, P.N.: GB 1286469 I.D. 720823.

Summary: Fibrous corrugated boards suitable for roof sheeting or guttering were prepared by a two-stage process in which 7 to 20 percent of weight of a dry heat-hardened binder with a melting point below its curing temperature was blended with the fibrous material, formed into a mat, and fused without curing by dielectric heating to give a never pressed green board, which was conventionally formed and cured in the second stage. A mixture of 69.5 kg Cellobond, J2458 (phenolic novolak-hexamine blend), 387.4 kg bagasse fibers, and 4.7 x 10^{-4} m^3 trixylyl phosphate was spread into a mat, heated to 70°C to 95°C to bond the fibers, and cooled to give a green board which was strong enough to be lifted for further processing. This green board was compacted at 110°C to 150°C to effect the final cure of the binder. Comminuted wood chips were similarly used as the fibrous material. The corrugated structural members were optionally faced on one or both sides with chipboard or plywood to give roof or wall panels, or other structural materials.

107. Glomera Limited. [nd.]. Glomera complete process of preparing and briquetting sugarcane bagasse. Pamphlet 104A. Basel, Switzerland: Glomera Ltd. 9 p.

Summary: The process produces long (10- to 50-mm), dry depithed fibers of high quality from raw bagasse and compresses the fibers into briquettes. The fibers are suitable for the manufacture of hardboard, insulating board, and chemical and mechanical pulp for paper.

108. Guha, S.R.D.; Singh, M.M.; Mukherjea, V.N.; Saxena, V.B. 1965. Fiberboards from bagasse. Indian Pulp and Paper. 20(4): 255-256.

Summary: Laboratory experiments on the production of insulation boards and hardboards from bagasse are described. Bagasse soaked in water for 15 h was steamed at 784.5 kPa pressure for 5 min (for insulation board) or 15 min (for hardboard), then defibrated, formed into sheets, and dried at 190°C for 30 mm at zero pressure (for insulation board) or 3.1 MPa (for hardboard). Average yield, based on the board, was 83 percent. Properties of the boards were satisfactory.

109. **Hesch. R.** 1968. Fiberboards from bagasse for the construction and furniture industry: a new bagasse plant at Reunion. Zeitschrift Zuckerind. 18(3): 114-120. [German; English, French, and Spanish summaries].

Summary: Boards in this study were comparable in quality to similar boards made of wood waste. The capacity of the plant on the island of Reunion is 42,000 board sheets per day. Bagasse is depithed in special machines in two stages (the pith content is 20 to 35 percent). Depithed and dried bagasse fibers are then mixed with the binder and hot pressed the same way as boards made of wood particles.

110. Hesch, R. 1970. Economics and perspectives on the use of sugarcane pulp in the making of pressed panels. Bol Azucar Mexico. 249: 2-4, 6-8, 10-14, 16. [Spanish].
(no abstract available)

111. Jain, N.C.; Gupta, R.C.; Bajaj, S.C.; Singh, D.D. 1964. Note on the utilization of sugarcane leaves. Indian Pulp and Paper. 19(5): 365-366.

Summary: Preliminary trials on the use of sugarcane leaves as a filler and an extender in plywood manufacture and for manufacturing hardboard are reported. When used as a filler or extender, glue adhesion values were satisfactory to up to 30 percent extension. Hardboards made from sugarcane leaves had suitable characteristics, although board strengths were low. Cooking sugarcane leaves in 3 percent NaOH produced material of sufficient strength to be utilized as a low grade hardboard. Trials for use in chipboards were not encouraging. Up to 30 percent powdered leaves may be used as a filler and extender in phenol-formaldehyde resins.

112. Lathrop, E.C.; Naffziger, T.R. 1948. Evaluation of fibrous agricultural residues for structural building board products. I. Methods and equipment. Paper Trade Journal. 127(27): 53-60.

Summary: Equipment and methods used for evaluating fibers for structural board manufacture are described. With sufficient study, it is possible to determine a factor between the strength values of experimental boards and boards made from the same pulps on commercial board machines. The high impact strength of boards made from bagasse and wheat straw is attributed to the long, tough fibers which are characteristic of these residues.

113. Lois Correa, J.A. 1979. Sugarcane bagasse as a material for the production of boards. Drevo. 34(7): 189-192. [Slovakian].

Summary: Compared with wood, bagasse contains a relatively high amount (51 percent) of cellulose, but the cellulose fibers in bagasse are rather short, especially in comparison with softwood pulp. Bagasse is a suitable material for the production of fiberboard, but the pith must first be removed. A table is given comparing the specifications for 12 depithing machines; the most frequently used machines are of the hammermill type.

114. Machado Brito, E. 1946. Vazcane cane fibre board. Sugar. 41(11): 28-30.
(no abstract available)

115. Madan, R.N. 1976. A summary of investigations carried out at the Cellulose and Paper Branch on suitability of agricultural residues for pulp, paper, and board. Indian Pulp and Paper. 30(4): 15-17, 19-21.

Summary: The suitability of bagasse, jute sticks, rice, and wheat straw for the production of pulp, paper, paperboard, and fiberboard is reviewed, 27 references are provided.

116. Mobarak, F.; Augustin, H. 1984. Composite hardboard from pith and depithed bagasse-filled plastics. Research and Industry. 29(2): 108-113.

Summary: Bagasse-polymethyl methacrylate composite was produced by sodium bisulfite initiated polymerization of methyl methacrylate (PMMA) monomer in water at 25°C in presence of pith and depithed bagasse. Increase in the polymer content only decreased the water resistance of bagasse-PMMA composite hardboard, pith or depithed, increased the bending strength of bagasse pith composite, and increased the bending strength of depithed bagasse only marginally. The improvement in composite properties due to plastic filling was considerably less for bagasse with pith than for depithed bagasse.

117. Nada, A.A.M.A.; El-Saied, H. 1989. Impregnation of hardboard with poly(methyl methacrylate). Polymer-Plastic Technology Engineering. 28(7/8): 787-796.

Summary: Dipping of bagasse and rice straw in poly-Me methacrylate Me_2CO solution followed by additional thermal curing improved the physical properties of treated hardboard sheets. Bagasse and rice straw were dipped in 2 percent poly-Me methacrylate Me_2CO solution for 4 min followed by curing for 39 s at 26.7°C and 4.9 MPa. The percentage of improvement in the physical properties of treated hardboard sheets of rice straw was higher than that of bagasse sheets. Carrying out the dipping step during the second or third phase of the pressure cycle improved the physical properties of the hardboard sheets, and less polymer was consumed without the necessity of an additional thermal curing step.

118. Nagy, V. 1976. Some knowledge gained from the research of agglomerated fiberboard production applicable for developing countries. Silvaecultura Tropica et Subtropica. 5: 127-134.

Summary: In the production of fiberboard from bagasse, the application of an agglomeration method reduced electric energy consumption by 20 to 30 percent and water use to 7 to 60 m^3/746.4 kg of product.

119. Nee, C.I.; Hsieh, W.C. 1969. Feasibility study on furfural and structural board from bagasse. In: Proceedings of the International Society of Sugar-Cane Technology: 13: 1881-1890.

Summary: A furfural plant with a daily capacity of 2,612.4 kg of 99.8 percent pure product in conjunction with a fiberboard plant which cooks 14,928 to 22,392 kg of bagasse daily is described. A solubility curve indicating the properties of furfural-H_2O systems, as they vary with temperature, is given as well as distribution procedures for separating H_2O and furfural. Heat balances in typical operations are provided.

120. Nnabuife, E.L.C. 1987. Study of some variables affecting the properties of sulfur-reinforced sugarcane residue-based boards. Indian Journal of Technology. 25(8): 363-367.

Summary: Low density boards made with bagasse fiber and post-treated with either sulfur or sulfur modified with Escopol (a drying type of oil) were studied. Beating time, pre-treatment (addition of phenolic resin or wax to slurry before board formation) and post-treatment were the manufacturing variables examined. The effects of the variables on the physical and mechanical properties (dry and after 48 h of soaking) of the products were investigated, using analysis of variance technique with significance levels of 10, 5, and 1 percent probability levels. Although the boards were affected by all the variables, the deterministic factor was the amount of sulfur or sulfur/Escopol picked up during post-treatment.

121. Raj, R.G.; Kokta, B.V. 1991. The effect of processing conditions and binding material on the mechanical properties of bagasse fibre composites. European Polymer Journal. 27(10): 1121-1123.

Summary: Steam-exploded bagasse fibers (60-mesh size) were used for the fabrication of composites. Polyethylene (high, medium, and linear low density) was used as the binding material to improve the mechanical properties and the dimensional stability of the composites. The effect of variation in processing conditions (compression molding temperature, molding heating time, and molding pressure) on mechanical properties of the composites was examined. The composites molded at high temperature showed improvement in mechanical properties. Fiber adhesion was improved with the addition of polyethylene. Significant increases in

tensile strength and modulus were observed for the composites of bagasse fibers pretreated with polyethylene as compared to composites without binder.

122. Reddy, B.S.; Bhatt, S. 1981. Panel boards from agricultural wastes for developing countries. A review (plywood, fiberboard, veneers). Holzforschung und Holzverwertung. 33(6): 110-114. [German; English summary].

Summary: Agricultural wastes such as bagasse, bamboo, coconut husks, groundnut shells, rice husks, and sawdust are alternative raw materials for boards. This paper reviews these materials and provides 56 references.

123. Rionda, J.A. 1969. Compositions based on bagasse and heat-hardenable resin. Assignee: Esso Research and Engineering Co. Patent, P.N.: FR 1565996, I.D. 690502. [French].

Summary: Bagasse components containing 10 to 30 percent phenol-formaldehyde resins are used to prepare panels with improved tensile strength, cohesion, surface solidity, and reduced H2O swelling. The fibers are separated from green bagasse, impregnated with 25 percent aqueous phenol formaldehyde resins solution, and converted to mats by a felting machine. The mats are assembled in such a manner that large fibers constitute the surface and pressed at 149°C to 177°C to give panels with reduced H_2O absorption and swelling. The panel surface can be polished to assure improved brilliancy.

124. Rowell, R.M.; Keany, F.M. 1991. Fiberboards made from acetylated bagasse fiber. Wood and Fiber Science. 23(1): 15-22.

Summary: Bagasse fiber was acetylated with acetic anhydride alone to various levels of acetyl weight gain. Acetylation caused the bagasse fiber to become more hydrophobic, as evidenced by a lowering of the equilibrium moisture content as the level of acetylation increased. Acetylated bagasse fiberboards made from acetylated fiber at acetyl weight gains of about 17 percent had an equilibrium moisture content of about one-third that of control boards at all relative humidities tested. Fiberboards made from acetylated fibers swelled at a much slower rate and to a lesser extent as compared to control fiberboards. Internal bond strength was higher in acetylated fiberboards, while moduli of rupture and elasticity were slightly lower in acetylated boards as compared to control boards.

125. Scott, W. 1950. The industrial utilisation of sugarcane by-products. Port-of-Spain, Trinidad: Kent House. 121 p.

Summary: The book includes a chapter on the manufacture of various products from bagasse, including insulation board, hardboard, corrugated board, boxboard, and paper.

126. Sefain, M.Z.; Naim, N.A.; Rakha, M. 1978. Effect of thermal treatment on the properties of sugar cane bagasse hardboard. Journal of Applied Chemistry and Bio-technology. 28(2): 79-84.

Summary: Thermal treatment of sugarcane bagasse hardboard reduced strength, but improved water resistance, whether the boards were produced with or without resin. The bending strength of boards produced with a high ratio of resin showed a different behavior, toward hardening, than boards made from rice straw or cotton stalks. Theories are proposed to explain this behavior.

127. Serna, N.L. 1986. Fibreboards. In: Cientificio-Tecnica, ed. La Habana, Cuba: La Industria de los Derivados de la Cana de Azucar: 227-292. [Spanish].
(no abstract available)

128. Shen, T.K. 1955. Manufacture of hardboard from sugar cane bagasse. Taiwan Sugar. 2(9): 25-30.

Summary: A review is given of processes for the manufacture of hardboard, including fiber stock preparation, sizing, sheet formation, drying and pressing, and after treatment. No reference is made to the utilization of bagasse with the exception of two passages dealing with fiber stock preparation.

129. Shen, T.K.; Chang, H.W.; Tseng, H.C.; Yang, C.T.; Ou, C.T.; Liang, C.T. 1955. The effect of pith removal on the quality of the resulting bagasse hardboard. Taiwan Sugar Experiment Station Rep.: 209-222.

Summary: In the manufacture of bagasse hardboard by the conventional wet process method, removal of pith resulted in a 28 percent increase in flexural strength and a 37 percent increase in wet strength. It also improved the water resistance of hardboard made from crude pulp. At a freeness level of 60 Defibrator s, however, the effect of pith removal on water resistance was negligible.

130. Shukla, K.S.; Chandra R. 1986. Building boards from bagasse. Part II. Hardboards. Journal of the Timber Development Association of India. 32(1): 5-10.

Summary: Binder-free standard hardboards were obtained by pressing a bagasse composition obtained by cooking bagasse for 1.5 h with 1 percent alkali (bath ratio 1:6) and then tempering the boards for 4 h in air or 3 h in oil. Tempered boards were obtained from a composition cooked for 1.5 h with 2 percent alkali and then tempered in oil for 3 to 4 h.

131. Sidney, G.E. 1986. TMP and CTMP bagasse pulp experience from Mexican fiberboard mill. In: TAPPI nonwood plant fiber pulping progress rep. 17. Atlanta, GA: TAPPI Press: 53-57.

Summary: Fibrasin S.A. de C.V., a TMP bagasse insulation board and hardboard plant in Navolato, Mexico, is discussed.

132. Sidney, G.E. 1991. Mexican mills utilizing bagasse to produce pulp and fiberboard. In: TAPPI nonwood plant fiber pulping progress rep. 19. Atlanta, GA: TAPPI Press: 45-48. (no abstract available)

133. Singh, S.C. 1945. Manufacture of boards and paper from bagasse. Journal of Science and Research. 3: 399-404.

Summary: Studies carried out at Dehra Dun, India, indicated that the Asplund process would be the most suitable for making insulating and pressed board from bagasse. Methods and agents are described which were found to give necessary protection against moisture, termites, and molds, and render the boards reasonably fire-retardant.

134. Singh, S.C. 1945. Manufacture of boards and paper from bagasse. Tech. Bull. 22. Paper Maker's Association of Great Britain and Ireland: 4-6.

Summary: Studies carried out at Dehra Dun, India, indicated that the Asplund process would be the most suitable for making insulating and pressed board from bagasse. Methods and agents are described which were found to give necessary protection against moisture, termites, and molds, and render the boards reasonably fire-retardant.

135. Smith, W.W. 1976. History and description of current (bagasse fiberboard) operations of Tablopan (de Venezuela, S.A.). In: TAPPI C.A. Rep. 67. Atlanta, GA: TAPPI Press: 87-91.

Summary: The formation of Tablopan de Venezuela in 1958 and the operation of a pilot plant in 1959-1960 made it clear that high-, medium-, and low-density bagasse fiberboard could be manufactured economically with a dry process. Bagasse processing offers good economic incentives to sugar-producing countries in which there are small but growing markets for board products, and consequently where flexibility is required in the range of products to be manufactured.

136. Sosa Griffin, M. 1988. Technical and economic aspects of bagasse fibreboards. Paris, France: University of Paris VI–Centre scientifique et technique du batiment. 355 p. Ph.D. thesis. [French].
(no abstract available)

137. Suchsland, O.; Woodson, G.E. 1986. Fiberboard manufacturing practices in the United States. Agric. Handb. 640. Rev. 1992. Washington, DC: U.S. Department of Agriculture. 263 p.

Summary: This book provides a thorough review of the manufacturing methods of fiberboard production, from collecting of raw material and manufacture to marketing. Nonwood raw materials mentioned include bagasse, cornstalks, flax shives, and wheat straw.

138. Tao, H.C. 1966. Bagasse fibre board. Taiwan Sugar. 13(2): 21-25.

Summary: The manufacture of insulating board and S2S hardboard from bagasse at the Changwa Board Factory, Taiwan, is described. To soften the depithed bagasse before refining, it is cooked with water, usually at a pressure of 620.5 MPa. If other grades of boards are to be produced, cooking conditions are varied. In general, about 1 percent rosin size is added to the pulp. After sheet formation, the wet mats are dried in a multiple-deck drier. For the manufacture of hardboard, the soft dry sheets are hot pressed without the use of wires at 238°C and a pressure of 9.7 MPa. The resulting boards have satisfactory physical properties meeting standard requirements. The difficulties involved in the utilization of bagasse are briefly discussed.

139. Wu, H.S. 1958. TSC—successfully made hard fibre board from sugar cane bagasse. Taiwan Sugar. 5(6): 13-14.

Summary: The Taiwan Sugar Corporation (TSC) succeeded in preparing hardboard from bagasse by adapting the manufacturing process to the particular requirements of this annual plant fiber. No details of the manufacturing process are given.

140. Wu, H.S. 1963. The manufacture of hardboard from bagasse. In: Proceedings of the 11 th congress of the International Society of Sugar Cane Technologists. Mauritius. New York: Elsevier Publishing Co.: 1205-1211.

Summary: The process used for the manufacture of hardboard at a plant in Taiwan is described. After depithing, the bagasse is subjected to steam digestion at a pressure of 617.8 kPa, then washed, refined, sized with rosin, formed into sheets, dried, and pressed at 9.8 MPa. Dielectrical heating and prepressed mates were found to be the most economical at 360 kW/2,279 kg of water removed.

(Also see references 6, 28, 80, 146, 235, 241, 497, 499, 660, 678, 834, 845, 850, 858, 860, 863, and 1149.)

Insulation Board

141. Anonymous. 1932. A new $2,500,000 mill in Hawaii. Pacific Pulp and Paper Industry. 6(4): 22-23.

Summary: The article describes the new insulating board plant at Hilo, which converts bagasse after a special process into "Canec" structural insulation.

142. Anonymous. 1939. The rise of Celotex. Southern Pulp and Paper Journal. 2(3): 6-11.

Summary: The Celotex process of manufacturing fiberboards from bagasse is described. The chief application of the board is for construction and insulation.

143. Anonymous. 1946. Celotex Corporation expands in United States and Britain. Pulp and Paper Industry. 20(9): 26.

Summary: The operations of Celotex Corporation in its various plants, all utilizing bagasse as a raw material for structural and insulating boards, are briefly described.

144. Börger, H.E.A. 1953. Paper and board from bagasse. Wochbl. Papierfabrik. 81(13): 476, 478, 480. [German].

Summary: Various attempts at making paper and board from bagasse, with particular reference to the Celotex and Vazcane processes, are reviewed. Data of the chemical composition of bagasse and the length of its fibers, which varies with the species, are presented.

145. Chapman, A.W. 1955. Purchasing, handling, and storing of bagasse (for insulating board manufacture). In: Proceedings of the Food and Agriculture Organization of the United Nations (FAO) conference on pulp and paper prospects in Latin America. New York: United Nations: 335-337.

Summary: The standard operating procedures and techniques developed by the Celotex Corporation for handling the large amounts of bagasse needed are described. The material must be baled or stored within a period of approximately 75 sugar mill operating days.

146. Colonial Sugar Refining Company-Building Materials Division. 1957. Bagasse as a raw material for insulation board. Food and Agriculture Organization of the United Nations Document (FAO) FAO/ECE/BOARD CONS/Paper 4.13. Fiberboard and particleboard. Geneva, Switzerland: Report of an international consultation on insulation board, hardboard, and particleboard.

Summary: The utilization of bagasse as a raw material for insulation boards is discussed. In general, bagasse is used in conjunction with a substantial amount of repulped waste paper (up to 30 percent) and/or other fiber to improve stiffness, wet strength, and appearance of the boards. Bagasse is cooked with water in rotary digestors at a pressure of 313.8 kPa for 15 min with the addition of small amounts of lime, and defibration in a double disc refiner readily after the softening treatment. The pulp is then mixed with waste paper and eucalyptus pulp, formed into a mat using an Oliver vacuum drum-type machine, and dried in an eight-deck drier. In addition to common insulation boards, medium density hardboards and coated boards can be made successfully.

147. FAO. 1957. Bagasse as a raw material for insulation board manufacture. Food and Agriculture Organization of the United Nations Document (FAO) FAO/ECE/BOARD CONS/Paper 4.13. Fiberboard and particleboard. Report of an international consultation on insulation board, hardboard, and particleboard. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).
(no abstract available)

148. Goldsmith, W.F. 1932. Hawaii's new insulation board plant possesses many advantages. Paper Trade Journal. 95(17): 19-21.

Summary: This paper describes the Hilo, Hawaii, mill which converts bagasse waste into structural insulation board.

149. Hirschfield, A. 1929. Composite sheets for wall and ceiling coverings, partitions, and electric insulation. Patent, P.N.: GB 328985, I.D.: 290208.

Summary: A suitable adhesive is applied to a sheet of metal or to a sound-absorbing material such as bagasse, banana fiber, reeds, wood shavings, straw pulp, cork, or seaweeds, and the material is then combined with one or more sheets of a material, such as cement asbestos, and the composite sheet is subjected to heat and pressure.

150. Kato, H. 1934. Utilization of bagasse. II. Drying of bagasse board. Cellulose Industries (Tokyo). 10(10): 289-293.

Summary: Equations for adiabatic parallel flow and isothermic counter-flow are calculated.

151. Kato, H. 1934. Utilization of bagasse. III. The physical properties of Celotex. Cellulose Industries (Tokyo). 10(12): 312-315.

Summary: The thermal conductivity of fiberboard made from bagasse (Celotex) shows it to be suitable for use in buildings as a heat-insulating material.

152. Kato, H. 1935. Studies on utilization of bagasse. IV. Physical properties of Celotex (Part 2). Tensile strength, bending strength and hardness. Cellulose Industries (Tokyo). 11(3): 10.

Summary: Several physical properties of bagasse fiberboards were tested.

153. Kato, H. 1935. Studies on utilization of bagasse. V. Physical properties of Celotex (Part 3). Surface color and its change. Cellulose Industries (Tokyo). 11(6): 19.

Summary: Celotex changes color upon exposure to outside atmospheric conditions, thus, it should be painted. Indoors, it will keep in its original condition for a long period of time.

154. Kato, H. 1936. Studies on utilization of bagasse. VI. Physical properties of Celotex (Part 4). Ignition point. Cellulose Industries (Tokyo). 12(3): 20.

Summary: The ignition points of four different samples of Celotex were found to be in the range of 203°C to 222°C.

155. Kato, H. 1936. Studies on utilization of bagasse. VII. Some measurements of thermal influences in a Celotex-room. Cellulose Industries (Tokyo). 12(4): 23.

Summary: Variations of temperature, humidity, and vapor pressure inside a house built with Celotex wall were found to be much smaller inside than outside.

156. Lathrop, E.C. 1930. The Celotex and cane sugar industries. Bagasse or sugar a by-product? Industrial and Engineering Chemistry. 22: 449-460 and Wochbl. Papierfabrik. 61(39): 1252-1257. [German].

Summary: Celotex is an artificial building board made from bagasse. The bagasse from cane mills is compressed into 569.8 kg bales which are stored in covered piles. During storage, the residual sugar in the bagasse rapidly undergoes fermentation and the fibers become softened and ratted. After cooking under pressure, the material is shredded, sized, and eventually pressed and dried.

157. Lathrop, E.C. 1931. Celotex, its manufacture and uses. Transactions of the American Institute of Chemical Engineers. 25: 143-155.

Summary: The present methods of manufacturing Celotex fiberboard, the main properties of the products, and their uses are described. Bagasse is used as the raw material.

158. Lengel, D.E. 1962. A report on the results of investigations to determine optimum methods of producing bagasse fiber boards in the softwood, particleboard and hardboard density ranges. In: Proceedings of the International Society of Sugar Cane Technologists. New York: Elsevier Publishing Co.: 1156-1174.

Summary: The results of the investigations conducted by the author provide evidence that insulation and structural boards can be manufactured economically from bagasse. The bagasse fiberboards have satisfactory physical and mechanical properties and compete well with wood fiberboards in the insulation board, hardboard, and particleboard market.

159. Lin, Y.; Xue, K.; Liu, Y.; Shi, Y.; Huang, Z. 1989. Multiple sound-absorbing and heat-insulating fiber board (G.F-II series). Patent, P.N.: CN 1030223, I.D. 890111. [Chinese].

Summary: The boards are prepared from industrial and agricultural wastes by treating the wastes with a mixture containing silicate 10 percent, carbonate 3 percent, phosphate 3.6 percent, Al_2O_3 15 percent, Fe_2O_3 15 percent, CaO 11.6 percent, carbamides (containing >40 percent N) 35 percent, glue 3.8 percent, and antiseptic 3 percent (by weight or volume-unknown). The wastes can be bagasse, straw, corncob, or sorghum stem. The boards are fire-resistant.

160. Munroe, T.B. 1924. Heat-insulating plaster-board. Patent, P.N.: US 1486535, I.D.: 240311.

Summary: A board comprised of heat insulating bagasse material is covered on each side with a layer of asphalt in which is embedded finely divided rock material.

161. Naffziger, T.R.; Hofreiter, B.T.; Rist, C.E. 1962. Upgrading insulating board and molded pulp products by minor additions of dialdehyde starch. Tappi. 45(9): 745-750.

Summary: Experimental insulating boards and handsheets were prepared from a range of furnishes containing sugar-cane bagasse pulp and waste paper to which 2.5 percent cationic starch or 2.5 percent cationic starch and dialdehyde starch had been added. Retention of as little as 0.5 percent dialdehyde starch resulted in greatly improved dry and wet strength properties. With boards made from 75 percent bagasse and 25 percent newsprint blends, increases of 64 and 130 percent in dry modulus of rupture and dry tensile strength were obtained by the use of dialdehyde starch. Wet strength increases for the same pulp blend were 400 and 900 percent of that of untreated boards. Dialdehyde starch also provides improved pulp drainage and lower board densities.

162. Sugaya, J. 1978. Plant fiber reinforced gypsum boards. Patent, P.N.: JP 53019335, I.D.: 780222. [Japanese].

Summary: A mixture of plant fiber, gypsum, and water is cast and hardened at 1.5 MPa ± 490.3 kPa to prepare a high strength board having 2 to 4 times the bending strength of gypsum board.

163. Sun, K.Y.; Wei, Y.C. 1963. Preliminary studies of perforated “sugar-cane fiberboard” sound absorbers. Acta Physica Sinica. 19(3): 151-159. [Chinese].

Summary: The sound-absorbing and vibration-dampening properties of insulation board made from sugarcane bagasse were investigated. Solid boards exhibited mechanical vibration determined by boundary conditions, as well as resonance absorption in thin panels backed by an air space. When the board was perforated, resonance peaks became less prominent. The overall sound absorption was higher than for other perforated insulating panels.

164. Temple, G. 1928. Utilizing waste. Science Progress. 22: 475-480.

Summary: The report describes the manufacture of Celotex insulating board using bagasse as a raw material and board properties.

165. Vasquez, E.A. 1945. Comparative examination of some insulating boards. Mem. Association Technicos Azucar (Cuba). 20: 441-447. [Spanish].

Summary: The report describes the processes for making board from old and fermented bagasse, and from fresh bagasse directly after crushing.

166. Whittemore, H.L.; Stang, A.H. 1940. Structural properties of wood-frame wall and partition constructions with Celotex insulating boards. United States National Bureau of Standards, Building Materials and Structures, Rep. BMS 42. 25 p.

Summary: The properties of two wall and two partition constructions submitted by the Celotex Corporation were tested. The results are presented in graphs and tables.

(Also see references 6, 89, 103, 107, 125, 131, 133, 134, 138, 660, 871, 1061, 1062, 1064, 1099, and 1154.)

Cement/Gypsum/Plaster Board

167. Barrable, V.E. 1976. Composition for manufacturing profiled articles. Assignee: Cape Boards and Panels Ltd. Document type: Patent, P.N.: FR 2296601, I.D.: 760730. [French].

Summary: The composition consisted of an hydraulic binder selected from $CaSiO_3$ or Portland, aluminous, or blast-furnace slag cement and fibrous reinforcing materials which are free of asbestos and contain organic fibers that do not melt at temperatures less than 140°C. The fibers can be cellulosic, such as wood pulp and bagasse, or synthetic, such as nylon, Terylene, or viscose. The composition is made up as a slurry containing 1 to 50 percent fibers and 50 to 99 percent binders and can be laid wet on a papermaking type of machine or molded in a press. A filler, such as vermiculite, perlite, or mica, can be added. The material can be used for building panels.

168. Carbajal, M. 1973. Moldable bagasse compositions. Patent, P.N.: US 3748160, I.D.: 730724.

Summary: Sugarcane bagasse is pretreated with hot lime and mixed with 10 to 15 percent by weight Portland cement to form a composition for making panels and wallboard. Wallboard formed from this composition is light, strong, waterproof, fireproof, and adheres to conventional building coatings such as plaster, paint, mortar, plastics, or paper sheets.

169. Dahlberg, C.F. 1924. Plaster board. Patent, P.N.: US 1503783, I.D.: 240805.

Summary: A heat-insulating plasterboard is comprised of a body portion and a supporting base of compressible fibrous bagasse. Both portions are coated with pitch, asphalt, or other waterproofing materials.

170. Galvez Taupier, L.O. 1988. Moulded boards and cement boards. In: Manual de los Derivados de la Cana de Azucar. Mexico: ICIDCA-GEPLACEA-PNUD: 117-126. [Spanish].
(no abstract available)

171. International Cooperation Administration. 1959. Plant requirements for manufacture of wallboard from bagasse. Washington, DC: International Cooperation Administration, Technical Aids Branch. 30 p.
(no abstract available)

172. Shaw, J.K. 1924. Plaster board. Patent, P.N.: US 1503211, I.D.: 240729.

Summary: A heat-insulating plasterboard is formed with a relatively unyielding hard and strong layer of bagasse fibers interlaced with a relatively soft and yielding layer of bagasse fibers. All the bagasse fibers used are associated with their natural pith and an attached layer of plaster.

173. Simunic, B. 1975. Process for production of high-quality cement-bound wood-chip or similar boards, especially wall panels made of wood, bagasse or other woodlike raw materials. Patent, P.N.: GB 1414310, I.D.: 751119.

Summary: A process is provided for making board from cement-bound particles of wood or bagasse, or the like. The particles are mixed with water and cement. This mixture is molded, pressed, and dried to form a finished board. A copolymer is incorporated in the board either by adding an aqueous dispersion of the copolymer to the chip/cement mixture before molding, or by treating the molded board before pressing. The preferred copolymer is a copolymer of 5 to 40 percent vinyl chloride, 40 to 80 percent vinyl carboxylic acid ester, and 5 to 25 percent ethylene.

174. Tantengco, P.T. 1958. The preparation and physical properties of plaster board from sugar cane bagasse. Philippine Agriculturist. 42(3): 201-209.

Summary: Successive l-day treatment with 1 percent sulfuric acid and 18 percent NaOH at room temperature was used to prepare bagasse for molding. Higher concentrations and longer processing periods did not increase fiber recovery or improve the quality of the resulting board. Bagasse treated with 60 percent urea-formaldehyde resin for 30 min at 150°C and 34.3 MPa gave the highest tensile strength and shearing stress. Unground bagasse gave products with higher strength than ground bagasse, but the latter showed much finer texture and higher surface gloss.

175. Thole, V.; Weiss, D. 1992. Suitability of annual plants as additives for gypsum-bounded particleboards. Holz als Roh- und Werkstoff. 50(6): 241-252. [German].

Summary: The semidry process for the manufacture of gypsum-bonded particleboards was suggested by Kossatz. This process offers the possibility of using annual plants (such as bagasse, bamboo, cotton stalks, rice straw, and wheat straw) as additives. The use of these annual plants was investigated. Besides phase analytical investigations regarding the characterization of the binders, the efficacy of various retardants, as well as the influence of different plants on the hydration, were determined. Test boards of varying formulas and densities were manufactured from annual plants in order to evaluate their suitability. The considerably retarded hydration of the gypsum plaster induced by different extracellular substances does not necessarily lead to boards with low strength properties; nor does moderate impairment lead to boards with high strength properties. As far as board strength is concerned, equal importance has to be attached to the surface condition of the particles, their spraying behavior and pore structure, the fineness ratio of the particles, and the portion of plant parts that cannot be reduced to particle-shaped structures.

176. Tilby, S.E. 1980. Apparatus for forming boards from plant fibers. Assignee: Intercane Systems Inc. Patent, P.N.: US 4212616, I.D.: 800715.

Summary: In this board-forming apparatus, plant fibers are oriented and compressed into slugs, which are then ejected into chambers that are moved successively past the ejection station. Platens defining the chambers are moved to compress the slugs, and heat is applied to effect curing of the binder. The finished boards are discharged from the chambers onto a take-off conveyor. Movement of the chambers can be accomplished by mounting the platens defining the chambers on a rotary drum.

177. Valdes, J.L.; Puig, J.; Torres, A.; Rodriguez, M.E.; Prado, R. 1989. Bagasse-gypsum boards. Preliminary study of the process. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 22(3): 3842. [Spanish; English summary].

Summary: Tests demonstrating the feasibility of sugarcane bagasse as the fibrous component of gypsum-bonded particleboards are reported. Depithed bagasse was used, either fresh, stored wet for more than 1 year, or predried and stored in bales for less than 1 year. Aqueous bagasse extracts were found to have little effect on setting time. The effects were tested of bagasse: plaster: water ratios on density, thickness, and bending strength of the boards produced. High fiber ratio (1 part bagasse to 2 rather than 5 of plaster) increased the strength but also greatly increased the shrinkage upon setting; a 1:3.5 ratio is preferred.

178. Valdes, J.L.; Puig, J.; Torres, A.; Rodriguez, M.E.; Prado, R. 1989. Bagasse-gypsum particle boards: preliminary study of process parameters. Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (Rev. ICIDCA). 23(3): 38-42. [Spanish; English summary].

Summary: This study examined the effects of the moisture content of bagasse on the setting time and bending strength of particleboards made from bagasse and gypsum. Three types of depithed bagasse were used: fresh, dry-stored for less than 1 year, and wet-stored for more than 1 year. Only fresh bagasse caused any appreciable delay in setting time, and the best mechanical properties, including bending strength, were obtained in boards with high fiber content.

(Also see references 149 and 160.)

Plastic/Plastic-Bonded Board

179. Mansour, O.Y.; Nagaty, A.; Beshay, A.D.; Hosseir, M.H. 1986. Lignocellulose-polymer composites. Cellular Chemistry and Technology. 20(1): 59-71.

Summary: The lignocellulose-polymer composites were prepared through graft polymerzation of Me methacrylate on semichemical pulp, bagasse, and pith of bagasse, or by impregnation with a monomer solution. Fillers (China clay and talc) were used to compare their effects on the grafting reactions and on the composite properties.

180. Saneda, Y.; Yamada, H.; Takizawa, T. 1977. Bagasse-based building boards. Assignee: Shadan Hojin Shinzairyo Kenkyu Kaihatsu Center. Patent, P.N.: JP 52093432, I.D.: 770805. [Japanese].

Summary: Bagasse is mixed with regulated set cement or $CaSO4 + 5H_2O$ in a 35 to 50:50 to 65 ratio (dry basis) and optionally 1 to 50 percent polyvinyl alcohol as aqueous 10 to 20 percent solutions, compacted at 49.0 to 147.1 kPa, and hardened. Thus, 82 g of bagasse containing 15 percent water were dipped in water for 3 h, mixed with 105 g regulated set cement after removing excess water, molded, compressed at 68.6 kPa for 24 h, and dried at 20°C to obtain bagasse board having a density of 0.56 g/cm^3 and a bending strength of 2.0 MPa.

(Also see references 55, 84, 116, 117, and 121.)

Roofing Board

181. Usmani, A.M.; Ball, G.L.; Salyer, I.O.; Werkmeister, D.W.; Bryant, B.S. 1980. Alternative low cost roofing material candidates based on bagasse filled composites. Journal of Elastomers and Plastics. 12(1): 18-44.

Summary: Four composite material systems useful for roofing in the tropics were developed which utilize major percentages of bagasse filler and minor amounts of phenolic or other resin binders. The various materials were actually manufactured in small quantities in three developing countries and trial exposure roofs installed. Extensive test data are included.

Unknown Board

182. Anonymous. 1954. Raw materials for wallboard; experiments with agricultural and wood working residue. World’s Paper Trade Review. 141(8): 587-588, 590.

Summary: The Mutual Security Agency briefly describes the use of bagasse, straw, rice hulls, peanut hulls, and wood waste in processes for making framings for dwellings.

183. Anonymous. 1968. Dry process bagasse treatment developed by Tablopan board plant. Sugar Y Azucar Yearbook: 86-87.
(no abstract available)

184. Anonymous. 1973. Animal fodder and building material from cane. International Sugar Journal. 75(896): 244.
(no abstract available)

185. Atchison, J.E.; Lengel, D.E. 1985. Rapid growth in the use of bagasse as a raw material for reconstituted panel board. In: Proceedings of the 19th Washington State

University international particleboard/composite materials symposium; 1985; Pullman, WA. Pullman, WA: Washington State University: 145-193.

Summary: This paper presents a summarizing history on the use of bagasse for use as a constituent of panel board material production and contains 72 references.

186. Becker, G. 1947. Board making in the Bushveld. Paper-Maker. 113(2): 84, 87.

Summary: This article describes the building board plant at Messina, northern Transvaal. Bagasse is used as the furnish material. Equipment at the plant is assembled from parts which happened to be available, but the properties of the boards are comparable to those produced with conventional equipment.

187. Campbell, C.C.; Schick, J.W.; Stockinger, J,H. 1968. Composition board made from fluxed-water-repellent-pretreated materials. Assignee: Mobil Oil Corp. Patent, P.N.: US 3410813, I.D.: 681112.

Summary: Composition boards are prepared which have increased bond strength and water resistance. They can be prepared using raw bagasse. Extensive explanation of the material preparation and board production is given. Water absorption is 11.9 percent by weight, and the internal bond is 510.2 kpa—compared with the commercial standards of 15 percent maximum water absorption and the minimum 482.6 kPa for internal bond.

188. Consolacion, F.J. 1970. Production of corrugating medium from sugarcane bagasse. Sugar News. 46(12): 561-564, 572-574.
(no abstract available)

189. De la Vega, E. 1981. Boards production from bagasse *Saccharum officinarum.* Seminario Internacional Instituto Cubano de Investigaciones de los Derivados de la Cana de Azucar (ICIDCA); 1981 April 22-24; Centro National Documentation e Informacion Agropecuaria, SEA; Santo Domingo, Dominican Republic. 24 p. [Spanish].
(no abstract available)

190. Eisner, K.; Travnik, A. 1970. Some experiences in research and manufacture of panels from agricultural wastes and nonwood fibrous raw materials in Czechoslovakia. United Nations Industrial Development Organization Document (UNIDO) ID/WG.83/CR.2. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 19 p.

Summary: The suitability of various agricultural residues and other nonwood fibrous raw materials for panel production is discussed, with emphasis on the research carried out on this subject in Czechoslovakia. Fibrous materials considered are bagasse, bamboo, corncobs, cotton stalks, esparto grass, flax shives, hemp shives, palm tree waste, papyrus, and reeds. The physical and strength properties of boards made from bagasse, cotton stalks, palm waste, bamboo, and esparto grass are tabulated.

191. Hesch, R.; Frers, H. 1968. World's biggest board industry in Pakistan. Board Manufacture. 11(12): 149-158.
(no abstract available)

192. Iya, V.K.; Majali, S.A.B.; Adur, A.M. 1976. Bagasse-fly ash-polymer composites. Assignee: Bhabha Atomic Research Centre. Patent, P.N.: IN 139260, I.D.: 760529.

Summary: Bagasse-fly ash-polymer composite boards or sheets were prepared by in situ polymerization of monomers or their mixtures in bagasse- and fly ash-based boards or sheets and heating to 50°C to 90°C.

193. Kulkarni, A.Y.; Chivate, S.G.; Managaonkar, N.D. 1986. Use of whole bagasse chemi-mechanical pulp as filler for duplex boards. Indian Pulp and Paper. 23(4): 122-128.

Summary: This report states that the use of bagasse pulp improved the bulk of the boards.

194. Lathrop, E.C. 1954. Economic factors to be considered in the use of sugarcane bagasse as a raw material for paper and board manufacture. Bull. ARS-71-2. Washington, DC: U.S. Department of Agriculture. 24 p.

Summary: The economics of paper and board manufacture from sugarcane bagasse are discussed.

195. Lathrop, E.C.; Irvine, F.A. 1932. Process of making panel board. Patent, P.N.: US 1881418, I.D.: 321004.

Summary: A process for manufacturing a panel board from bagasse is discussed.

196. Laurie, C.K. 1978. A process for producing high quality sugar cane fibers for pulping and for use in composition panels. In: TAPPI nonwood plant fiber pulping progress report 9. Atlanta, GA: TAPPI Press: 83-89.
(no abstract available)

197. Lugembe, P.; Muti, A.L.; Ndatulu, M. 1985. Use of agricultural and industrial waste for building purposes. Building Research Unit working report WR 37. Dar Es Salaam, Tanzania: Building Research Unit. 32 p.

Summary: The utilization of bagasse, bamboo, banana stem, cassava stalk, coconut, coffee bean hulls, cotton stalk, reeds, rice, sisal, and straw for the production building materials was reviewed. Building materials covered include brick mixes, wall panels, and house framing.

198. Lumen, B.O.; Banagan, P.V.; Villaneuva, L.J. 1962. Effect of different pressing cycles on properties of bagasse boards. In: Proceedings of the 9th annual convention of the Philippines Sugar Technical Society: 192-196.
(no abstract available)

199. Mansour, O.Y. 1993. Lignocellulose polymer composite. 3. Journal of Applied Polymer Science. 47(5): 839-846.

Summary: A linear relationship was achieved between the polymer load and the monomer concentration up to 200 percent when China clay or talc replaced the glass in the initiating system, sodium bisulfite-soda lime glass, for the free-radical graft polymerization reactions using semichemical pulp of bagasse as the substrate. The properties of the prepared composite from the cografted semichemical pulp-polymethyl methacrylate revealed that the China clay leads to composites with high compression strength and hardness. Deformation percent increased with increasing polymer load. Water uptake of the composites prepared from this work ranged from 6.8 to 7 percent. After 48 h, the water uptake increased to 8.5 to 14.1 percent. Impregnation of the composites in water for 72 h increased the water uptake to 10.2 to 18.1 percent.

200. Ni, C.; Yang, C.T.; Shen, T.K. 1961. Asphalt-impregnated bagasse board. Rep. 23. Taiwan Sugar Experiment Station: 125-145.

Summary: Asphalt-impregnated bagasse board was developed as an inexpensive structural material with water-proof and termite-resistant properties, and moderate strength. The best board for impregnating purposes was made from pulp of uncooked bagasse. A base board of density 0.5 g/cm^3 was suitable. Roofing asphalt or waterproofing asphalt was used as the impregnating agent. Introduction of melted asphalt into the board by gravity was preferable to introduction by vacuum. The density of the resulting board was always between 0.9 to 1.0 g/cm^3, provided enough impregnation time was allowed. The impregnated board had a modulus of rupture of 19.6 to 24.5 MPa and water absorptivity below 10 percent, and showed less than 5 percent swelling.

201. Olbrich, H. 1979. Two marginal questions: what is bagasse? What is its main use? Branntweinwirtschaft. 119(6): 90-92, 94-100. [German].

Summary: The composition of bagasse and its utilization as fuel and fodder, in manufacturing pulp and building boards, and in moldings are reviewed with 17 references.

202. Raj, R.G.; Kokta, B.V. 1991. The effect of processing conditions and binding material of the mechanical properties of bagasse fibre composites. European Polymer Journal. 27(10): 1121-1123.
(no abstract available)

203. Smith, W.W.; Cordovez, C.Z. 1977. Case study of a successful bagasse board plant in Venezuela. In: Proceedings of the International Society of Sugar Cane Technologists. Sao Paulo, Brazil: Impres: 3235-3240.
(no abstract available)

204. Usmani, A.M. 1985. Bagasse composite science and engineering. In: Polymer 85: an international symposium on characterization and analysis of polymers; 1985 February 11-14; Melbourne, Australia. Parkville, Australia: Royal Australian Chemical Institute, Polymer Division: 478-480.

Summary: This paper discussed the general uses of bagasse fiber in several tropical nations. It also indicated that bagasse can be upgraded by bonding with resins to produce composites that are suitable as building materials.

205. Usmani, A.M.; Salyer, I.O. 1983. Chemistry and technology of in-situ generated resin bonded bagasse composite materials. Polymer Science and Technology. New York: Plenum Press: 89-101. Vol. 17.
(no abstract available)

206. Usmani, A.M.; Salyer, I.O. 1981. In-situ generated resin bonded bagasse composite materials. In: Proceedings of conference on organic coatings and plastics chemistry; 1981 August 23-28; Washington, DC. Washington, DC: American Chemical Society: 459-465.
(no abstract available)

207. Van der Klashorst, G.H. 1989. Utilization of soda bagasse hemicellulose as corrugated board adhesive. American Chemical Society symposium series 385: 305-325.

Summary: Hemicellulose from bagasse spent soda pulping liquors was used as an adhesive in the manufacture of corrugated paperboard. The adhesive gave a ply adhesion comparable to that of compressed starch-based adhesives.

208. Williams, W.L.S. 1932. Wallboard material from bagasse. Patent, P.N.: US 1847050, I.D.: 320223.

Summary: Pith was removed from shredded fibers by screening, cooking the material under pressure with 4 to 6 percent CaO (based on fiber weight) and simultaneously submitting the fibers to mechanical abrasion, and finally by passing it through a pulper.

209. Yu, Q. 1988. Composite materials made from bagasse. Huaxue Tongbao. 3: 18-23. [Chinese].

Summary: This paper reviewed 33 references on composites produced from bagasse with phenolic resin, natural rubber, thermoplastics, urea resin, and furfural resin.

(See references 3, 224, 225, 245, and 665.)

Cement/Clay/Gypsum/Plaster Materials

210. Agopyan, V. 1988. Vegetable fibre reinforced building materials-developments in Brazil and other Latin American countries. In: Swamy, R.N., ed. Natural fibre reinforced cement and concrete. Glasgow, Scotland: Blackie and Son Ltd.: 208-242. Chapter 6.

Summary: The use of bagasse, bamboo, coir, flax, hemp, jute, and rice husk fibers as sources of raw material for the production of cementious building materials in Latin America is described in detail. This chapter deals primarily with the improvement of the durability of the natural fiber through different processing methods.

211. Anonymous. 1975. Construction material containing coral-reef rock and bagasse-and hardening agent containing slag, lignin resin, sodium silicate and Portland cement. Assignee: (NISH-) Nishimoku Kosan Co. Patent, P.N.: JP 75027656, I.D.: 750909. [Japanese].

Summary: Construction material is prepared by mixing hydraulic hardening agent consisting of 40 to 60 parts by weight slag, 10 to 60 parts by weight silicate material, 0.3 to 2 parts by weight lignin resin derived from waste pulp, $\geq$5 percent by weight sodium silicate and 5 to 40 parts by weight Portland cement, with a mixture of finely pulverized coral-reef rock and bagasse fibers, and hardening. The material has good heat insulating and sound absorbing properties.

212. Guimaraes, S.S. 1990. Vegetable fiber-cement composites. In: Vegetable plants and their fibres as building materials. Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 98-107.

Summary: A study covering the physical and mechanical properties of fibers from bagasse, bamboo, coir, and sisal is presented in relation to their use in cement composites. The influence of fiber length, fiber volume fraction, matrix proportioning, and casting processes for roof tiles, flumes, kitchen sinks, and water tanks is also covered in detail. Partial results from durability tests are presented.

213. Herrera, H.E. 1981. Utilization of sugarcane bagasse in three mixtures of light concrete building materials, housing. Guatemala City, Guatemala: Universidad de San Carlos de Guatemala. 51 p. Ph.D. thesis. [Spanish].
(no abstract available)

214. Miller, A.C.; Fishman, N. 1958. Bagasse concrete. Patent, P.N.: US 2837435, I.D.: 580603.

Summary: A mixture of bagasse fiber, Portland cement, lime, CaCl, and a pozzolan forms a lightweight concrete for use in structural applications and in the formation of paper-faced wallboard.

(Also see references 196 and 674.)

Molded Masses

Plastics

215. Usmani, A.M.; Salyer, I.O.; Ball, G.L.; Schwendeman, J.L. 1981. Bagasse-fiber-reinforced composites. Journal of Elastomers and Plastics. 13(1): 46-73.
(no abstract available)

216. Wang, U. 1974. Gamma ray induced gaseous phase polymerization and copolymerization of vinyl monomers in bagasse. Journal of the Chinese Chemical Society (Taiwan, ROC). 21(4): 255-261.

Summary: In the gamma-ray induced gaseous phase in situ polymerization of vinyl chloride in bagasse, no binding force between the polymer and the board occurred-as confirmed by no increase in tensile strength. Mixtures of vinyl chloride containing 20 to 30 percent vinyl acetate, when polymerized in bagasse, showed slightly better binding strength than with vinyl chloride alone.

Refractory Materials

217. Gammel, T.E. 1981. Thermally insulating refractory mouldings containing inexpensive bagasse; used especially as hot top lining panels for ingot moulds. Assignee: (FOSE) Foseco Trading Ag. Patent, P.N.: DE 2948162, I.D.: 810604. [German].

Summary: The preferred molding contains by weight 50 to 90 percent refractory powder, 3 to 10 percent binder, and 5 to 30 percent defibered bagasse powder or similar crushed trash, pressed as a mixture in a mould or die while the binder hardens and sets. Molding is preferably used as a lining in the top of an ingot mould; it may also form an insulating- or exothermic-lining in tundishes and other such applications.

Rubbers

218. Usmani, A.M.; Salyer, I.O. 1981. Bagasse-fiber reinforced natural rubber composites. In: Proceedings of conference on organic coatings and plastics chemistry; 1981 August 23-28; Washington, DC. Washington, DC: American Chemical Society: 459-465. Vol. 45.
(no abstract available)

219. Yu, Q. 1988. Composite materials made from bagasse. Huaxue Tongbao. 3: 18-23. [Chinese].

Summary: This paper reviewed 33 references on composites produced from bagasse with phenolic resin, natural rubber, thermoplastics, urea resin, and furfural resin.

(Also see reference 29.)

Miscellaneous
Economics

220. Alcayde. G.; Valadez, E.; Hernandez, L.; Barrientos, M. 1980. Process technology for manufacturing boards using cane bagasse and urea formaldehyde resins. Advances in Material Technology in the Americas—1980. Vol. 1. Material recovery and utilization. Presented at Inter-American conference on material technology, 6th, Century 2—Emerging technology conference; 1980 August 12-15; San Francisco, CA. New York: ASME (MD-l): 105-108. [Spanish].

Summary: This paper includes product and equipment technology and economic studies, and also describes the performance required in a pilot plant for getting technical results, which are processed with a computer program. Results are then used for making process nomographs.

(Also see references 34, 36, 59, 89, 110, 136, 194, and 231.)

Loose Insulation

221. Niven, C.D. 1933. On the thermal conductivity of various insulators at room temperature. Canadian Journal of Research. 9(2): 146-152.

Summary: Studies were made on the thermal conductivity of organic and inorganic materials used in the walls of houses, such as wood fiber, bagasse, cork, flax waste, and concrete. The results obtained indicate that thermal conductivity increased with an increase of density much more rapidly at higher density than it did at low density.

Material Preparation/Pulping/Storage Methods

222. Atchison, J.E. 1962. Bagasse becoming a major raw material for manufacture of pulp and paper-background, present status, and future possibilities. In: Proceedings of the 11th Congress of the International Society of the Sugar Cane Technologists. Mauritius. New York: Elsevier Publishing Co.: 1185-1205.

Summary: A review of past and present uses of bagasse is given. Included are purchase, collection, storage, and preservation aspects. Additionally, the preparation for pulping and the process and equipment necessary for pulping are described.

223. Atchison, J.E. 1962. Progress in preparation and rapid continuous pulping of agricultural fibers. In: Pulp and paper prospects in Asia and the Far East. Bangkok, Thailand: Food and Agriculture Organization of the United Nations (FAO): 431-443. Vol. 2.

Summary: The paper reviews the methods of cleaning straw and depithing bagasse. A two-stage depithing system has been suggested for bagasse, involving a partial pith separation in a humid condition followed by wet depithing. Flow diagrams are given.

224. Atchison, J.E. 1962. Utilization of bagasse for manufacture of pulp, paper, and board. Indian Pulp and Paper. 17(1): 37-41, 46.

Summary: The recent history of pulp, paper, and board manufacture from bagasse is presented. Methods of bagasse collection, storage, preservation, depithing, and pulp processing are given.

225. Atchison, J.E. 1970. Modem methods of bagasse depithing: the key to large-scale utilization of bagasse for manufacture of pulp, paper, and board. In: TAPPI C.A. Rep. 34. Atlanta, GA: TAPPI Press: 21-90.

Summary: A review of bagasse depithing methods is given, including the history of depithing bagasse, newly developed depithing techniques, aspects to be considered prior to selection of the depithing method and equipment, and the effect of depithing on pulp properties.

226. Atchison, J.E. 1971. Modem methods of purchasing, handling, storage and preservation of bagasse. Major advances in the sixties. In: TAPPI C.A. Rep. 40. Nonwood plant fiber pulping. Progress rep. 2. Atlanta, GA: TAPPI Press. 1-49.

Summary: New developments in purchasing, handling, storing, and preserving of bagasse are discussed. Newly developed storage methods include wet bulk storage direct from the sugar mill with or without biological treatment, moist bulk storage from the sugar mill without treatment, dry storage in dense pads under cover after artificial drying, and storage in dry briquettes or pellets.

227. Biagiotti, P. 1971. Methods for bagasse storage. Peadco 4th international forum; 1971 September 19-22. 13 p.

Summary: The advantages and disadvantages of available bagasse storage methods and their economics are discussed.

228. Chapman, A.W. 1957. Purchasing, handling and storing of bagasse. Food and Agriculture Organization of the United Nations Document (FAO) FAO/ECE/BOARD CONS/Paper 4.12. Fiberboard and particleboard. Report of an international consultation on insulation board, hardboard, and particleboard; Geneva, Switzerland. Rome, Italy: Food and Agriculture Organization of the United Nations.

Summary: The American practice of purchasing, storing, and handling bagasse, and the layout and equipment required are described in detail. Mechanization of harvesting sugarcane may adversely affect its use in board manufacture since mechanically harvested bagasse contains a larger percentage of leaves and other debris than that harvested by hand.

229. Cheng, S.; Huang, H. 1976. Effect of organic acids on the preservation of bagasse. K’o Hsueh Fa Chan Yueh K’an (Progress in Science). 4(1): 2098-2103. [Chinese].

Summary: One percent Propionic acid was superior to 1 percent acetic acid and 1 percent formic acid for preservation of bagasse against microbial activity during a 6-month test. None of the acids was effective at 0.05 percent. The effect of the various treatments on the color and strength of particleboards manufactured from the treated raw materials is discussed.

230. Cusi, D.S.; Jolley, P.W.R. 1968. How bagasse is pulped by method used in Mexico. Pulp and Paper International. 10(6): 56-59.

Summary: The Simon-Cusi multistep pulping method is used at the world's largest bagasse pulp mill. All steps in the process, including storage of baled bagasse, and both wet depithing and a cheaper alternative moist process are described.

231. FAO. 1962. The economic availability of fibrous raw materials in India, Burma, and Thailand. In: Pulp and paper prospects in Asia and the Far East. Bangkok, Thailand: Food and Agriculture Organization of the United Nations: 27-113. Vol. 2.

Summary: The objective of this study was to determine the delivered cost of alternative fibrous pulping materials to selected pulp mills in India, Burma, and Thailand. The methods of the evaluation were developed by the Stanford Research Institute. Supply, extraction/harvesting cost, collection cost, and transportation cost were considered along with other cost elements such as overhead, insurance, and interest. Nonwood materials analyzed in this study included bagasse, bamboo, rice straw, and some grasses.

232. Gabir, S.; Khristova, P. 1983. Fibrous semi-products from raw materials resources for paper and board production in Sudan. Agricultural residues: bagasse and cotton stalks. Agricultural Wastes. 8(1): 9-15.

Summary: High temperature shock (HTS) cooking of cotton stalks and bagasse at 204.4°C to 260°C for 2 to 4 min gave pulps in 68 to 74 percent yield as compared with 46 to 59 percent yield obtained in the soda process. The alkali consumption of the HTS process was lower than that of soda pulping, and strength properties of HTS pulps were comparable to those of soda pulps.

233. Gremler, H. 1969. Preparation of bagasse as a pulp raw material. Boletim ABCP. 2(11): 10-18. [Portuguese].

Summary: Methods and equipment used in dry and wet depithing and preservation of bagasse are reviewed in detail.

234. Hansen, R.M. 1955. Utilization and mechanical separation of sugarcane bagasse. Pub. 12522. Baton Rouge, LA: Louisiana State University. 207 p. Ph.D. thesis.
(no abstract available)

235. Kossoi, A.S.; Zvirblite, A.; Livshits, E.M. [and others]. 1972. Pulp for fibrous slabs. Assignee: Leningrad Technological Institute of the Cellulose-Paper Industry and Astrakhan Cellulose-Cardboard Combine. Patent, P.N.: SU 334309, I.D.: 720330. [Russian].

Summary: Pulp for fiberboard was produced by thermochemical treatment of lignocellulose, such as chopped sugarcane, followed by beating. To improve the quality of the board and lower the energy consumption during beating, the lignocellulose was treated with spent sulfate liquor of density 1.03 to 1.04 g/m^3 and total alkalinity of 11.5 to 15 g/l Na_2O and containing 70 to 100 g/l solids at a pH of 10.5 to 11.5.

236. Laurie, C.K. 1978. Separation-a process for producing high-quality sugar cane fibers for pulping and for use in composition panels. In: TAPPI Nonwood plant fiber pulping. Progress rep. 9. Atlanta, GA: TAPPI Press: 83-89.

Summary: The Tilby separation process removes the rind from the split sugarcane stalk by milling away the soft pithy interior and then machining off the epidermal layer and wax on the outside of the rind. The rind, which is 18 to 20 percent of the weight of the cane stalk, contains some 46 percent bagasse fiber on a wet basis. The fibers are substantially free of pith and may be washed free of hot-water solubles and used in the production of corrugating medium and particleboard.

237. McGovern, J.N.; Brown, K.J.; Marti, R.A. 1951. Corrugating boards from southern hardwood cold soda and bagasse and straw mechno-chemical pulp. Madison, WI: United States Department of Agriculture, Forest Service, Forest Products Laboratory. 12 p. and board samples.
(no abstract available)

238. Moeltner, H.G. 1980. Sugar cane separation process and composition board manufacture from "Combrind." In: Proceedings of the 17th congress of the International Society of Sugar Cane Technologists: 2764-2786.
(no abstract available)

239. Moeltner, H.G. 1981. Sugar cane separation process and composition board manufacture from "Combrind." In: TAPPI nonwood plant fibers pulping. Progress rep. 12. Atlanta, GA: TAPPI Press: 67-75.
(no abstract available)

240. Moeltner, H.G. 1981. The sugar cane separation process and composition board manufacture from "Combrind." In: Proceedings, pulping conference: 217-225.

Summary: The mechanical separation of sugarcane into rind, pith, and epidermis, and their uses (especially the rind for particleboard) were discussed.

241. Nolan, W.J. 1967. Processing of bagasse for paper and structural boards. Tappi. 50(9): 127A-136A.

Summary: A depithing procedure is described, consisting of decortication of bagasse in an attrition mill at 20 percent consistency, followed by washing pith and fines from the fiber on a traveling screen belt. Short fiber is recovered from tailings, resulting in an overall fiber yield of 70 percent of whole bagasse. Possible uses of pith are discussed. Sections of the study deal with the production and properties of wallboard and hardboard from depithed bagasse fiber.

242. TAPPI. 1971. Non-wood plant fiber pulping. Progress rep. 2. TAPPI C.A. Rep. 40. 333 p.

Summary: This progress report contains 10 separate contributions covering new methods of handling and storage of nonwood plant fibers, such as bagasse, straw, bamboo, reed, and grasses.

243. TAPPI. 1991. Determination of useful fiber in bagasse. Tappi Useful Method 3 (formerly Routine Control Method RC 334).

Summary: This method describes a procedure for estimating the percentage of fiber, pith, and soluble matter in bagasse. The apparatus needed includes a standard disintegrator, sieves, rubber tubing, a drying oven, and balance.

244. Tiwary, K.N.; Kulkarni, A.Y.; Jivendra, _. 1983. Sugar cane leaf—a potential raw material for cheap grades of paper and board. Part II. Indian Pulp and Paper. 37(4): 27-30.

Summary: Soda cooking of sugarcane leaves under optimum conditions gave a pulp yield of 56 percent. The paper is mainly concerned with optimum conditions to produce low-grade paper with sugarcane leaves.

245. Tiwary, K.N.; Sah, S. 1982. Sugar cane leaf-a potential raw material for board and cheap-grade paper manufacture. Indian Pulp and Paper. 36(6): 3-6, 8-10.

Summary: Cooking of dry sugarcane leaves with 10 percent NaOH for 3 h gave soda pulp in a 38 to 45 percent yield, with breaking length of 3,440 to 5,330 m, burst factor of 14 to 26, tear factor of 37 to 64, and doublefold of 8 to 103.

(Also see references 42, 56, 91, 92, 113, and 357.)

General Information/Reviews

246. Anonymous. 1979. Sugar, forage and construction materials: a new technology from sugarcane. Afrique Agriculture. 50: 16-17. [French].
(no abstract availble)

247. Creighton, S.M.; Raczuk, T.W. 1966. Construction materials as by products of sugar cane. Assignee: Robert Boothe Miller. Patent, P.N.: FR 1460600, I.D.: 661202. [French].
(no abstract available)

248. Ennist, A.L. 1961. Operation of bagasse fiber pilot plant of central El Palmar. The Sugar Journal. 3: 12-16.
(no abstract available)

249. Lopez Hernandez, J.A.; Adris, J.J. 1977. Conductimetric determination of moisture in mixtures of bagasse and soy glues (for the fiberboard industry). Miscelanea. Universidad National de Tucuman. Facultad de Agronomia y Zootecnia. 16 p. [Spanish and English].
(no abstract available)

250. Mahadevan, N.; Sridhar, N.C.; Rao, P.N.; Kalyanasundaram, K.; Rao, A.R.K. 1986. Adaptation of existing recovery system for handling blend of black liquors from bagasse and wood-experience of Seshasayee Paper and Boards. Indian Pulp and Paper. 23(4): 155-159.

Summary: Differences between bagasse and wood black liquor are discussed. Modifications made to economically and effectively accommodate a mixture of bagasse and wood black liquor in the chemical recovery system at Seshasayee Paper and Boards Ltd., India, are described. Modifications included increasing the liquor's alkali content to improve evaporation of the very dilute liquor obtained from washing bagasse, as well as furnace design changes that counteract the slower drying and combustion rates of bagasse black liquor.

251. McLaughlin, E.C. 1980. The strength of bagasse fibre-reinforced composites. Journal of Materials Science. 15(4): 886-490.
(no abstract available)

252. Ysbrandy, R.E.; Gerischer, G.F.R.; Sanderson, R.D. 1991. Adhesives from auto-hydrolysis bagasse lignin, a renewable resource. Properties of bagasse board made with a pith-lignin adhesive mixture and its thermal behavior as analyzed by DSC. Cellulose Chemistry and Technology. 25(5/6): 369-374.

Summary: Pitch was used as a binder and functioned as a plasticizer for lignin in an adhesive mixture used for bagasse board manufacture. The lower density board did not comply with the strength specifications for industrial particleboard, but it could be used as insulation and as core material for low strength composites. The pitch in the resin gave faster press cycles, and the lignin decreased the heat of reaction, based on the amount of lignin present.

Material Used in Natural State

(See reference 197.)

Bamboo [Stalk]

Panel Board

Particleboard

253. Chen, T.Y.; Wang, Y.S. 1981. A study of structural particleboard made from bamboo waste. Quarterly Journal of Chinese Forestry. 14(2): 39-60. [Chinese; English summary].

Summary: The manufacture and mechanical properties of particleboards made from slender particles glued with urea-formaldehyde and phenol-formaldehyde resins and of three-ply boards made with a middle layer of slender particles and outer layers of fine shaving particles glued with phenol-formaldehyde resin are described. Properties were compared with those of oriented three-layer and random boards made from wood veneer wastes. Species used were *Pyllostachys makinoi, Pyllostachys edulis,* and *Bambusa stenostachia*. Board production with bamboo waste was determined to be feasible.

254. Chu. B.L.; Chen, T.Y.; Yen, T. 1984. Influence of the form of bamboo and particleboard on their bending strength and thermal conductivity. Forest Products Industries. 3(3): 291-318. [Chinese; English summary].

Summary: Results of uniaxial tensile, uniaxial compression, simple shear, and flexural bending strength tests on moso bamboo (*Phyllostachis edulis*) flat-pressed and corrugated particleboards and thermal conductivity tests on flat-pressed moso particleboard are presented. Coefficients of thermal conductivity and grades of thermal insulation are also tabulated for building materials currently used in Taiwan. Bamboo, particleboard, and wood are all considered to be good heat insulating materials for building construction.

255. Lemoine, R. 1974. Resin impregnated bamboo lattice panels-with stiffness and moisture resistance enhanced by melamine resins. Patent, P.N.: FR 2216102, I.D.: 741004. [French].

Summary: Crossply panels are made of superimposed panels of woven bamboo strips impregnated with resin and subsequently hot pressed and cured. Panels incorporating one, two, and three layers of woven lattices weigh approximately 1.5, 3, and 4 kg/m^2, respectively. Panels can enclose a layer of thermal or acoustical insulation. The material can be cut into smaller pieces without disintegrating,

256. Lo, M.P.; Tsai, C.M. 1975. Experiment on the manufacturing of bamboo particleboard. I. Splinterboard. Bull. of the Experimental Forest of National Taiwan University: 116: 527-544. [Chinese; English summary].

Summary: Particleboard manufactured from hammer-milled splinter-type bamboo particles was evaluated by testing water evaporation during hot pressing, springback, moisture content, specific gravity, water absorption, thickness swelling, modulus of rupture in static bending, tensile strength perpendicular to the surface, and hardness. The best properties were obtained with splinter-type particles and fine particles, 8 parts phenol formaldehyde resin solids per 100 parts dry particles, and a hot pressing time of 15 min. Lengthening the pressing time from 10 to 15 min accelerated water evaporation and reduced internal stresses as well as the moisture content and springback or thickness swelling of the board. Nine percent or more resin content solids was recommended to improve the quality of the boards.

257. Meshramkar, P.M. 1974. Solid waste from wood and bamboo as an asset for profitable uses. Indian Pulp and Paper. 28(10): 11-15.

Summary: The use of bamboo and hardwood residues for particleboard in India was reviewed.

258. Narayanamurti, D.; Bist, B.S. 1948. Preliminary studies on building boards from bamboos. Building boards, II. Boards from bamboo. Indian Forest Leaflet 103. Dehra Dun, India: Forest Research Institute. 12 p.

Summary: Preliminary studies on the production of building boards from bamboo are described. The possibility of commercial production of such materials from mats woven from bamboo sticks and bonded by a small percentage of synthetic resins and fillers is discussed.

259. Narayanamurti, D.; Prasad, B.N.; George, J. 1961. Protection of chipboards from fungi and termites. Norsk Skogind. 15(9): 375-376.

Summary: Particleboards made from bamboo (*Dendrocalamus strictus*) were treated with pentachlorophenol or Xylamon and exposed to attack by fungi and termites, as well as soil burial. The results obtained in laboratory and graveyard tests are reported. In laboratory culture tests, 5 percent penta gave the best protection, whereas 2 percent Xylamon was ineffective. In graveyard tests, all treated boards remained sound for 170 to 329 days, and those treated with 2 or 5 percent Xylamon for 482 to 630 days. Boards containing 1 to 2 or 5 percent penta resisted termite attack in South Africa for 2 years.

260. Rowell, R.M.; Norimoto, M. 1988. Dimensional stability of bamboo particleboards made from acetylated particles. Mokuzai Gakkaishi. 34(7): 627-629. [Japanese; English summary].
(no abstract available)

261. Shin, F.G.; Xian, X.J.; Zheng, W.P.; Yipp, M.W. 1989. Analysis of the mechanical properties and microstructure of bamboo-epoxy composites. Journal of Materials Science. 24(10): 3483-3490.

Summary: Unidirectional bamboo-epoxy laminates of varying laminae number were experimentally evaluated for

their tensile, compressive, flexural, and interlaminar shear properties. The disposition of bamboo fiber, parenchymatous tissue, and resin matrix under different loading conditions was examined. Mechanical properties were comparable to those of glass-fiber composites. The fracture behavior of bamboo–epoxy under the different loading conditions was evaluated using acoustic emission techniques and scanning electron microscopy. The fracture mode was found to be similar to carbon and glass reinforced composites.

262. Takahashi, M. 1980. Veneer used in plywood decorative boards etc. obtained by pressing wood from broad-leaf or pine trees with bamboo using thermosetting adhesive, and slicing product. Patent, P.N.: JP 55164141, I.D.: 801220. [Japanese].

Summary: A natural log of a broadleaf tree or a pine tree is cut or torn in the fiber direction with the proper rotary cutter having blades to provide slider fiber rods. A bamboo, hemp, or reed is tom or divided in the longitudinal direction to provide slender fiber matters. After the slender fiber rods or matters are put together with a thermosetting adhesive in a hydraulic press comprising stationary side plates and movable press plates, they are pressed in the vertical direction to produce block. The block is sliced off in the pressed direction to produce veneers. Equal straight-grained veneers may be easily produced to provide the equal strength and constrictive ability.

263. Tsai, C.M.; Lo, M.P. 1978. Study on the manufacture of uni-layer and three-layer particleboards made from (*Phyllostachis edulis*) bamboo and (*Chamaecyparis formosensis*) wood particles. Bull. of the Experimental Forest of National Taiwan University: 121: 41-62. [Chinese; English summary].
(no abstract available)

264. Tsai, C.M.; Lo, M.P.; Poon, M.K. 1978. Study on the manufacture of uni-layer and three-layer particleboards made from bamboo and wood particles. Bull. of the Experimental Forest of National Taiwan University: 121: 41-62. [Chinese].

Summary: Shavings, fine shavings, and splinters of moso bamboo (*Phyllostachis edulis*) and the shavings of red cypress (*Chamaecyparis formosensis*) were used along with urea-formaldehyde resin to make particleboards. A conventional process was used to prepare single-layer particleboards using five different ratios of fine shavings of bamboo and shavings of red cypress with 9 percent resin as binder, and six kinds of three-layer boards using fine shavings of bamboo or shavings of red cypress with 7 percent resin as a binder for the inner layer. Boards were evaluated by testing moisture content, springback, specific gravity, water absorption, thickness swelling, static bending, tensile strength perpendicular to surface, and hardness. Each type of board met the Chinese National Standard specifications.

265. Wang, S.Y.; Hwang, W.S. 1981. Studies on the improving effects of bending strength and bending creep behaviors of bamboo particle boards (I). Quarterly Journal of Chinese Forestry. 14(1): 71-94. [Chinese; English summary].
(no abstract available)

(Also see references 5, 46, 53, 83, and 1075.)

Fiberboard/Hardboard

266. Jain, N.C.; Dhamaney, C.P. 1966. Studies on hardboard preparation. (1) From materials received from Nagaland. Indian Pulp and Paper. 21(4): 259-262.

Summary: Experimental hardboards were prepared from 12 fibrous raw materials, including bamboos, grasses, and hardwoods, indigenous to Nagaland, Burma-Assam region. The materials were cooked with aqueous NaOH at atmospheric pressure for 3 h, washed, felted, and pressed at 160°C and 5.5 MPa for 20 min. Sizing agents, such as wax emulsions, for improving water resistance were not incorporated. The boards were tempered by heat treatment or with cashew nut oil at 170°C for 3 h. The physical properties of the boards complied with the Indian standard specifications for hardboards with regard to specific gravity and modulus of rupture. Water absorption values were in excess of that allowed by the Indian standard.

267. Naffziger, T.R.; Clark, T.F.; Wolff, I.A. 1961. Structural board from domestic timber bamboo–*Phyllostachys bambusoides.* Tappi. 44(2): 108-112.

Summary: Dry, mature, timber bamboo was investigated as a raw material for the insulation boards and hardboards by several pulping techniques. Results of preliminary studies indicated that pulping with lime alone was adequate. To establish preferred manufacturing conditions, a series of experiments was conducted on a pilot-plant scale using 6, 9, and 12 percent lime at 142°C for pulping. Yields of pulp when cooked for 1, 3.5, and 6 h ranged from 83 to 94 percent. The resulting boards (both insulating and hardboards) had strength properties equal or superior to those of standard commercial boards.

268. Pakotiprapha, B.; Pama, R.P.; Lee, S.L. 1976. Development of bamboo pulp boards for low-cost housing. In: Proceedings, IAHS international symposium on housing problems; South Carolina: 1096-1115. Vol. 2.
(no abstract available)

269. Sano, Y.; Ishihara, S.; Nagasawa, S. 1959. Studies on the production of fiberboards from bamboo. I. Manufacturing process at high temperature cooking and the atmospheric defibering from Mosochiku (*Phyllostachys pubescens*). Bull. 113 of the Government Forest Experiment Station: 135-144. [Japanese].

Summary: Laboratory studies on the manufacture of hardboards from Japanese bamboo are described. The bamboo

chips were impregnated with water-2 percent Na_2CO_3 solution or sulfuric acid (0.5, 1.0, and 2.0 percent), then cooked at 173°C for 5 to 45 min. After refining, the pulp was formed into sheets and pressed at 180°C and a pressure of 2.9 MPa for 11 min. Pretreatment with dilute sulfuric acid gave boards of good strength, but pulp yield was low. Satisfactory boards and pulp yield were obtained with water-impregnated chips. Water resistance of the boards can be improved considerably by subsequent heat treatment at 150°C to 170°C for 4 h.

270. Sano, Y.; Nagasawa, S. 1959. Studies on the production of fiberboards from bamboo. II. On the manufacture of Mosochiku by high-temperature cooking and high-pressure defibering and other experiments. Bull. 126 of the Government Forest Experiment Station: 51-61. [Japanese].

Summary: Fiberboards were prepared from various bamboos and bamboo-wood mixtures by the high temperature/high pressure Asplund process. Pulp yields of 60 to 70 percent were obtained in 20 to 25 min cooking time. The boards showed good strength properties but water resistance of unsized boards was inadequate; hence the addition of a sizing agent. Atmospheric refined boards generally had better properties than Asplund refined boards. Addition of hardwood chips further improved board properties.

271. Shepardson, R.M. 1959. Composition containing bamboo particles and thermosetting resin. Patent, P.N.: US 2898314, I.D.: 590804.

Summary: Green bamboo is ground to 16-mesh, dehydrated to one-third its original weight, mixed with 20 percent urea-formaldehyde resin and 1 percent paraffin wax, and pressed so that 10.16 cm of the original material is decreased to 2.22-cm thickness after 20 min at 149°C and 10.3 MPa. The product is useful for mounting electro-typing and engraving plates.

272. Singh, M.M. 1960. Pressed boards from bamboo dust. Indian Pulp and Paper. 15(3): 201, 203.

Summary: Laboratory experiments carried out at the Indian Forest Research Institute on the manufacture of hardboard from bamboo dust by the wet process are described. Results were not encouraging.

(Also see references 6, 9, 122, and 358.)

Insulation Board

273. Aung, T.; Kha, M.M. 1969. Thermal properties of insulating boards made from Burmese bamboo. Union of Burma Journal of Science and Technology. 2(1): 215-219. (no abstract available)

(Also see references 6, 267, and 356.)

Cement/Gypsum/Plaster Board

274. Bose, T.N. 1950. Use of bamboo as reinforcement in Portland cement concrete. Journal of the Association of Engineers (India). 26(2): 52-62.

Summary: Various types of satisfactory bamboo building boards were produced by substituting imported phenol with cashew nut shell liquid that yields a water-resistant adhesive when condensed with formalin in the presence of xylene and small amounts of aqueous NaOH. The physical properties of the boards obtained are tabulated.

275. Chen, T.Y.; Shueh, S.H. 1985. Studies on cement bonded bamboo particleboard and bamboo bars for reinforcing concrete. Forest Products Industries. 4(2): 2-16. [Chinese; German, and English summaries].

Summary: Particleboards were made from moso bamboo (*Phyllostachis edulis*) shavings and Portland cement to a density of 1 g/cm^3. The effects of water:cement ratio and mortar content on bending and compression strengths were investigated. The effects of mixing China fir (*Cunninghamia lanceolata*) with the bamboo were also studied. The mixing of the China fir with the bamboo increased the compressive strength but decreased the bending strength of the boards. Thermal conductivity of the particleboards was improved by reducing the moisture content. Bamboo, concrete, and steel bars were compared with regard to their coefficient of linear expansion, modulus of elasticity, and yield and tensile strengths.

(Also see reference 175.)

Plastic/Plastic-Bonded Board

276. Jain, S.; Kumar, R.; Jindal, U.C. 1992. Mechanical behaviour of bamboo and bamboo composite. Journal of Materials Science. 27(17): 4598-4604.

Summary: The tensile, flexural, and impact strengths of bamboo and bamboo fiber reinforced plastic composite were evaluated. The high strengths of bamboo, in the fiber direction, were explained by its anatomical properties and ultra structure. Bamboo fibers and bamboo orthogonal strip mats were used to reinforce epoxy resin. Bamboo fiber-reinforced plastic composites with unidirectional, bidirectional, and multidirectional strengths were made. In bamboo mat composites, the fiber volume fraction achieved was as high as 65 percent. The tensile, flexural, and impact strengths of bamboo along the fibers were 200.5 MPa, 230.09 MPa, and 63.54 kJ/m^2, respectively, whereas those of bamboo fiber composites and bamboo mat composites were 175.27 MPa, 151.83 MPa, and 45.6 kJ/m^2, and 110.5 MPa, 93.6 MPa, and 34.03 kJ/m^2, respectively. These composites possess a close linear elastic behavior.

277. Liao, K.F. 1981. Studies on the manufacture of bamboo and plastic composites. I. The manufacture of bamboo and plastic composites treated with thermoplastic monomers. Scientific Research Abstracts in Republic of China 1980, Part I: 619-620.
(no abstract available)

278. Narayanamurti, D.; Singh, H. 1955. Studies on building boards. IX. Utilization of wood waste, tree barks and other lignocellulosic materials as a source of plastics and building boards. Composite Wood. 2(3): 53-62.

Summary: While continuing previous investigations, agricultural and forest wastes, bamboo sawdust, and other lignocellulosic materials were subjected to a mild acid or alkaline hydrolysis at 160°C to 170°C. Molded products and boards were formed from the hydrolyzed powders. The results are presented in tables and graphs.

279. Wang, S.Y.; Joe, I.S. 1983. Studies on the properties of composite panels of bamboo (I). Static bending behaviour. Forest Products Industries. 2(2): 17-31. [Chinese; English summary].

Summary: Composite panels were constructed with ply-bamboo faces and either cores of polyurethane or polystyrene foam, or hollow cores. The density of the composite panels was 17.5 percent (for foam) to 84.5 percent (for hollow) lower than the density of the face materials. Static bending strength decreased linearly with an increase in the square of the construction coefficient (thickness of face/ thickness of core), and modulus of elasticity decreased linearly with an increase in the cube of the construction coefficient. Static bending stiffness of the composite panels was higher than that of the face materials.

280. Wang, S.Y.; Joe, I.S. 1983. Studies on the properties of bamboo composite panels (II). Thermal conductive behaviors. Forest Products Industries. 2(3): 29-44. [Chinese; English summary].

Summary: Low-density panels were manufactured using *Sinocalamus latiflorus* [*Dendrocalamus latiflorus*] as face and back layers filled with polyurethane or polystyrene foam, or left hollow. Thermal conductivity was measured according to ASTM C177 and JIS A1412 standards. The insulation of polyurethane-filled panels was better than that of polystyrene-filled panels, which was much better than that of hollow panels.

Unknown Board

281. Dhamaney, C.P. 1967. Development of bamboo boards based on cashew nut shell liquid. Indian Pulp and Paper. 22(l): 4.
(no abstract available)

282. Dhamaney, C.P. 1967. Development of bamboo boards based on cashew-nut shell liquid. Indian Pulp and Paper. 22(4): 259-261.

Summary: Various types of satisfactory bamboo building boards were produced by using cashew nut shell liquid (in place of imported phenol) condensed with formalin (in the presence of xylene and small amounts of aqueous NaOH), thus giving a water-resistant adhesive. Tabulated data are provided displaying the physical properties of the manufactured boards.

283. Kuroiwa, J. 1984. Prefabricated Quincha construction. Earthquake relief in less industrialized areas conference paper; 1984 March 28-30; Zurich, Switzerland. Rotterdam, Netherlands and Boston, MA: A.A. Balkema: 115-121.

Summary: A method for housing construction has been developed using prefabricated wood and bamboo panels, improving traditional Peruvian construction termed Quincha. Tests made in 1972 and then from 1981 to 1983 on individual panels and on two full-scale models have shown high resistance to earthquakes due to the light weight of the panels. The panels have good thermal and acoustic characteristics when mud and straw are applied to the surface.

284. Nandi, N.C.; Saikia, C.N.; Choudhury, N.; Chaliha, B.P.; Lodh, S.B.; Iyengar, M.S. 1972. Matrix board. Assignee: Council of Scientific and Industrial Research (India). Patent, P.N.: IN 125684, I.D.: 720429.

Summary: A mixture of 5 kg of bamboo pulp and 5 kg of rag pulp was beaten to 65 degree Schopper-Riegler freeness, mixed with 0.1 kg rosin soap, 0.2 kg peanut oil emulsion, 0.2 kg melamine-formaldehyde resin, 0.3 kg alum, and 2 kg clay. The slurry was beaten for 0.5 h, and the wet layers containing 60 to 80 g/m^2 pulp were removed, pressed together, and dried to give matrix boards useful for making printing plates.

285. Narayanamurti, D. 1956. Building boards from bamboos. Composite Wood. 3(1): 1-13.

Summary: A comprehensive review is given of the manufacture, properties, and uses of building boards from bamboo. The experiences with these products in the building industry are satisfactory. Extensive manufacturing and performance data are included.

286. Narayanamurti, D.; Bist, B.S. 1963. Building boards from bamboos. Composite Wood. 10(2): 54.
(no abstract available)

287. Narayanamurti, D.; Bist, B.S. 1963. Building boards from bamboo. Indian Forest Records. Composite Wood. 1(2): 9-54.

Summary: A review is given of recent literature concerning the manufacture of building boards from bamboos. Some unpublished data are included.

288. Singh, M.M.; Jain, H.C.; Sekhar, A.C. 1969. Some investigation on pressed boards from bamboo. Indian Pulp and Paper. 23(12): 651-656.

Summary: Experiments on the production of pressed board from bamboo by the Asplund Defibrator process showed that relatively small changes in steaming temperatures resulted in considerable variations of power consumption and certain mechanical properties. Power consumption dropped markedly with increases in steaming temperature. The manufactured boards tensile and bending strengths, compression parallel and perpendicular to plane strengths, hardness, water absorptivity, and swelling properties were determined and presented in a table format.

289. Singh, M.M.; Mukherjea, V.N. 1965. Fibrous raw materials for the Indian pulp, paper, and board industry. Indian Forester. 91(7): 505-529.

Summary: The Forest Research Institute, Dehra Dun, India, has been testing indigenous fibrous raw materials for the production of pulp, paper, and board. Some of the results collected in the course of these investigations are presented in tabular form, including data on fiber dimensions, chemical analyses, method of pulping, yield, and pulp uses. The following materials were covered: 11 bamboos, 18 grasses and reeds, 36 broadleaved wood and conifers, and 11 agricultural wastes.

290. White, D.G. 1949. Bamboo culture and utilization in Puerto Rico. Circular 29. Puerto Rico: Federal Experiment Station. 34 p.

Summary: A background on the utilization and culture of 30 species of bamboo at the Federal Experiment Station in Mayaguez, Puerto Rico, is discussed. The circular briefly discusses the utilization of bamboo for structural applications such as panels and housing framework.

291. White, D.G.; Cobin, M.; Seguinot, P. 1946. Relation between curing and durability of *Bambusa tuldoides*. Caribbean Forester. 7: 253-274.
(no abstract available)

(Also see references 3, 190, 197, 609, and 665.)

Cement/Clay/Gypsum/Plaster Materials

292. Abu Sadeque, A.H.M. 1975. Behavior of bamboo reinforced tied columns. Bangkok, Thailand: Asian Institute of Technology. 58 p. Thesis 816.
(no abstract available)

293. Ali, Z. 1974. Mechanical properties of bamboo reinforced slabs. Bangkok, Thailand: Asian Institute of Technology. 41 p. Thesis 676.
(no abstract available)

294. Ali, Z.; Pama, R.P. 1978. Mechanical properties of bamboo reinforced slabs. In: Proceedings of the International conference on materials of construction for developing countries; 1978 August; Bangkok, Thailand: 49-66.
(no abstract available)

295. Anonymous. 1958. Bamboo reinforcement for concrete. Civil Engineering and Public Works Review. 53: 627.
(no abstract available)

296. Bigg, G.W. 1975. Bamboo reinforced ferrocement grain storage silo. Journal of Structural Engineering. 2: 173-182.
(no abstract available)

297. Brink, F.E.; Rush, P.J. 1966. Bamboo reinforced concrete construction. United States Naval Civil Engineering Laboratory, California. 17 p.
(no abstract available)

298. Cabrillac, R.; Buyle-Bodin, F.; Duval, R.; Luhowiak, W. 1990. Study of the possible use of bamboo in fibre concretes. In: Vegetable plants and their fibres as building materials. Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 50-59. [French].

Summary: The utilization of bamboo as a reinforcement in concrete elements is presented in detail. The paper includes test results.

299. Chadda, L.R. 1956. Bamboo reinforced soil cement lintels. Indian Concrete Journal. 30: 303-304.
(no abstract available)

300. Chadda, L.R. 1956. The use of bamboo for reinforcing soil-cement eliminating shrinkage cracking in walls. Indian Concrete Journal. 30: 200-201.
(no abstract available)

301. Chu, H.K. 1914. Bamboo for reinforced concrete. Cambridge, MA: Massachusetts Institute of Technology. Ph.D. thesis.
(no abstract available)

302. Cook, D.J.; Pama, R.P.; Singh, R.V. 1978. The behaviour of bamboo-reinforced concrete columns subjected to eccentric loads. Magazine of Concrete Research. 30: 145-151.
(no abstract available)

303. Cox, F.B.; Geymayer, H.G. 1969. Expedient reinforcement for concrete for use in Southeast Asia: Report 1—Preliminary tests of bamboo. Tech. Rep. C-69-3. Vicksburg, MS: United States Army Engineer Waterways Experiment Station, CE. 123 p.
(no abstract available)

304. Cox, F.B.; Geymayer, H.G. 1970. Bamboo reinforced concrete. Misc. Pap. C-70-2. Vicksburg, MS: United States Army Engineer Waterways Experiment Station, CE. 15 p.
(no abstract available)

305. Datta, K. 1936. Investigations on the use of bamboo as reinforcement in concrete structures. Bauingenieur. 17(3/4): 17-27. [German].

Summary: The design and properties of bamboo-reinforced concrete structures were described. If the reinforcement is installed in the proper manner, increase in strength will result.

306. Datta, K. 1936. Investigation on the use of bamboo in concrete. Der Bauingenieur. 17: 17-27. [German].
(no abstract available)

307. Durrani, A.J. 1975. A study of bamboo as reinforcement for slabs on grade. Bangkok, Thailand: Asian Institute of Technology. 56 p. Thesis 801.
(no abstract available)

308. Fang, H.Y.; Mehta, H.C. 1978. Sulfur-sand treated bamboo rod for reinforcing structural concrete. In: New uses of Sulfur-II. Advanced Chemical Series 165. Washington, DC: American Chemical Society: 241-254.
(no abstract available)

309. Fricke, T. 1982. Bamboo-reinforced concrete rainwater tanks. Washington, DC: AT International. 50 p.
(no abstract available)

310. Glenn, H.E. 1950. Bamboo reinforcement of Portland cement concrete structures. Bull. 4. Clemson, SC: Clemson Agricultural College. 171 p.
(no abstract available)

311. Gupchup, V.N.; Jayaram, S.; Sukhadwalla, J. 1974. Suitability of bamboo strips as tensile reinforcement in concrete. In: Impact of research on the built environment. Theme 11/3: the impact of research on design. Proceedings of CIB 6th congress on new techniques in concrete and reinforced concrete. 1974 October 3-10; Budapest, Hungary: 464-470.
(no abstract available)

312. Hamid, A. 1973. Structural aspects of bamboo reinforced soil cement. Bangkok, Thailand: Asian Institute of Technology. 105 p. Thesis 523.
(no abstract available)

313. Kalita, U.C.; Khazanchi, A.C.; Thyagarajan, G. 1977. Bamboocrete low-cost houses for the masses. Indian Concrete Journal. 51(10): 309-319.
(no abstract available)

314. Kalita, U.C.; Khazanchi, A.C.; Thyagarajan, G. 1978. Bamboo-Crete wall panels and roofing elements for low-cost housing. In: Proceedings of the international conference on materials of construction for developing countries; 1978 August; Bangkok, Thailand: 21-36.
(no abstract available)

315. Kankam, J.A.; Ben-George, M.; Perry, S.H. 1986. Bamboo-reinforced concrete two-way slabs subjected to concentrated loading. Structural Engineering. 64B: 85-92.
(no abstract available)

316. Kankam, J.A.; Perry, S.H.; Ben-George, M. 1986. Bamboo-reinforced concrete one-way slabs subjected to line loading. International Journal of Cement Composites and Lightweight Concrete. 20: 1-9.
(no abstract available)

317. Kowalski, T.G. 1974. Bamboo-reinforced concrete. Indian Concrete Journal. 48: 119-121.
(no abstract available)

318. Krishnamurthy, D. 1986. Use of bamboo as a substitute for steel in conventional reinforced concrete. In: Use of vegetable plants and fibres as building materials; joint symposium RILEM/CIB/NCCL; Baghdad, Iraq: C71-C78.
(no abstract available)

319. Kurian, N.P.; Kalam, A.K.A. 1977. Bamboo-reinforced soil-cement for rural use. Indian Concrete Journal 51(12): 382-389.
(no abstract available)

320. Manga, J.B. 1983. The feasibility of bamboo as reinforcement for ferrocement housing walls. Journal of Ferrocement. 13: 345-349.
(no abstract available)

321. Mansur, M.A.; Aziz, M.A. 1983. Study of bamboo-mesh reinforced cement composites. International Journal of Cement Composites and Lightweight Concrete. 5(3): 165-171.

Summary: Cement mortar reinforced with woven bamboo mesh in a similar manner to ferrocement was investigated experimentally. The volume fraction of the bamboo and its surface treatment were the main factors, as was the effect of casting pressure. Results of tension, flexure, and impact are given in the paper.

322. Masani, N.J.; Dhamani, B.C.; Singh, B. 1977. Studies on bamboo concrete composite construction. Delhik, India: Controller of Documents. 39 p.
(no abstract available)

323. Mehra, S.R.; Ghosh, R.K.; Chadda, L.R. 1957. Bamboo-reinforced soil-cement as a construction material. New Delhi, India: Central Road Research Institute. 18 p.
(no abstract available)

324. Mehra, S.R.; Ghosh, R.K.; Chadda, L.R. 1965. Consideration as material for construction of bamboo-reinforced soil-cement with special reference to its use in pavement. Civil Engineering and Public Works Review. 60: 1457-1461, 1643-1645, 1766-1768.
(no abstract available)

325. Mehra, S.R.; Uppal, H.L.; Chadda, L.R. 1951. Some preliminary investigations in the use of bamboo for reinforcing concrete. Indian Concrete Journal. 25: 20-21.
(no abstract available)

326. Mentzinger, R.J.; Plourde, R.P. 1966. Investigation of treated and untreated bamboo as reinforcing in concrete. Philadelphia, PA: Villanova University. Thesis.
(no abstract available)

327. Mokhtari, F.C. 1991. Contribution to the study of composites made with pozzolanic binders and bamboo. France: University of Lyon, National Institute of Applied Science. 162 p. Ph.D. thesis. [French; English summary].
(no abstract available)

328. Nagaraja, R. 1986. Strength and behaviour of concrete elements reinforced with bamboo fibres and strips. In: RILEM symposium FRC86; 3d International symposium on developments in fibre reinforced cement and concrete; 1986 July; Sheffield, England: 1: 13-17.
(no abstract available)

329. Narayana, SK.; Rehman, P.M.A. 1962. Bamboo-concrete composite construction. Journal of the Institute of Engineers (India). 42: 426-440.
(no abstract available)

330. Pakotiprapha, B. 1976. A study of bamboo pulp and fiber cement paste composites. Bangkok, Thailand: Asian Institute of Technology. 59 p. Dissertation D20.
(no abstract available)

331. Pakotiprapha, B.; Pama, R.P.; Lee, S.L. 1979. Study of bamboo pulp and fiber cement composites. International Journal for Housing Science and Its Applications. 3(3): 167-190.

Summary: The important characteristics of fiber-reinforced composites resulting from the use of different sizes of fiber reinforcement (i.e., ability of bamboo pulp to improve first crack strength of composite and ability of bamboo fibers to provide post-cracking ductility) were identified. The minimum volume fraction of each type of fibers as well as an optimum mix proportion between bamboo pulp and fibers are suggested for various composites to meet the required mechanical properties. Experiments were conducted to verify analytical predictions and tests were made to evaluate the performance of the materials under service conditions based on ASTM requirements for building boards.

332. Pakotiprapha, B.; Pama, R.P.; Lee, S.L. 1983. Analysis of a bamboo fibre-cement paste composite. Journal of Ferrocement. 13: 141-159.
(no abstract available)

333. Pakotiprapha, B.; Pama, R.P.; Lee, S.L. 1983. Behavior of a bamboo fibre-cement paste composite. Journal of Ferrocement. 13: 235-248.
(no abstract available)

334. Pama, R.P.; Durrani, A.J.; Lee, S.L. 1976. A study of bamboo as reinforcement for concrete pavements. In: Proceedings of the 1st international conference of the Road Engineering Association of Asia and Australia; 1976; Bangkok, Thailand: 45-96.
(no abstract available)

335. Perry, S.H.; Kankam, J.A.; Ben-George, M. 1986. The scope for bamboo-reinforced concrete. In: Proceedings of the 10th international congress FIP; 1986 February; New Delhi, India: 205-214.
(no abstract available)

336. Purushotham, A. 1963. A preliminary note on some experiments using bamboo reinforcement in cement concrete. Journal of the Timber Dryers and Preservers Association of India. 9: 3-14.
(no abstract available)

337. Ramaswamy, H.S.; Ahuja, B.M.; Krishnamoorthy, S. 1983. Behaviour of concrete reinforced with bamboo, coir, and jute fibres. International Journal of Cement Composites and Lightweight Concrete. 5: 3-13.
(no abstract available)

338. Rehsi, S.S. 1988. Use of natural fibre concrete in India. In: Swamy, R.N., ed. Natural fibre reinforced cement and concrete. Glasgow, Scotland: Blackie and Son Ltd.: 243-255. Chapter 7.

Summary: The use of bamboo, banana, coir, jute, pineapple leaf, and sisal for the reinforcement of concrete in India is described in detail. Physical testing of the materials showed that tensile strength ranges from 9 to 740 kg/mm^2, modulus of elasticity ranges from 4 to 510 GPa, and elongation at break ranges from 1.1 to 40 percent. Only coir fiber was found to resist deterioration when subjected to alternate cycles of wetting in saturated lime solution of NaOH and drying. Different measures to render natural fibers resistant to alkali attack were mentioned.

339. Robles-Austriaco, L.; Pama, R.P. 1988. Bamboo reinforcement for cement and concrete. In: Swamy, R.N., ed. Natural fibre reinforced cement and concrete. Glasgow, Scotland: Blackie and Son Ltd.: 92-142. Chapter 3.

Summary: A review is given on the utilization of bamboo as reinforcement for cement mortar and concrete. Properties of

bamboo not only vary with individual species, but also are dependent on age, moisture content, extent of seasoning, time of cutting, maturity, and soil and climatic conditions of the bamboo growing site. Topics included research and development on bamboo and its properties, bamboo as reinforcement for slabs, walls, beams, roofs, columns, water containers, well and reservoir linings, silos, septic tanks, and slabs on soil or soil-cement. Also discussed are composites reinforced with bamboo fibers.

340. Saucier, K.L. 1964. Precast concrete elements with bamboo reinforcement. Tech. Rep. 6-646. Vicksburg, MS: United States Army Engineer Waterways Experiment Station, CE. 33 p.
(no abstract available)

341. Saucier, K.L.; Smith, E.F. 1967. Design, analysis and construction of precast concrete elements with bamboo reinforcement. Misc. Pap. 6-926. Vicksburg, MS: United States Army Engineer Waterways Experiment Station, CE. 17 p.
(no abstract available)

342. Singh, R.V. 1977. A study of bamboo as reinforcement for concrete columns subjected to eccentric loads. Bangkok, Thailand: Asian Institute of Technology. 81 p. Thesis 1046.
(no abstract available)

343. Smith, E.F.; Saucier, K.L. 1965. Design, analysis and construction of precast concrete elements with bamboo reinforcement. Misc. Pap. 6-705. Vicksburg, MS: United States Army Engineer Waterways Experiment Station, CE. 33 p.
(no abstract available)

344. Smith, P.O.; Amedoh, A.; Nawa-Acheampong, H.; Bailey, W.A. 1979. Bamboo fibre reinforcing material in concrete. Appropriate Technology. 6: 8-10.
(no abstract available)

345. Soundarajan, P. 1979. A novel technique using bamboocrete as roofing material. Appropriate Technology. 6(2): 20.
(no abstract available)

346. Sriruenthong, P. 1986. Rainwater catchment tank-bamboo reinforced concrete. In: Proceedings of the regional seminar and workshop on rainwater catchment: Status and research priorities in the Southeast Asian Region; 1983 November 29-December 3; Khon Kaen, India: 75-87.
(no abstract available)

347. Subrahmanyan, B.V. 1984. Bamboo reinforcement for cement matrices. In: Swamy, R.N., ed. New reinforced concretes. Glasgow, Scotland: Blackie and Son, Ltd.: 141-194.
(no abstract available)

348. Suzuki, T.; Yamamoto, T. 1990. Fire resistant materials made with vegetable plants and fibres and inorganic particles. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 60-68.

Summary: Methods of producing incombustible lightweight materials by preparing bamboo coated with water-soluble ceramics and pouring them into a mortar of plant and fiber mixture were covered in this paper. Additionally, production of blocks with a compressive strength of 40 to 50 kg/cm^2 using vegetable plants, fibers, fly ash, rice husk ash, and cement is described.

349. Tankrush, S. 1981. Bamboo-cement water tank-a solution to water shortage problem in Thailand. Journal of Ferrocement. 11: 255-258.
(no abstract available)

350. Thiensiripipat, N. 1986. Bamboo reinforced concrete water tanks. In: Proceedings of the regional seminar and workshop on rainwater catchment: Status and research priorities in the Southeast Asian Region; 1983 November 29 -December 3; Khon Kaen, India: 50-67.
(no abstract available)

351. Vadhanamkkit, C.; Pannachet, V. 1987. Investigations of bamboo reinforced concrete water tanks. In: Proceedings of the 3d international conference on rainwater cistern systems; 1987 January; Khon Kaen, India: C13-1-C13-6.
(no abstract available)

352. Youssef, M.A.R. 1976. Bamboo as a substitute for steel reinforcement in structural concrete, Part I. In: Fang, H.Y., ed. New horizons in construction materials. Lehigh Valley, CA: Envo Publishing: 525-534. Vol. 1.
(no abstract available)

(Also see references 197, 210, 311, 455, and 925.)

Molded Masses

Plastics

353. Espeland, A.J.; Stekhuizen, T.R. 1988. Building material composition production—comprises styrenated unsaturated polyester, hydrated alumina, sand or perlite and bamboo filled with glass fibers. Assignee: (ESPE/) Espeland, A.J. Patent, P.N.: US 4730012, I.D.: 880308.

Summary: A building material is made by mixing a styrenated unsaturated polyester with hydrated alumina and a mineral filler, adding 1 percent by weight methyl ethyl ketone peroxide based on the styrenated unsaturated polyester at a temperature of 23.9°C, embedding bamboo filled with glass fibers in the mixture and permitting the mixture to cure and harden. The material can be poured and molded into various shapes, and has higher compressive (approximately 133.8 MPa), tensile (approximately 13.1 MPa), and flexural strength (approximately 17.1 MPa) than Portland cement. Shear strength and modulus of elasticity are approximately 40.9 MPa and 541.1 MPa, respectively.

354. Jindal, U.C. 1986. Development and testing of bamboo-fibres reinforced plastic composites. Journal of Composite Materials. 20(1): 19-29.

Summary: Bamboo-fiber reinforced composites were tested for tensile and impact strengths and Young's modulus of elasticity by using a simple casting technique. It was observed that these composites possessed high strength and ductility. The ultimate tensile strength of some bamboo-fiber reinforced composites is more or less equal to the ultimate tensile strength of mild steel, while their density was approximately one-eighth the density of mild steel. The mechanical behavior of these composites is similar to other composites, such as glass-fiber reinforced plastics.

355. Saget, M. 1980. Reinforcement of molded surf-boards etc.-by resin impregnated bamboo rovings to enhance specific stiffness without loss of elasticity. Patent, P.N.: FR 2429377, I.D.: 800222. [French].

Summary: The cores of stiff boards used as sporting platforms are reinforced by strands of ligneous material woven in concentric or interlocking hoops. Bamboo, which is split, dried, resin impregnated, and woven, is the process especially suitable for stiffening surfboards, skateboards, and wind surfing boards which have a foamed polyurethane resin core enclosed in an impermeable molded skin.

(Also see reference 278.)

Miscellaneous

Economics

(See reference 231.)

Material Preparation/Pulping/Storage Methods

356. Aung, U.M.; Fleury, J.E. 1960. Breakthrough in bamboo pulping. Pulp and Paper International. 2(5): 21-23.

Summary: Shredded bamboo has shown distinct advantage over chipped bamboo in the production of kraft pulp and hardboard. The shredder developed at the institute in Rangoon tears the long fibers from the bamboo culm along its natural axis and eliminates most of the undesirable waste material and silica. For the production of hardboard, no binder or chemicals are required.

357. Birdseye, C. 1959. Process for storing and digesting of fibrous agricultural residues. Patent, P.N.: US 2889350, I.D.: 590811.

Summary: A method for storing shredded bamboo, straw, bagasse, and other agricultural residues involves impregnating the baled or piled material with NaOH and effecting roughly 20 percent of digestion without decay. Prior to storage, the material may be sterilized by heating it to at least 180°C. After 9 to 12 months, the material is treated with kraft white liquor, subjected to a steam pressure of 1.0 MPa and a temperature of 185°C for 5 min before being exploded through a break valve.

(Also see references 231, 232, and 269.)

General Information/Reviews

358. Adur, A.M. 1977. Gamma-radiation processed bamboo-polymer composites. I. Preparation, process parameters and product microstructure. Journal of Radiation Curing. 4(4): 2-17.
(no abstract available)

359. Adur, A.M. 1978. Gamma-radiation processed bamboo-polymer composites. II. Mechanical properties, moisture content and water absorption characteristics. Journal of Radiation Curing. 5(2): 4-12.
(no abstract available)

360. Adur, A.M. 1978. Gamma-radiation processed bamboo polymer composites. III. Possible applications for tensile reinforcement of concrete. Journal of Radiation Curing. 5(4): 9-16.
(no abstract available)

361. Anonymous. 1992. Bamboo fibre composites may have uses. Advanced Composites Bulletin. August: 2-3.

Summary: Researchers at the Indian Institute of Technology and Delhi College of Engineering published the results of an investigation of bamboo fiber composites. This paper reviews the research and results by these two Indian institutions.

362. Datye, K.R.; Nshstsju, S.S.; Pandit, C.M. 1978. Engineering applications of bamboo. In: Proceedings of the International conference on materials of construction for developing countries;. 1978 August; Bangkok, Thailand: 3-20. Vol. 1.
(no abstract available)

363. Ghavami, K.; Van Hombeeck, R. 1981. Application of bamboo as a construction material. In: Proceedings of the Latin American symposium Rat. Organization of Building Applications in Low-Cost Housing; 1981 October; Sao Paulo, Brazil: 49-66.
(no abstract available)

364. Heinrichs, D. 1989. Bamboo. Winter varieties for the climatic region of North Germany and to be used as building material. Schriftenreihe des Fachbereichs Landespflege der

Fachhochschule Osnabrueck: Bonn, Germany. 92 p. [German].
(no abstract available)

365. Iwai, Y.K. 1982. Study on the formation process of bamboo producing center for building materials, in Kyoto (Japan). Bulletin of the Kyoto University Forests. 54: 67-83. [Japanese; English summary].
(no abstract available)

366. Limaye, V.D. 1943. Bamboo nails, their manufacture and holding power. Indian Forest Resources. No. 3. 12 p.
(no abstract available)

367. McClure, F.A. 1948. Bamboos for farm and home. Separate No. 2101. 1948 Yearbook of Agriculture. Washington, DC: United States Department of Agriculture: 735-740.
(no abstract available)

368. Ono, K. 1965. Studies on bamboo pulp industry. (1) Bamboo forest resources in Indonesia and Burma. Japan Pulp and Paper. 3(2): 62-69.

Summary: This paper presents data on the geographic distribution, types, utilization (including uses other than for pulp), cost of harvesting, and total resources on the bamboo pulp industry.

369. Rangan, S.G.; Ravindaranathan, N. 1982. Wet-end operations with a furnish of 70% hardwoods and 30% bamboo at SPB Seshassayee Paper and Boards Ltd. Indian Pulp and Paper. 19(1): 63-66.

Summary: Increasing a paper machine furnish to 70 percent hardwood (with 30 percent bamboo) produced more fines and permitted a reduction in consumption of rosin size. The effectiveness of cationic-wax emulsion size declined, but the use of guar gum improved strength properties. Gentle treatment with double-disk refiners is recommended to achieve maximum fibrillation with minimum power consumption.

370. Van der Woude, C.A.A. 1951. New building materials in Indonesia. OSR News (monthly of Organization of Scientific Research for Indonesia). 3: 106-110.
(no abstract available)

371. Wang, Z. 1986. Bamboo fibre reinforced composite material unites fibre reinforcement lamination and particulate composite in same process. Assignee: (WANG/) Wang Zefei. Patent, P.N.: CN 85107095, I.D.: 860910. [Chinese].
(no abstract available)

Material Used in Natural State

372. Abang Abdullah, A.A. 1983. Utilization of bamboo as a low cost structural material. In: Appropriate building materials for low cost housing, African Region. London, England: E. and F.N. Spon: 177-182.
(no abstract available)

373. Bond, P.S. 1913. Some experiments in the use of bamboo for hasty bridge construction. United States Army Corps of Engineers. Prof. Memo. 5: 593-602.
(no abstract available)

374. Charters, D. 1976. Model study of bamboo hydraulic structures for erosion abatement. In: Fang, H.Y., ed. New horizons in construction materials. Lehigh Valley, CA: Envo Publishing: 511-523. Vol. 1.
(no abstract available)

375. Datye, K.R. 1976. Structural uses of bamboo. In: Fang, H.Y., ed. New horizons in construction materials. Lehigh Valley, CA: Envo Publishing: 499-510. Vol. 1.
(no abstract available)

376. Hidalgo, O.; Langlais, G. 1988. Using bamboo as building material in developing countries. Centre Scientifique et Technique du Batiment (CSTB, France). 313 p. [French].
(no abstract available)

377. Horn, C.L.; Arboyo, A. 1943. New bamboo reventment construction. Military Engineer. 35(212): 284-286.
(no abstract available)

378. Huybers, P. 1990. The use of forestry thinnings and bamboo for building structures. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 295-304.

Summary: The utilization of bamboo for structural purposes is described. In particular, the use of a special tool that is operated by hand to form tight connections between bamboo structural elements is covered in detail.

379. Janssen, J. 1980. The mechanical properties of bamboo used in construction. In: Proceedings of the workshop on bamboo research in Asia; 1980 May; Singapore: 173-188.
(no abstract available)

380. Karamchandani, K.P. 1959. Role of bamboo as a constructional material. In: Proceedings of the symposium on timber and allied products, NBO; 1959 May 18-22, New Delhi, India: 430-435.
(no abstract available)

381. Kumpe, G. 1937. Experimental bamboo truss. Military Engineer. 29: 288-289.
(no abstract available)

382. Lipangile, T.N. 1990. The use of timber and bamboo as water conduits and storage. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 305-313.

Summary: This paper gives a brief explanation of the technology used in bamboo utilization for water conduits such as water supply, irrigation, road culverts, sewage disposal, and drainage.

383. McClure, F.A. 1981. Bamboo as a building material. United States Peace Corps, Information Collection and Exchange, R-33. Washington, DC: Department of Housing and Urban Development. Office of International Affairs. 52 p.

Summary: This document provides an excellent overview on the utilization of bamboo as a building material. Additional information concerning physical and mechanical properties of bamboo is tabulated and descibed thoroughly. This publication was originally published in 1953 and again in 1963, 1967, 1972, 1979, and 1981. It contains 59 references.

384. Narayanamurti, D.; Mohan, D. 1972. The use of bamboo and reeds in building construction. United Nations Document ST/SOA/113. New York: Department of Economic and Social Affairs. United Nations Publication Sales No. E.72.IV.3. 95 p.

Summary: This document contains an overview of how bamboo and reeds are utilized in building construction, especially in third-world countries.

385. Nitschke, G. 1976. Framing or edging of plastics for furniture-using bamboo rods which can be nailed or adhered to wood substrate or frame. Patent, P.N.: DE 2502048, I.D.: 760722. [German].

Summary: Plastic panels are framed, or box-like bodies, consisting of plastic panels (for use as furniture elements) and are provided with edging by using longitudinally split bamboo rods which may be nailed or adhered to concealed wooden-frame members. The bamboo rods, which are semicircular and have mitered free ends, are attractive and provide good contrast to dark colored plastic panels.

386. Tamolong, F.N.; Lopez, F.R.; Semana, J.A.; Casin, R.F.; Espiloy, Z.B. 1980. Properties and utilization of Philippine erect bamboos. In: Proceedings of a workshop on bamboo research in Asia; 1980 May; Singapore: 189-200. (no abstract available)

387. White, A.G. 1990. Bamboo architecture a selected bibliography. Architecture series-Bibliography, A-2344. Monticello, IL: Vance Bibliographies: 5 p.

Summary: This paper contains a bibliography on the use of bamboo, grasses, and reeds in architecture.

(Also see references 197, 278, 292, and 927.)

Banana [Stem]

Panel Board

Particleboard

388. Pablo, A.A.; Ella, A.B.; Perez, E.B.; Casal, E.U. 1975. The manufacture of particleboard using mixtures of banana stalk (saba: *Musa compreso,* Blanco) and Kaatoan bangkal (*Anthocephalus chinensis,* Rich. ex. Walp.) wood particles. Forpride Digest. 4: 36-44.

Summary: Particleboards with densities of 0.59 to 0.64 g/cm^3 and 0.67 to 0.72 g/cm^3 were prepared from banana stalk and wood chips in various proportions, with 10 percent urea-formaldehyde resin as the binder. The physical and mechanical properties of the high-density boards were superior to those of the low-density boards. The strength of the boards increased with increase in the proportion of wood chips in the mixture.

389. Pablo, A.A.; Ella, A.B.; Perez, E.B.; Casal, E.U. 1976. Development of particleboard on a pilot-plant and semi-commercial scale using plantation and secondary wood species and agricultural fibrous waste materials (Banana stalk and Kaatoan bangkal). Los Banos: Forest Products Research and Industries Development Commission, Laguna College of Forestry, University of the Philippines. 20 p. (no abstract available)

Insulation Board

(See reference 149.)

Cement/Gypsum/Plaster Board

(See reference 149.)

Plastic/Plastic-Bonded Board

(See references 444, 1025, and 1026.)

Unknown Board

(See references 3 and 197.)

Cement/Clay/Gypsum/Plaster Materials

(See references 197 and 338.)

Miscellaneous
Material Preparation Pulping/Storage Methods

390. Anonymous. 1975. Banana fibre processing. Hamburg, Germany: Atlanta-Industrie- und Unternehmensberatung GmbH. 181 p.

Summary: An economic and technical study of the possibilities and conditions for extracting and processing banana fibers and their utilization in the pulp, paper, and board industry is reported.

(Also see reference 14.)

General Information/Reviews

391. Narayanamurti, D.; Jain, N.C.; George, J. 1962. The industrial use for banana stems. The Indian Buyer. 1:9. (no abstract available)

Barley

Panel Board
Particleboard

(See references 660 and 1148.)

Fiberboard/Hardboard

(See references 660 and 858.)

Insulation Board

(See reference 660.)

Cement/Clay/Gypsum/Plaster Materials

392. Acevedo, S.; Alvarez, M.; Navia, E.; Muñoz, R. 1990. Fibre-concrete roofing tiles in Chile. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 199-203.

Summary: The process for converting fibrous agricultural residues, such as barley and wheat fiber, into natural fiber concrete roofing tile is explained. A manually powered vibrating table was designed and constructed to produce a uniform mix. The study covered the fiber materials and their characteristics, production technology, properties of natural fiber concrete roofing tiles, and production methods and costs.

Molded Masses
Refractory Materials

(See reference 961.)

Miscellaneous
General Information/Reviews

(See reference 1003.)

Beet

Panel Board
Unknown Board

(See reference 784.)

Cashew Nut

Molded Masses
Resins/Binders

(See references 57, 274, 282, 440, and 1029.)

Cassava/Tapioca [Stalk]

Panel Board
Particleboard

393. Flaws, L.J.; Palmer, E.R. 1968. Production of particle board from cassava stalk. Rep. G34. London, England: Tropical Products Institute (TPI).

Summary: Experiments were carried out using 455.8 kg of 91.44-cm-long and 2.54-cm-diameter cassava stalks. Splinters were produced under controlled conditions, mixed with urea-formaldehyde resin in a rotary mixer, cold pressed, then hot pressed. The standard panel was compared to British Standard 2604 for bending and tensile strengths. Results using 6, 8, and 10 percent resin were tabulated. It was determined that satisfactory board, exceeding the British Standard, can be made with 8 percent resin content, resulting in 0.64 g/cm^3 board density.

Fiberboard/Hardboard

394. Narayanamurti, D.; Singh, J. 1953. Studies on building boards. V. Utilization of tapioca stems and hoop pine bark. Composite Wood. 1(1): 10-17.

Summary: Hardboards were prepared from tapioca stems (*Manihot utilissima*) and hoop-pine bark, insulating boards from tapioca only. For disintegration, a laboratory-scale Asplund Defibrator was used. Pressing into boards was carried out using standard procedures. The resulting boards compared favorably with similar commercial products.

395. Narayanamurti, D.; Singh, J. 1954. Studies on building boards. VI. Preparation of plastics, boards, etc., from wood waste, barks, etc., by thermal treatment in presence of water and other methods. Composite Wood. 1(4): 89-93.

Summary: A thermal-plasticization process on a laboratory scale using different tropical lignocellulosic materials and barks for the manufacture of board and molded products was described. The results show that products of satisfactory strength and water resistance can be obtained; tapioca wood gave the best results under the conditions employed. A few experiments were also carried out in which tapioca stalk or hoop-pine bark were either subjected to a mild acid or alkaline hydrolysis or allowed to react with sulfur or phenol and added to the cook.

(Also see reference 6.)

Insulation Board

(See references 6 and 394.)

Unknown Board

(See references 3 and 197.)

Cement/Clay/Gypsum/Plaster Materials

(See reference 197.)

Cellulose

Panel Board

Cement/Gypsum/Plaster Board

396. Anonymous. 1976. Construction plate. Assignee: Cape Boards and Panels Ltd. Patent, P.N.: NL 7500051, I.D.: 760706. [Dutch].

Summary: Cellulose, polyamide-polyester, polypropylene, or viscose fibers are bound with a hydraulic binder, such as calcium silicate, tobermorite, xonotlite, Portland cement, or similar cements. Inorganic fibers may be added to improve fire resistance of the panels. Mineral fillers may also be added for bulk. Final boards had a density of 0.76 g/cm^3 and a modulus of rupture of 10.6 MPa.

397. Beshay, A.D. 1991. Cellulose fiber-reinforced cement and gypsum composites. Patent, P.N.: US 5021093, I.D.: 910604.

Summary: Composites consist of cement or gypsum, cellulose fibers, and water (optional). Cellulose fibers are pregrafted with a silylating agent such as γ-aminopropyltriethoxysilane. Optionally, the cellulose fibers are treated with a $CaCl_2$ solution, before or after the grafting process. Composites contained an additional inorganic filler.

398. Matsumoto, T.; Mita, T.; Inoue, T.; Nishioka, K. 1989. Manufacture of asbestos-free calcium silicate sheets for building materials. Assignee: Mitsubishi Mining and Cement Co. Ltd. and Mitsubishi Cement Asbestos Co. Ltd. Patent, P.N.: JP 01208355, I.D.: 890822. [Japanese].

Summary: To manufacture asbestos-free calcium-silicate sheets, a batch is prepared of 15 to 30 percent by weight slurry of slaked lime and fine diatomite particles containing 0.5 to 3 percent by weight cellulose fibers having Schopper-Riegler freeness greater than 80 degrees; a second batch is then prepared of 2 to 10 percent by weight slurry of calcareous and siliceous materials containing natural cellulose having Schopper-Riegler freeness of 50 to 70 degrees, 5 to 20 percent by weight inorganic additives, and 0.5 to 2 percent by weight organic synthetic fibers. The two slurries are mixed at a desired ratio, shaped, and cured.

399. Simatupang, M.H.; Lange, H. 1987. Lignocellulosic and plastic fibers for manufacture of fiber cement boards. International Journal of Cement Composites and Lightweight Concrete. 9(2): 109-112.

Summary: This paper presents the effect of Dolanit 10 and ATF 1055 polyacrylonitrile, Krenit polypropylene, and Kuralon polyvinyl fibers on the properties of laboratory fiber-cement boards made from thermomechanical pulp, sulfate pulp, and pretreated flax fibers. The tests were carried out according to a 4x3x3 factorial experimental design, and the results were compared with those of boards made without synthetic fibers. The type of synthetic fiber, its amount, and the type of cellulosic fiber all had a significant effect on the board properties. The addition of synthetic fibers, except Krenit fibers, increased the bending strength.

Unknown Board

400. Pawlowski, T.; Baranowski, P.; Mikulicz, G. 1974. Lignocellulose construction board. Pr. Zakresu Towarozn. Chem., Wyzsza Szk. Ekon. Poznaniu, Zesz. Nauk., Ser. 1. 53: 119-124. [Polish].

Summary: Constructional boards made of flax or hemp scutching residues bonded with phenol-formaldehyde resin and impregnated with boric acid or borax have improved fire and water resistance and satisfactory mechanical properties. The addition of mineral-wool or asbestos-fibers reduced the flexibility and elasticity of the boards. The phenolic smell of the board is reduced by adding Almask Formol deodorant.

Molded Masses

Resins/Binders

401. Diehr, H.J.; Kraft, K.J.; Sachs, H.I. 1975. Pressure molded lignocellulosic articles comprising isocyanurate group-forming mold release agent. Assignee: Bayer A.G. Patent, P.N.: US 3870665, I.D.: 750311.

Summary: Polyisocyanate-bonded lignocellulosic materials, molded in a press, can be completely separated from the metal parts provided the compounds which catalyzed the formation of isocyanurates from isocyanates are used as the mold release agents.

Coconut/Coir [Dust, Husk, Shell, Shell Flour]

Panel Board

Particleboard

402. Aggarwal, L.K. 1991. Development of coir fiber reinforced composite panels. Research and Industry. 36(4): 213-274.

Summary: This paper describes a process for production of coir fiber reinforced cement panels. These newly developed composite panels have bending strengths of 9 to 11 MPa and modulus of elasticity of 2,500 to 2,800 MPa, and show thickness swelling of less than 1.2 percent and water absorption of 14 to 16 percent when tested with standard procedures. The panels show better dimensional stability and behavior towards fire when compared with traditional materials such as plywood, wood particleboard, and wood fiberboard and can be used as an alternative to these materials.

403. Chittenden, A.E.; Flaws, L.J.; Hawkes, A.J. 1970. Particle boards from coconut palm timber. Ceylon Coconut Quarterly. 21(3/4): 107-112.
(no abstract available)

404. Fotheringh, R.H. 1981. Building boards from coconut husks by pressing powdered water-soaked husks at temperatures above boiling point. Assignee: (LONM-) London and Malaga Boa. Patent, P.N.: GB 1599215, I.D.: 810930.

Summary: Coconut husk material with a water content of 30 to 75 percent by weight, gained by soaking or steaming material, is hot pressed. A preferable binder material was added to the husks, preferably comminuted, before hot pressing between a screen and platen or between two screens. The hot-press temperature is between 130°C to 165°C with a minimum pressure of 1.4 MPa and a maximum pressure of 13.8 MPa.

405. George, J. 1961. Complete utilization of coconut husk. III. Particle boards from by-products of the coir industry. Indian Pulp and Paper. 15(10): 613, 616.

Summary: Preparing particleboard from coconut husk with pith waste and coir shearing waste was described. An aqueous extract of unretted coconut husk, a tannin-formaldehyde resin, or a phenol-formaldehyde resin was used as the binder. The mixture was formed into a sheet and pressed at 145°C and 4.9 MPa for 15 min for a 6-mm board. The boards had satisfactory strength and water resistance.

406. George, J. 1964. Production of particle board from coconut husk. Indian Com. Journal. 19(2): 1.
(no abstract available)

407. George, J. 1983. Building materials from coconut husk and its by-products. In: Proceedings of the international symposium on coconut research and development; 1976 December 27-31; Kerala, India. New Delhi, India: Wiley Eastern Limited: 288-290.

Summary: In a brief presentation, the self-bonding ability of coir and coconut waste into particleboards is described.

408. George, J.; Bist, B.S. 1962. Complete utilization of coconut husk. Part IV. Three-layer particle boards with coconut husk particle core. Indian Pulp and Paper. 16(7): 437-438.

Summary: Wood particles were used for faces and coconut particles for the core in the preparation of three-layer particleboards of medium density. The amount of phenol-formaldehyde resin binder added was relatively minor. Strength and water resistance were within the usual range for medium-density particleboard. The boards were found to be highly fire-resistant and tough, and possessed smooth surfaces.

409. George, J.; Joshi, H.C. 1961. Complete utilization of coconut husk. I. Building boards from coconut husk. Indian Pulp and Paper. 15(8): 507-510.

Summary: Coconut husks shredded by hand or in a disk mill were pressed into boards at about 150°C and pressures of 343.2 kPa to 15.2 MPa for 30 min. On manual shredding, most of the pith remained on the fiber, whereas disk milling separated the fibers from the pith (60:40 weight ratio). Hardboards from fiber and pith had satisfactory bending strength which could be improved by adding a formaldehyde donor or tar acid formaldehyde resin. Three-layer boards had particularly good bending strength, and, like other insulating and medium-density boards, high water absorption values too.

410. George, J.; Shirsalkar, M.N. 1963. Particle board from coconut husk. Research and Industry. 8(5): 129-131.
(no abstract available)

411. Kochuzhathil, M.T.; Kochuzhathil, T.M. 1988. A process of manufacture of fire-resistant coconut pith sheets. Patent, P.N.: IN 162132, I.D.: 880402.

Summary: To prepare coconut pith sheets to be used as building materials, spray or mix dry coconut pith with adhesives, which are prepared by copolymerizing cashew nutshell liqour with H_3PO_4 , neutralizing the polymer, and mixing the polymer with formaldehyde and hexamethylenetetramine, forming and cold pressing the mats. The mat was cold pressed for 16 h and dried in open air for 10 days to give a 2-mm-thick sheet with a density of 0.80 g/cm^3 and no ignitability.

412. Narayanamurti, D.; Narayanan, P.; Prasad, T.R.N. 1968. Boards from coir waste. Board Manufacture. 11(9): 102-104.

Summary: Experiments are described in which building boards were prepared from coconut coir waste. The coir waste was sprayed and/or mixed with various additives (such as wattle bark tannin plus formaldehyde), cold pressed followed by hot pressing for the required time. The boards obtained had satisfactory modulus of elasticity, modulus of rupture, impact resistance, and swelling. It was concluded that larger scale trials are warranted due to the encouraging results.

413. Ogawa, H. 1977. Utilization of coir dust for particleboards. Osaka Kogyo Gijutsu Shikensho Kiho. 28(3): 231-233. [Japanese].

Summary: Particleboards having bending strengths greater than 9.8 MPa were prepared from coir dust, >10 percent coir fibers, and 87 percent urea resin.

414. Pablo, A.A.; Lovian, A.F. 1989. Utilization of coconut coir dust, coir fiber, pineapple fiber and wood wastes particles for the production of particleboard. Tokyo, Japan: International seminar on underutilized bioresources in the Tropics; Japan Society for the Promotion of Science: 192-209.
(no abstract available)

415. Pablo, A.A.; Suguerra, J.B. 1977. Particleboard from wood species and aggie fibrous waste materials. V. Coconut trunk and wood/coconut trunk particle mixtures. National Science Development Board (NSBD) Journal. 11(2): 34-43.
(no abstract available)

416. Pablo, A.A.; Segurra, J.B.; Tamolang, F.N.; Ella, A.B. 1977. Particle board from wood species and fibrous materials. V. Coconut trunk and wood/coconut trunk particle mixtures. Forest Products. 2: 33-43.
(no abstract available)

417. Pablo, A.A.; Tamolang, F.N.; Casal, E.U. 1978. Panel particleboard products from coconut palm. National Science Development Board (NSBD) Technology Journal. 3(1): 57-61.
(no abstract available)

418. Tamolang, F.N. 1976. The utilization of coconut trunk and other parts for particleboard-making, charcoal production, briquetting, electrical and telecommunication poles in the Philippines. National Science Development Board (NSBD) Technology Journal. 1(2): 36-48.
(no abstract available)

419. Thampan, P.K. 1975. The coconut palm and its products. Karala, India: Green Villa Publishing House. 302 p.

Summary: This book covered all major and minor products produced with coconut wood and coir fiber. Included are references concerning the use of coconut timber in the framing of houses, and the use of coconut coir fiber for the production of particleboard.

420. Thampan, P.K. 1981. Handbook on coconut palm. New Delhi, India: Oxford and IBH Publishing Company. 311 p.

Summary: The culture and use of coconut palm and coir waste are described, and particleboard made from coir fiber and framing timber made from coconut wood were examined.

(Also see references 53, 83, and 493.)

Fiberboard/Hardboard

421. Anonymous. 1944. Industrial utilisation of coir. Journal of Scientific and Industrial Research. 2: 174.

Summary: This paper explains how fiberboards were manufactured by treating beaten coir with shellac and boiled linseed oil. This mixture was exposed to the sun for 4 h to promote oxidation and then pressed for 30 min at 54.4°C. The boards were hard, did not warp, and showed a high chemical resistance to water, cold 10 percent sodium carbonate, and dilute nitric acid.

422. George, J.; Joshi, H.C. 1961. Complete utilization of coconut husk. II. Hardboards from coconut fiber. Indian Pulp and Paper. 15(9): 573-575.

Summary: Hardboards with satisfactory strength properties were prepared from unretted coconut husk and coir shearing waste. To improve the felting quality of the pulps, the fibers were subjected to a softening treatment prior to forming into a mat. Boards from unretted fiber had better strength properties than those from coir shearing waste. The somewhat high water absorption could be reduced to a sufficiently low level by oil tempering or by using suitable sizing agents.

423. Hadinoto, R.C. 1957. Coconut husk is a new raw material for board production in copra producing countries. Tech. Inf. Circ. 25. South Pacific Commission: l-10.

Summary: In Indonesia, during 1951, plans were drawn up to produce hardboard to meet the increasing demand for sheet materials for housing. Coconut husks were chosen as the raw material. In East-Java, a pilot plant with a production capacity of 3,500 t of board annually was erected. The German C.T.C. process was chosen because it appeared to be economical for medium- and small-sized units and was suited for producing a great variety of boards.

424. Kristnabamrung, W.; Takamura, N. 1968. Suitabilities of some Thai hardwoods and coconut fiber for manufacturing hardboards by wet and dry processes. Journal of Japanese Tappi. 22(3): 154-64. [English; Japanese summary].

Summary: This paper reports the following hardwoods were examined for suitability to yield wet-process and/or dry-process hardboards via Asplund Defibrator process: *Cocoas nuclear, Sterculia campanulata, Tetramele nudiflora, Anisoptera glabra, Shorea curtisii, Tectona grandis, Dipterocarpus alatus,* and *Hevea brasiliensis.* No heat treatment or oil treatment was applied to the boards. Phenolic resin and paraffin emulsions were added to the fiber furnish in amounts of 0.5 percent for the wet and 4 percent for the dry process. Boards from coca fiber showed outstanding flexural stiffness when compared with wet-process hardwood boards.

425. Kristnabamrung, W.; Takamura, N. 1972. Suitabilities of some Thai hardwoods and coconut-husk fibre for manufacturing hardboards by wet and dry processes. Thai Journal of Agricultural Science. 5: 101-125.

Summary: This paper reports on hardwoods tested, which included *Sterculia campanulata, Tetramele nudiflora, Anisoptera glabra, Shorea curtisii, Tectona grandis, Dipterocarpus alatus,* and *Hevea brasiliensis.* Of these, *T. nudiflora, S. curtisii, A. glabra,* and *D. alatus* were most suitable, giving both wet- and dry-process hardboards of the quality required by Japanese standards. *S. campanulata* hardboards were of satisfactory strength but their water resistance was insufficient; *H. brasiliensis* gave a very low pulp yield; *T. grandis* was suitable for dry but not wet processing; and coconut-fiber (*Cocos nucifera*) wet-process hardboards, though not very strong, were extraordinarily flexible.

426. Melgarjo, F.R. 1977. Process for the manufacture of hardboards from coconut husk and the products produced therefrom. Patent, P.N.: Philippine patent document 10468/C/, I.D.: 770428. Patent classification: 161-87, 88. (no abstract available)

427. Menon, S.R.K. 1944. Coconite (fiber board from immature coconuts). Journal of Scientific and Industrial Research. 2: 172-174.

Summary: Fiberboards were manufactured from windfall immature coconuts which were shredded, boiled with water, pulped, and mixed with waste paper, rosin, and alum. For preparing the sheets, the usual fiberboard technique was used. Boards were pressed for 20 min at 160°C and 3.9 MPa, and the resulting boards were strong and tough, and displayed good heat and sound insulating properties.

428. Pama, R.P.; Cook, D.J. 1976. Mechanical and physical properties of coir-fibre boards. In: Fang, H.Y., ed. New horizons in construction materials. Envo Publishing Co.: 391-403.
(no abstract available)

429. Prasad, S.V.; Phillai, C.K.S.; Satyanarayana, K.G. 1986. Paper and pulp board from coconut leaves. Research India. 31(2): 93-96.

Summary: The process of pulping coconut leaves was quite easy and gave a pulp with average fiber length of 1.75 mm and yield of 30 percent. Hand sheets made from pulp showed a breaking length of 718.51 mm and burst factor of 4.00, which were nearer to those of straw board, packing paper, and other such materials. The use of improved methods of sheetmaking and the addition of bonding resins improved the properties of the paper.

430. Semana, J.A. 1965. Coconut coir fibre board. Hard Fibres Research Series 19. Manilla, Philippines: Forest Products Research and Industry Development Commission.
(no abstract available)

431. Semana, J.A. 1975. Coconut coir for fiberboard; Paper 12. Manila, Philippines: Committee on Commodity Problems, Intergovernmental Group on Hard Fibers-Session 8. 10 p.
(no abstract available)

(Also see references 122, 409, 437, 444, and 860.)

Insulation Board

432. Anonymous. 1976. Lightweight sound and heat insulating constructional material-made of resin impregnated coconut fibres. Assignee: (SHIG-) Shigeru Mfg. KK. Patent, P.N.: JP 51039780, I.D.: 760402. [Japanese].

Summary: A shape-providing body consisting of entangled coconut fiber is impregnated with thermosetting resin, by means of fins, as a coloring binder. Plate elements of required dimension are obtained by cutting the impregnated body when the resin is semihardened and then heated and pressed to provide desired shape and internal corrugation of the wall member as the binder resin is completely hardened. The architectural wall members have superior noise and heat insulating properties as well as reduced weight at a lower cost.

433. Iyengar, N.V.R.; Anandaswamy, B.; Raju, P.V. 1961. Thermal insulating materials from agricultural wastes: coconut (*Cocos nicifera,* Linn.) husk and pith. Journal of Scientific and Industrial Research. 20D(7): 276-279.

Summary: This paper reports on the possibility of utilizing sun-dried coconut husk and pith obtained by wet retting for the production of thermal insulation boards. Insulation boards prepared from different fractions of husk and pith have been found to possess good thermal-insulating properties.

434. Rao, C.V.N.; Prabhu, P.V.; Venkataraman, R. 1971. Thermal insulation boards from coconut pith. Fish Technology. 8(2): 185-188.
(no abstract available)

(Also see references 493 and 494.)

Cement/Gypsum/Plaster Board

435. Hussin, M.W.; Zakaria, F. 1990. Prospects for coconut-fibre-reinforced thin cement sheets in the Malaysian construction industry. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 77-86.

Summary: This paper reports on the current research and developments on the use of coconut fibers as reinforcement for thin cement sheets as roofing materials. Tests on 500- by 500- by 10-mm flexural plates and on 1,220- by 630- by 10-mm corrugated sheets are reported. The load deflection curves and cracking performance are also reported based on several curing regimes. Additional test results provided are water absorption, water tightness, and bulk density. Performance characteristics of the thin sheets are shown to be a function of fiber concentration and method of specimen fabrication.

436. Mattone, R. 1990. Comparison between gypsum panels reinforced with vegetable fibres: their behaviour in bending and under impact. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 161-172.

Summary: The behavior of thin panels of gypsum reinforced with either coconut or sisal fibers was investigated. Test pieces were produced through a vacuum process to reduce the water:gypsum ratio, increase the compaction, and improve the bond between fibers and the matrix so as to obtain a high-performance composite. Bending tests were performed on test pieces measuring 30 cm by 40 cm, and impact tests were performed on panels sized 80 cm by 80 cm. The behavior of the reinforced panels was compared with that of panels traditionally utilized in the building materials industry.

437. Tropical Products Institute. 1968. Attempts to use coir dust in the preparation of building boards, slabs or hardboard. Rep. G35. London, England: Tropical Products Institute (TPI).

Summary: Coir dust of two distinct particle-size distributions were mixed with cement in ratios of from 1:1 to 6:1 cement: coir dust which produced concrete of load bearing qualities only when extra water was added to the coir. The cement fraction was then increased to what was considered uneconomical levels before adequate concrete was produced. Non-load bearing panels of 0.64, 0.96, 1.12, and 1.28 g/cm^3 densities were also produced, but with some difficulty. Hardboard production required both excessive pressures and resin amounts and appeared not to be feasible.

(Also see references 886, 1014, and 1016.)

Plastic/Plastic-Bonded Board

438. Anonymous. 1981. Fire-resistant plastic composites. Assignee: Meisei Kagaku Kogyo KK, Kasugai. Patent, P.N.: JP 56118848, I.D.: 810918. [Japanese].

Summary: Fire-resistant plastic molding compositions contain cellulosic materials, such as sawdust, powdered coconut shell, powdered walnut shell, and powdered rice bran, and are fireproofed by treating with ammonium polyphosphate and urea.

439. Casin, R.F.; Generalla, N.C.; Tamolang, F.N. 1977. Preliminary studies on the treatment of coconut lumber with vinyl monomers. Proceedings of the coconut stem utilization seminar; University of the Philippines: 413-419.

Summary: Impregnating coconut wood with a mixture of styrene and unsaturated polyester and then heat-curing resulted in a high-density strong composite. The increase in the quality of the inner portion of specimen was higher than that of the outer portion. The treated specimens from the inner portion had higher plastic content than those from the outer portion due to the porosity of the inner portion.

440. Narayanamurti, D.; Ranghunatha Rao, D.M.; Narayana, P.T.R.; Zoolagud, S.S.; Rangaraju, T.S. 1969. Plastic materials from lignocellulosic wastes: utilization of coconut coir pith. Indian Pulp and Paper. 24(1): 57-60.

Summary: Coconut coir pith was powdered, molded, and pressed into disks and boards at various temperatures and pressures, and the resultant density, rupture moduli, water absorption, and volume swelling were noted. After 24 h, the moisture absorption and swelling values were good, the pieces were still good after a 4-month aqueous immersion. The boards were slightly stronger when tempered in cashew nut shell oil, except when made at low temperatures.

441. Ohtsuka, M.; Uchihara, S. 1973. Boards from resin-impregnated coconut husk. Assignee: Otsuka Chemical Co. Ltd. Patent, P.N.: JP 48022179, I.D.: 730320. [Japanese].

Summary: Fibers and cork from coconut husk were impregnated with vinyl monomers and pressed after polymerizing the monomers to give a board. One kg coconut fibers and 1 kg coconut cork were evacuated and impregnated with 1.6 kg of a mixture of styrene, Me methacrylate, and divinyl benzene. The mixture was heated for 4 h at 65°C to polymerize the monomer, and the product was arranged in such a way that the cork was sandwiched between fiber layers and pressed 15 min at 100°C and 2.0 MPa to give a board with a density of 0.80 g/cm^3, flexural strength of 73.5 MPa, and compressive strength of 84.3 MPa.

442. Prasad, S.V.; Pavithran, C.; Rohatgi, P.K. 1983. Alkali treatment of coir fibers for coir-polyester composites. Journal of Materials Science. 18(5): 1443-1454.

Summary: Coir fibers were treated with an alkali to improve wettability by a commercial resin such as polyester. Tensile strength of the fibers increased by 15 percent on soaking in 5 percent aqueous NaOH at 27°C to 29°C for 72 to 76 h after which it showed a gradual decrease. Flexural strength, modulus, and impact strength of composites containing alkali-treated fibers were 40 percent higher than those containing the same volume fractions of untreated fibers.

443. Shirsalkar, M.N.; Jain, R.K.; George, J. 1964. Fire resistant building boards from coconut pith. Research and Industry. 9(12): 359-360.
(no abstract available)

444. Shirsalkar, M.N.; Jain, R.K.; George, J. 1966. Fire-resistant building boards from coconut pith. Oils Oilseeds Journal (Bombay). 18(7): 13-14.

Summary: Fire-resistant lightweight building boards suitable for insulation and as expansion joint filler were produced from unretted coconut pith by felting with wood fibers or banana stem fibers. The pith was mixed pulp and water giving a 3 to 4 percent slurry, the pH was adjusted to 4 to 5, a paraffin wax or rosin-paraffin wax emulsion was stirred in for 5 min as a sizing agent, and the size was precipitated by adding an alum solution.

445. Varma, D.S.; Badarinarayana, N. 1988. Modifications of coir by grafting for use in composites. Indian Journal Textile Research. 13(4): 179-183.

Summary: Coconut fibers modified by treatment with alkali or graft polymerization with Me methacrylate using ceric ammonium nitrate and HNO_3 as catalysts had an increase in density, denier, and initial modulus, and a decrease in tenacity and moisture regain compared to the untreated fibers. Hybrid composites composed of glass fiber mats, a 50:50 blend of unsaturated polyester resin and unsaturated urethane-acrylate-styrene resin, and alkali-treated or graft polymerized coconut fibers had better flexural strength, flexural modulus, and interlaminar shear strength than composites containing untreated coconut fibers.

446. Varma, D.S.; Varma, M.; Ananthakr, S.R.; Varma, I.K. 1988. Evaluation of coir and jute fibers as reinforced in organic matrix resins. Integral Fundamentals of Polymer Science Technology. 1987: 599-603.

Summary: Unsaturated-polyester resin blended with urethane-acrylate-styrene resin and their reinforced composites with jute/coir fibers were evaluated to develop resins having varying strain-to-failure characteristics. Composites having 66 percent resin and 22 percent coir fiber mat showed approximately a 240 percent improvement in flexural Strength compared to that of neat resin sheets.

(Also see references 1025 and 1026.)

Roofing Board

(See references 1014 and 1016.)

Unknown Board

447. Anonymous. 1975. Building panel from coir waste. Appropriate Technology Document Bulletin. 2(1): 3.
(no abstract available)

(Also see references 3 and 197.)

448. Jayaratna, S.M. 1960. A possible use for coir dust. Ceylon Coconut Quarterly. 11(3/4): 1-4.

Summary: A brief description is given of a process development in Ceylon at the Coconut Research Institute for the economical manufacture of molded articles for many domestic and constructional purposes from coir dust.

449. Menon, D.; Prabhu, B.T.S.; Pillai, S.U. 1989. Construction of low-cost vault-shaped dwelling units using coconut shell composites. Journal of the Institution of Engineers (India). Part AR Architectural Engineering Division: 69: 37-43.

Summary: This paper describes a complete building system designed for a typical dwelling unit area of 25 m^2, using coconut shell sandwich panels for the building envelope and coconut shell cellular blocks for the construction of cross walls.

450. Narayanamurti, D.; Singh, J. 1954. Moulding powders and boards from coconut shells. Composite Wood. 1(2): 38-40.
(no abstract available)

451. Singh, S.M. 1978. Coconut husk-a versatile building panels material. In: Proceedings of the international conference on materials of construction for developing countries; 1978 August; Bangkok, Thailand: 207-219.
(no abstract available)

452. Singh, S.M. 1978. Coconut husk-a versatile building panels material. Journal of the Indian Academy of Wood Science. 9(2): 80-87.
(no abstract available)

453. Yamamoto, S.; Azuma, T. 1977. Building material with high strength and improved waterproofness. Assignee: Matsushita Electric Works Ltd. Patent, P.N.: JP 52005836, I.D.: 770117. [Japanese].

Summary: A detailed outline of the process and procedure for the manufacture of building materials is given. Water absorption was 0.8 percent and bending strength 2.4 MPa, compared with 4.2 percent and 2.0 MPa for those boards made without coconut oil.

Cement/Clay/Gypsum/Plaster Materials

454. Das Gupta, N.C.; Paramasivam, P.; Lee, S.L. 1978. Mechanical properties of coir reinforced cement paste composites. Housing Science. 2: 391-406.
(no abstract available)

455. Filho, R.D.T.; Barbosa, N.P.; Ghavami, K. 1990. Application of sisal and coconut fibres in adobe blocks. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 139-149.

Summary: To prevent cracking of adobe blocks used in houses built in Northeast Brazil, coconut, sisal, and bamboo, fibers have been studied extensively as additives for strengthening these blocks. Primary results of research carried out at the Federal University of Paraiba on fiber-reinforced blocks is presented.

456. Fuentes, P. 1982. Material for use as glass fiber substitutes mixed with grit, plastic and plastic fibers. Patent, P.N.: BR 8005861, I.D.: 820518. [Portuguese].

Summary: Equal parts of coconut and/or palm tree fiber may be substituted for fiberglass as a reinforcing filler in construction materials.

457. Jain, R.K; George, J. 1970. Utilisation of coconut pith for thermal insulating concrete. Coir. 14(3): 25-31.
(no abstract available)

458. Marotta, P. 1973. Tests on panels of coconut fibre impregnated with Portland cement. Report 2. Victoria, Australia: Commonwealth Scientific and Industrial Research Organization (CSIRO), Division of Building Research. 18 p.
(no abstract available)

459. Ohtsuka, M.; Uchihara, S. 1973. High-strength inorganic hydraulic material-coconut fiber-polymer composite. Assignee: Ohtsuka Chemical Drugs Co. Ltd. Patent, P.N.: JP 51003354, I.D.: 760202. [Japanese].

Summary: A paste containing long or short coconut fibers, hydraulic material, and water was molded, hardened, and impregnated with monomer or oligomer, followed by polymerization of the monomer or oligomer. High-early-strength cement, coconut fiber, and water were mixed, molded, and hardened for 12 h, cured in water for 10 days, and dried at 60°C for 24 h. The molded product was impregnated with a solution containing methyl methacrylate, styrene, and benzoyl peroxide, heated with hot nitrogen at 60°C, and treated in a furnace at 105°C for 20 min. The composite contained 22 percent polymer and had a density of 1.18 g/cm^3 and a bending strength 23.0 MPa, compared to a density of 1.15 g/cm^3 and 14.2 MPa for that made with crushed rice hulls.

460. Paramasivam, P.; Nathan, G.K.; Das Gupta, N.C. 1984. Coconut fibre reinforced corrugated slabs. International Journal of Cement Composites and Lightweight Concrete. 6(1): 19-27.
(no abstract available)

461. Savastano, H. 1990. The use of coir fibres as reinforcements to Portland cement mortars. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 150-158.

Summary: The production of coir reinforced-cement mortar is presented in this paper. Mortars with three different water:cement ratios were tested with dry or saturated fibers and the consistency of the mixtures was determined. At the age of 28 and 90 days, the compressive, tensile, and impact strengths of the composites are described. The use of coir fibers as a cement mortar reinforcement increased the impact strength of the matrix up to 220 percent and the tensile strength up to 175 percent. Compressive strength was found to be reduced with coir fiber utilization.

462. Singh, S.M. 1975. Corrugated roofing sheet and building panel from coir wastes. Coir. 19(4): 3-6.
(no abstract available)

463. Tsuji, S.; Noda, Y. 1975. Cement adhesives. Assignee: Toyoda Spinning and Weaving Co. Ltd. Patent, P.N.: JP 80121335, I.D.: 740304. [Japanese].

Summary: This patent describes how adhesives containing cement and latex are prepared. Fibers (10 to 100 denier and 0.1 to 10 parts) are added to the major component cement (100 parts), to the minor component latex, or to the mixture of cement and latex. The adhesives may be applied to concrete walls for holding asbestos and gypsum boards.

(Also see references 197, 210, 212, 337, 338, 876, 912, and 925.)

Molded Masses

Plastics

464. Schueler, G.B.E. 1946. Uses of coconut products. Modem Plastics. 23(10): 118-119.

Summary: This paper describes how coconut shell flour is used as a filler for plastics. Data are presented in tables along with associated physical properties.

465. Pavithran, C.; Mukherjee, P.S.; Brahmakumar, M. 1991. Coir-glass intermingled fiber hybrid composites. Journal of Reinforced Plastic Composites. 10(1): 91-101.

Summary: This paper reports on how the enhancement in the properties of coir-polyester composites by incorporating glass as intimate mix with coir was investigated. The

addition of a relatively small volume fraction (0.05) of glass enhanced the tensile strength by approximately 100 percent, flexural strength by more than 50 percent, and impact strength by more than 100 percent. Coir-glass intermingled hybrid composites absorbed 4 to 5 times less moisture compared to coir-polyester composite upon immersing in boiling water for 2 h, thereby showing considerably better resistance to weathering.

466. Varma, D.S.; Varma, M.; Varma, I.K. 1986. Coir fibers. 3. Effect of resin treatment on properties of fibers and composites. Industrial Engineering Chemical Products Research and Development. 25(2): 282-289.

Summary: This paper describes the treatment of bristle-coir fibers with a diluted solution of unsaturated polyester in MEK. Treatment of bristle-coir fibers with diluted-resin solutions resulted in an increase in weight and denier of the fibers. These results, along with Fourier-transform IR studies, confirmed the deposition of polyester on the fibers. A significant reduction was observed in moisture regain for all the resin-treated fibers.

Refractory Materials

467. Murali, T.P.; Prasad, S.V.; Surappa, M.K.; Rohatgi, P.K.; Gopinath, K. 1982. Friction and wear behaviour of aluminum alloy coconut shell char particulate composites. Wear. 80(2): 149-158.

Summary: Friction and wear characteristics of A1-11.8 percent Si alloys containing 10 to 25 percent by volume (3 to 8 percent by weight) dispersions of coconut-shell char particles (average size, 125 MU m) were evaluated under dry conditions with a pin-on-disc machine. At the lower sliding speed of 0.56 m/s, the wear rates and friction coefficients of the composites decreased with increasing volume percent of dispersed char particles in the aluminum-alloy matrix.

468. Murali, T.P.; Surappa, M.K.; Rohatgi, P.K. 1982. Preparation and properties of Al-alloy coconut shell char particulate composites. Metallurgical Transactions B (Process Metallurgy). 13B(3): 485-494.

Summary: This paper describes the process of dispersing a relatively large volume percentage, up to 40 percent, of shell-char particles in A1-11.8 percent Si alloy melts. The mechanical, tribological, and electric properties of cast-aluminum alloy shell-char composites were measured and reported.

Resins/Binders

469. Heinemann, K.H.; Cherubim, M.; Michaiczyk, G. 1979. Hardener for phenol resin size. Assignee: Deutsche Texaco A.G. Patent, P.N.: DE 2821219, I.D.: 791122. [German].

Summary: A mixture of paraformaldehyde, coconut shell meal, and grits from phenolic or urea resin-blended board was used as hardener for phenol-formaldehyde copolymer adhesive in plywood. A mixture of 100 g of 45 percent phenol-formaldehyde copolymer solution and 15 g hardener consisting of 1:1 blend of meal and grit containing 4 percent coconut shell meal was applied to beech veneer, pressed for 10 min at 130°C and 20 bar to give five-ply plywood with 4.6 MPa AW20 tearing resistance, 50-50-50 puncture test.

470. Villaflor, A.A. 1978. Developing potential of tannin extracts from tree barks and coconut coir dusts as replacement of synthetic phenolics in wood adhesive for plywood and particleboard in the Philippines. Don Ramon Arevalo memorial professorial chair lecture; Los Banos, Philippines: Laguna College of Forestry, University of the Philippines. 24 p.
(no abstract available)

Rubbers

471. Arumugam, N.; Selvy, K.; Rao, K.; Rajalingam, P. 1989. Coconut-fiber-reinforced rubber composites. Journal of Applied Polymer Science. 37(9): 2645-2659.

Summary: Different formulations of rubber with chopped coconut fiber (treated and untreated) as reinforcing agent were prepared. The reinforced systems were vulcanized at 153°C and the properties of the vulcanizates were studied by stress-strain, shore A hardness, and abrasion loss measurements. The bonding between the rubber and fillers improved with the addition of bonding agents. The bonding effect of different bonding agents was compared and the reinforcing property of the treated fiber was compared with that of the untreated one. Aging resistance of the composites was studied. The fracture surfaces were studied by scanning electron microscopy, and the failure mechanism was explained.

472. Bodrei, M.; Roventa, I.; Petru, G.; Meinic, V. 1986. Elastic fiber-rubber composites. Assignee: Intreprinderea de Paruri, Sighetu Marmatiei. Patent, P.N.: RO 88888, I.D.: 860331. [Romanian].

Summary: This patent describes how elastic composites, used for cushions and mattresses, are comprised of 30 to 80 percent natural rubber, SBR, isoprene rubber, or nitrile rubber and 20 to 70 percent Luffa cylindrica fruit mesocarp fibers and optionally curled fibers containing pig hair (4 cm long $\leq$ 60 percent), cattle or goat hair, sisal fibers, manila fibers, polyamide monofilaments, or PVC monofilaments, coconut fibers, and palm fibers.

Miscellaneous

General Information/Reviews

473. Czvikovszky, T. 1985. Chemistry and technology of radiation processed composite materials. Radiation Physics and Chemistry. 25(4-6): 439-449.

Summary: This paper reports on how composite materials of synthetics (based on monomers, oligomers, and thermoplastics) and natural polymers (wood and other fibrous cellulosics), prepared by radiation processing, offer valuable structural materials with enhanced coupling forces between the components. The applied polymer chemistry of such composites shows several common features with that of radiation grafting.

474. George, J. 1970. Building materials from coconut husk and its byproducts. Coir. 14(2): 19-44.
(no abstract available)

475. George, J.; Joshi, H.C. 1962. Complete utilization of coconut husk. Indian Coconut Journal. 12(2): 46-51.
(no abstract available)

476. Ghavami, K.; Van Hombeeck, R. 1984. Application of coconut husk as low cost construction material. In: Ghavami, K.; Fang, H.Y., eds. Proceedings of the international conference on development of low-cost and energy saving construction material. 1984 July; Rio de Janeiro, Brazil: Envo Publishing Co.: 53-60.
(no abstract available)

477. Nayar, N.M. 1983. Coconut research and development. Proceedings of the international symposium on coconut research and development; 1976 December 27-31; Kerala, India. New Delhi, India: Wiley Eastern Limited. 518 p.

Summary: This proceedings reports on an international symposium on coconut development and research. The majority of the papers in the proceedings deals with products from coconut other than building materials. Building materials produced from coconut are briefly covered in one presentation.

478. Owolahi, O.; Czvikovszky, T. 1983. Radiation processing of composite materials on the basis of coconut hair and plastics. Proceedings, Tihany symposium radiation chemistry: 5(2): 799-804.

Summary: Acceptable mechanical properties were gained through the use of coconut fibers instead of glass fibers in unsaturated polyester-based composites. When coconut fibers were pretreated by y-radiation, the tensile and flexural strengths increased by at least 20 and 45 percent, respectively, compared to that of samples containing untreated fibers. Boiling fibers in 20 g/l NaOH increased tensile and flexural strengths of the reinforced polyesters by another 5 percent. Results were shown for 40 to 116 phr coconut fibers in diethylene glycol-ethylene glycol-maleic anhydride-phthalic anhydride-sebacic acid polymer.

479. Owolabi, O.; Czvikovszky, T. 1987. Composite materials of radiation-treated coconut fiber and PVC. Proceedings, Tihany symposium radiation chemistry: 6(2): 611-618.

Summary: Chopped coconut fibers were applied in composites with plasticized and hard PVC. Thermoplastic processing was not affected if the fiber content was not greater than 40 percent by weight and if suitable processing aids were used. Dynamical mechanical analysis (DMA) data, as well as tensile and impact strengths of coir composites (of up to 50 percent coir content) have not been found superior to that of the starting thermoplastics. Considering coconut fiber as an inexpensive filler, composites with acceptable tensile and impact strengths could be produced with coir content as high as 30 percent.

480. Owolabi, O.; Czvikovszky, T. 1988. Composite materials of radiation-treated coconut fiber and thermoplastics. Journal of Applied Polymer Science. 35(3): 573-582.

Summary: This paper describes how polypropylene and two different kinds of PVC were compounded with chopped coconut fiber (coir). Pre-irradiation of coir was applied together with some crosslinking additive to achieve chemical bond between thermoplastics and fibrous biopolymer. Dynamical mechanical analysis (DMA) data as well as tensile and impact strengths of coir composites (of up to 50 percent coir content) were not found to be superior to that of the starting thermoplastics. Considering coconut fiber as an inexpensive filler, composites with acceptable tensile and impact strengths could be produced with coir content as high as 30 percent.

Material Used in Natural State

481. Mosteiro, A.P. 1980. The properties, uses and maintenance of coconut palm timber as a building material. Forpride Digest. 9(3/4): 46-55, 67.
(no abstract available)

482. Palomar, R.N. 1979. Pressure impregnation of coconut sawn lumber for building construction materials study conducted at PCA, Zamboanga Research Center, Philippines. Philippine Journal of Coconut Studies. 4(4): 15-28.

Summary: This paper tells how the absorption of chromated copper arsenate (CCA) by coconut lumber depended on the moisture content and density of the lumber, and decreased with increasing moisture content and density. At moisture contents greater than 25 percent, the lumber of 0.34 to 0.37 g/cm^3 density could be treated satisfactorily under pressure. Tests on CCA penetration showed that soft coconut wood has deeper penetration than hardwood.

483. Palomar, R.N. 1980. Pressure impregnation of coconut lumber sawn for building construction lumber. Agricultural Research Branch, Philippine Coconut Authority: 80-94.

Summary: This paper reports how the satisfactory penetration of preservative was obtained by pressure-treating lumber 25 or 50 mm thick after drying for at least 30 and 45 days, respectively. A suitable preservative was 2 percent CCA.

(Also see references 197, 419, 420, and 925.)

Coffee Bean [Hull, Grounds]

Panel Board

Particleboard

484. Tropical Products Institute. 1963. Manufacture of particle board from coffee husks. Rep. 18/63. London, England: Tropical Products Institute (TPI). 4 p.

Summary: Particleboards 1.27 cm thick were prepared from coffee husks, from a mixture of coffee husks and cotton seeds, and from a mixture of coffee husks and groundnut shells. Urea-formaldehyde resin in varying amounts was used as a binder. The material was formed into a mat and pressed at 140°C for 10 min at pressures ranging from 206.8 kPa to 2.1 MPa. Increased resin content and increased density resulted in improved board strength and water resistance. Boards containing 15 percent resin and having a density of 1.1 g/cm^3 exceeded the British Standard minimum strength. Coffee husks mixed with other waste materials gave boards of lower strengths than coffee husks alone.

(Also see reference 487.)

Unknown Board

(See references 3, 197, and 517.)

Cement/Clay/Gypsum/Plaster Materials

(See reference 197.)

Molded Masses

Resins/Binders

485. Runton, L.A. 1972. Producing molded articles from coffee bean hulls. Assignee: Industrial de Cascarillas-Ciscana SA. Patent, P.N.: US 3686384, I.D.: 720822.

Summary: Waste coffee bean hulls were molded at 232.2°C to 260°C with reduced cellulose oxidation by adding waste rice hulls, colloidal silica, ground glass, or glass fiber waste. The material was found to be suitable for structural materials.

486. Runton, L.A. 1972. Resin-coated molded articles from coffee bean hulls. Assignee: Industrial de Cascarillas-Ciscana SA. Patent, P.N.: US 3687877, I.D.: 720829.

Summary: A mixture of ground-coffee bean hulls and rice hulls was coated with phenol-formaldehyde resin, cold molded into a preform, and molded at 143.3°C to 204.4°C and 1,524 to 10,160 kg/in^2 to give a product useful for furniture parts.

Corn/Maize [Cob, Husk, Stalk]

Panel Board

Particleboard

487. Chow, P. 1975. Dry formed composite board from selected agricultural fiber residues. Food and Agriculture Organization of the United Nations (FAO); world consultation on wood based panels; 1975 February; New Delhi, India. 8 p.

Summary: Dry-process medium density interior-type experimental boards were made from both pressurized Bauer treated and hammer-milled corncobs and cornstalks including husks and leaves, hammer-milled kenaf stalks, peanut hulls, spent instant coffee grounds, sunflower seed hulls, scotch pine needles, leaves from oaks, maple shavings, and commercial oak flakes made from a Pallmann flaker. The properties of boards made from pressurized Bauer treated corn crop residues were better than those made from hammer-milled corn crop residues and exceeded the requirements for commercial particleboard. Hardwood leaves were unsuitable for board production. Needle board and coffee ground board can be used as vertically installed interior paneling. In general, each type of residue material had its own physical and chemical characteristics.

488. Durso, D.F. 1949. Building panels from agricultural residues. West Lafayette, IN: Purdue University, School of Agriculture, Department of Biochemistry. Unpublished thesis.

Summary: This thesis describes how the methods for the production of building panels from corn plant residues were investigated. Corn cobs ground to 20 mesh and mixed with 20 percent resin were molded, at moderate pressure, into very hard, smooth materials, which were easily sanded and polished. Reduction in particle size from 20 to 40 mesh gave a 10 percent increase in tensile strength of the panels. Hardboard materials were fabricated with shredded cornstalks and 10 percent resin content. Shredding was performed by a Wiley hammermill operating without a screen. Insulation panels were fabricated with whole corn stalks using 20 percent resin and a press pressure of 344.7 kPa.

489. Hazen, T.E. 1950. Utilization of whole vegetable stalks bonded with adhesives for building boards and structural panels. West Lafayette, IN: Purdue University, School of Agriculture, Department of Agricultural Engineering. Unpublished thesis.

Summary: Shredded corn stalks were bonded to form boards with as low as 10 percent resin content at press pressures of 2.4 MPa; the resulting boards were hard and dense and could be sawn and sanded. Corn cobs ground to 20 mesh were mixed with 20 percent resin and molded at moderate press pressures. With an increase in resin content, improvement was noticed but not proportionately. Additionally, ragweed stalks were utilized to fabricate panel board.

490. Janos, S.; Kalman, S.; Zoltan, S. 1986. Panels pressed from mixture of threshed maize cobs and especially carbamide-formaldehyde resin, cobs being longitudinally split. Assignee: (DEBR-) Debreceni Agrartudo. Patent, P.N.: IT 1150928, I.D.: 861217. [Italian].

Summary: Panels, boards, and the like are made from vegetable materials and setting binding agents. The vegetable materials are comprised of threshed maize cobs split longitudinally into several parts (two to four pieces) and mixed with binding agent. The mixture is shaped by pressing and allowed to harden. The method is based upon the knowledge that a maize cob, if compressed along its axis, readily splits into a number of long components without the outer rough coating breaking away.

491. Lewis, R.L.; Dale, A.C.; Whistler, R.L. 1960. Building panels from cornstalks. Res. Bull. 690. West Lafayette, IN: Purdue Agricultural Experiment Station, Purdue University. 16 p.

Summary: A building material was developed from cornstalks as a result of a project concerned with the utilization of farm residues, and how the feasibility of using plant stems and stalks in a structural building panel was investigated. This study included extensive data tables, illustrations, and methods of production information.

492. Odozi, T.O.; Akaranta, O.; Ejike, P.N. 1986. Particle boards from agricultural wastes. Agricultural Wastes. 16(3): 237-240.

Summary: This paper reports on studies to develop composite panels based on agricultural wastes and by-products. An attempt is also being made to reduce the cost influence of adhesives by modifying them with naturally occurring tannins from mangrove and red-onion skin extract. The combination of bagasse, mangrove bark, wood shavings, and corncob treated with 25 percent tannin-urea-formaldehyde resin gave boards with the highest dry and wet strengths, as well as the lowest water absorption after 5 h of soaking (4.4 percent). The strength values may be due to high content of tannin capable of being polymerized as well as the high resin dosage employed.

493. Sampathrajan, A.; Vijayaraghavan, N.C.; Swaminathan, K.R. 1991. Acoustic aspects of farm residue-based particle boards. Bioresource Technology. 35(1): 67-71.

Summary: Acoustic aspects of particleboards made from five typical farm residues were evaluated. The sound absorption coefficient, attenuation factor, damping factor, and dynamic modulus were determined for each board. The noise reduction coefficient of the boards varied from 0.39 to 0.54 which compared well with commercial boards. The paddy-straw (rice) board exhibited maximum noise reduction and the groundnut shell board exhibited the minimum. The attenuation was found to be maximum in maize-based boards (2,100 to 7,600 db/m) and least with coconut pith board (100 to 1,500 db/m). Data on dynamic modulus and loss modulus indicated lower values for paddy-straw and higher values for maize-based boards. Based on the results, groundnut shell and coir pith boards are suggested for sound-proof insulation applications.

494. Sampathrajan, A.; Vijayaraghavan, N.C.; Swaminathan, K.R. 1992. Mechanical and thermal properties of particle boards made from farm residues. Bioresource Technology. 40(3): 249-251.

Summary: Five farm residues were used for the manufacture of low-density particleboards in a hot-platen press using urea formaldehyde as the binding material, and mechanical and thermal properties of the boards were evaluated. The maize-cob board was superior to other boards in mechanical and screw/nail holding strength, suggesting its use for interior applications, while paddy-straw (rice) board and coconut pith board were found suitable for insulation purposes.

495. Xiao, Y.; Zhang, S.; Wang, D.; Jia, Y.; Jiang, S. 1987. Method for producing corn-stalk boards. Assignee: Siping Cement Plant. Patent, P.N.: CN 103594, I.D.: 871125. [Chinese].

Summary: Roughly 78 to 82 percent cornstalk and 18 to 22 percent binders were mixed, placed, and heated at 120°C to 140°C and 1.47 to 2.45 MPa for 40 to 50 s to prepare boards for building materials and furniture. The binders contained 96 to 98 percent urea-formaldehyde resin, 0.21 percent ammonium chloride, and 1.5 to 3 percent paraffins. The stalks had a fiber length less than 25 mm and contained more than 85 percent fibers having length 5 to 25 mm and 5 to 7 percent water.

(Also see references 53, 70, 661, and 678.)

Fiberboard/Hardboard

496. Demirel, T. 1967. Acid-treated corncob construction material. Patent, P.N.: US 3301800, I.D.: 670131.

Summary: This patent describes a process of making wallboard or construction board by contacting a batch of corncobs with a phosphoric acid solution of 20 to 30 percent concentration at 80°C to 110°C, withdrawing the phosphoric solution from the digested corncob product, reducing the particle size of the corncob product to a fine texture, mixing the fine-textured product with a resin forming liquid, shaping the mixture, and curing it at an elevated temperature. The resin-forming liquid includes furfural alcohol, spent sulfite liquor, and phosphoric acid.

497. Tamura, Y.; Tanaka, R.; Goma, T. 1992. Laminated materials prepared from annual plant straws, stalks and wastes. Assignee: Koyo Sangyo KK. Patent, P.N.: JP 04047902, I.D.: 920218. [Japanese].

Summary: Laminated materials prepared from annual plant straws, stalks, and wastes are used for walling, display, and insulation. The boards are prepared from sheets containing, as the structural part, straight, dimensionally cut, optionally depithed and flattened, and aligned stalks of corn, kaoliang, bagasse, wheat, and rice stalks, and binder from wastes obtained from chopping process, such as leaves, sheath, knots, and pitches after solubilizing them with phenol, and allowing to react with formaldehyde in the presence of acid or base catalyst. The use of additional adhesive resins is also claimed.

498. Tsolov. V. 1985. Boards from beech fibres and agricultural wastes. Gorsko Stopanstvo Gorska Promishlenost. 41(6): 15-17. [Bulgarian].

Summary: Fiberboards were manufactured using beech fibers mixed with fibers from hemp, vine, tobacco, cotton, raspberry, maize, and sunflower stalks. The agricultural wastes comprised 10, 20, 30, 40, or 50 percent of the fiber mixture. The press schedule was 6.0, 1.2, and 3.5 MPa for 75, 480, and 600 s, respectively, at a temperature of 185°C to 190°C. The physical and mechanical properties of the boards were represented graphically. All of the wastes were suitable for board manufacture but best results were obtained for hemp and tobacco. Board density and strength decreased with increasing proportion of agricultural wastes in the fiber mixture. Boards of Bulgarian Class I can be produced with up to 18 percent of agricultural wastes in the mixture.

499. Wingfield, B.; Naffziger, T.R.; Whittemore, E.R.; Overman, C.B.; Sweeny, O.R.; Acree, S.F. 1936. Production of pressboard from cornstalks. Misc. Pub. M123. United States National Bureau of Standards. 10 p.

Summary: This study focused on optimal conditions for producing pressboard from cornstalks. Cooking the stalks under pressure before fiberizing yielded stronger pulps than an exclusively mechanical treatment did. Proper pressure conditions were 150°C and 3.4 MPa. The best sizing results were obtained by impregnation of the finished board; however, sizing in the beater is more economical.

(Also see references 137, 488, 491, 678, and 862.)

Insulation Board

500. Arnold, L.K. 1930. Making insulation board from cornstalks. Cellulose. 1: 272-275.

Summary: A process for the manufacture of insulation board from cornstalks is described. Stalks are digested for 2 h under 689.5 kPa pressure, after having been broken up with a cutter and a swing-hammermill. Rosin size is added to the washed stock before refining, then the board is formed on a special machine. The stalks can also be disintegrated, without previous cooking, in a Bauer refiner.

501. Arnold, L.K. 1938. Acoustical board from cornstalk pulp. Paper Industry. 20(5): 47-50.

Summary: This paper indicates that it is possible to make excellent acoustical boards from cornstalks. The absorption coefficient may be varied over a wide range, and depends on pulp composition, number of grooves, and number of holes. Results of tests are given.

502. Arnold, L.K. 1938. Low-temperature drying of cornstalk insulating board. Paper Industry. 20(1): 48-5 1.

Summary: At room temperature and low humidity, drying of insulating board made from cornstalk required about 4 days whereas about 2 weeks were necessary at summer temperatures and humidities. Very little drying occurred at temperatures below the freezing point.

503. Arnold, L.K.; Gleaves, D.L. 1935. The adsorption of zinc chloride by cornstalk insulating board pulp. Paper Trade Journal. 98(24): 31-33.

Summary: Decay of cornstalk insulating board can be retarded by adding zinc chloride to the refined mixture before forming into a wet mat. Part of the preservative is firmly adsorbed by the pulp. An analytical method was developed to study the adsorption of zinc chloride by the board pulp.

504. Arnold, L.K.; Plagge, H.J.; Anderson, D.E. 1937. Cornstalk acoustical board. Bull. 137. Ames, IA: Iowa Engineering Experiment Station. 47 p.

Summary: Sound absorption properties of various acoustical boards made from cornstalks and the effect of pulp composition and surface treatment were studied. Results showed that cornstalks can be utilized as a raw material for acoustical boards.

505. Emley, W.E. 1929. Insulating board from cornstalks. Paper Trade Journal. 88(25): 61-62.

Summary: This paper gives an outline of cooperative work between Iowa State College (Ames, Iowa) and the Bureau of Standards (from 1927 to 1929) on the semicommercial experimental work on insulation boards constructed from cornstalks.

506. Fattah, A.; Rahman, S.M.F. 1966. Studies on the thermal and electrical insulation properties of boards made from waste materials indigenous (to Pakistan). Science and Industry (Pakistan). 4(1): 31-40.

Summary: Studies of the thermal and electrical properties of boards made from waste material (corn husk, jute sticks and cutting waste, and sawdust) indigenous to Pakistan were reported. The waste materials were mixed in various

combinations and proportions with a phenol-formaldehyde binder and pressed at 180°C and a pressure of 5.5 MPa for 15 to 20 min. Most boards obtained showed thermal and electrical insulation properties comparable to those of commercially produced boards.

507. Hartford, C.E. 1930. Making boards from cornstalks at Dubuque (Iowa). Paper Trade Journal. 91(18): 80-82.

Summary: The manufacturing process used at the Dubuque mill for converting cornstalks into insulation board is described. Shredded stalks are cooked under pressure for 2 h, yielding a pulp which is then sized, formed into a mat, pressed, and dried.

508. Hartford, C.E. 1930. The production of insulating board from cornstalks. Industrial and Engineering Chemistry. 22(12): 1280-1284.

Summary: The manufacture of "Maizewood" insulation board from cornstalks and the properties of the product is described in detail. A considerable bibliography of various proposed processes for the utilization of corn waste is included.

509. Lathrop, E.C. 1948. Industrial utilization of corn crop residues. Chemurgic Digest. 7(6): 20-26.

Summary: This article covers the history of cornstalk use in the production of insulation board. Due to high collection cost and the fact that leaves are of no value, manufacture of the insulation boards has been abandoned.

510. Naffziger, T.R. 1934. I. Some factors affecting the production of insulation board. II. The development of the commercial production of refrigeration board and press-board. Ames, IA: Iowa State College Journal of Science: 9(1): 183-185.

Summary: The properties of commercial boards were tested, and experiments were made with different fireproofing, moldproofing, and sizing agents. The grade of refrigeration board obtained from the pith of cornstalks was better than that obtained from the whole stalk.

511. Plagge, H.J.; Arnold, L.K.; Whittemore, E.R. 1933. The surface treatment of acoustic tile. Paper Trade Journal. 96(6): 27-29.

Summary: The effect of several types and degrees of surface treatment on sound absorption coefficient of cornstalk fiberboard was examined. Acoustic tile had a specific absorption coefficient characteristic of the fiber mass. It can be designed by a proper balance of bevel, number, width, and depth of grooves to have any specific absorption coefficient over a wide range.

512. Porter, R.W. 1950. Modernization at Maizewood's insulating board mill. The Paper Industry. 32(3): 270-274.

Summary: Maizewood's board mill at Dubuque, Iowa, has been modernized. Since 1929, the mill has made insulative board from cornstalks. Now it uses any type of fibrous material, including straw, flax shives, hemp, wood, and waste paper. The process and equipment were described.

513. Rao, Ramachandra, K. 1965. Utilization of corn-cobs for manufacture of plywood. Indian Forester. 91(6): 405.

Summary: Insulating-type building boards, made from corncobs by cutting the cobs in transverse sections of required thickness and forming into slabs covered on both sides with a veneer, are lighter and cheaper than ordinary plywood.

514. Sweeny, O.R.; Arnold, L.K. 1937. Studies on the manufacture of insulating board. Bull. 136. Ames, IA: Iowa Engineering Experiment Station. 75 p.

Summary: Strong insulating board was produced from cornstalk pulp cooked in water at atmospheric pressure for 3 h. Adding repulped newsprint (up to about 20 percent) improved the strength of the board. The optimal forming consistency and sizing conditions were determined. High-density boards were made by cold pressing followed by drying, or drying under pressure. Surface coatings increased the strength and reduced the air permeability of the board. Drying tests were conducted varying the temperature, humidity, pulp composition, and type of drying equipment.

515. Sweeny, O.R.; Arnold, L.K. 1948. Moisture relations in the manufacture and use of cornstalk insulating board. Bull. 163. Ames, IA: Iowa Engineering Experiment Station. 35 p.

Summary: The moisture effects in drying and application of cornstalk and other insulating boards were studied. It was found that boards having high initial moisture content absorbed less water upon immersion than dry boards, although the final moisture content total was greater in the former.

516. Sweeny, O.R.; Emley, W.E. 1930. Manufacture of insulating board from cornstalks. Misc. Pub. 112. United States National Bureau of Standards. 27 p.

Summary: Shredded stalks, in some cases after digesting with water either with or without the addition of chemicals, were pulped by means of a Hollander beater, and a swing-hammermill or a rod mill. After refining and washing, the pulp was fed on to a modified Oliver filter and the mat pressed in three sets of heavy rolls. The resulting board properties are similar to those of commercial boards, but the boards will not withstand frequent or continuous immersion in water.

(Also see references 159, 493, 494, 681, and 1064.)

Unknown Board

517. Chow, P. 1976. The use of crop (corn, peanut, sunflower, coffee) residues for board-making. Environmental Conservation. 3(1): 59-62.

Summary: Experimental boards were made from corncobs, cornstalks, peanut hulls, sunflower seed hulls, and spent coffee grounds. Most of the residues alone, and mixtures of either a wood waste and a crop residue or two different crop residues, produced composite boards that had properties comparable with or better than those of boards made from conventional wood materials. Boards made from only sunflower-seed hulls or spent coffee grounds had weak bending properties; therefore, vertical use of these boards was recommended.

518. Colov, V.; Genov, I.; Todorov, T.; Karagozov, T. 1979. Boards made from maize stalks. Drevo. 34(5): 134-135. [Slovakian; Russian and English summaries]. (no abstract available)

519. Hinde, J.J. 1930. Wall board. Patent, P.N.: US 1755781, I.D.: 300422.

Summary: The hard-fibrous material of the external casing of pithy plants, such as cornstalks, is alternately layered with layers of the internal pithy structure of the plant to yield wall board.

520. Kirkpatrick, S.D. 1928. Cornstalks as chemical raw materials. Chemical and Metallurgical Engineering. 35: 401-403.

Summary: This paper describes experiments of production of wallboard and pulp from cornstalks.

521. Lewis, R.L. 1955. Structural properties of cornstalk building panels. West Lafayette, IN: Purdue University, School of Agriculture, Department of Agricultural Engineering. Unpublished thesis.

Summary: Standard test methods were applied to the testing of corn stalk (cutin free) panel boards. Thirteen groups of boards were produced with variables being veneer, stalk arrangement, stalk variety, and adhesive. All panels were 121.92 by 243.84 by 6.35 cm. Press pressure was 103.4 kPa or less at temperatures of 90°C to 130°C at surface center of the board. Beams of 81.28 cm and columns of 12.70, 27.94, 31.75, 63.50, 127.00, and 160.02 cm were tested for modulus of elasticity, modulus of rupture, and ultimate stress as dependent variables. It was found that structural properties were a function of the core density and moisture content of the specimens. Veneers (of plywood and aluminum) did not increase the load carrying capacity of the specimens relative to nonveneered counterparts. Modulus of elasticity increased with the addition of veneer. The effect of stalk arrangement was significant; the strength being in proportion to the amount of material running parallel to the applied load.

522. Midwest Research Institute. 1961. Industrial utilization opportunities for corn products. Midwest Research Institute Project 2398-Ec. Final report. Nebraska Agricultural Products Research Fund Committee: 54-56.

Summary: The volume of corn grown in Nebraska and potential uses for corn and its residues are discussed in detail. Included in the study is a brief overview of the use of corn residues for wallboard and paper.

523. Samek, J. 1960. Review of the most important properties of new wood products. Drevo. 15(5): 143-145. [Slovakian].

Summary: The mechanical and physical properties of wood products introduced on the Czechoslovakian market are tabulated in this paper. In some of the products, agricultural residues (corn cob, straw) are used. Likus is a board made of a mixture of wood waste and agricultural residues; solomit is a reinforced board made from rape straw.

524. Sweeny, O.R. 1931. Production of synthetic lumber from cornstalks. Patent, P.N.: US 1803737, I.D.: 310505.

Summary: Unshredded cornstalks are cooked in water of pH 7 under 206.8 kPa of pressure for 3 h, allowed to remain in the water for a further 4 to 24 h, macerated in a rod mill to produce fibers several centimeters in length, and washed on a sieve. The pulp is then formed into boards by pressure using typical methods.

525. Winslow, R.L. 1951. Structural panels from corn stalks. West Lafayette, IN: Purdue University, School of Agriculture, Department of Biochemistry. Unpublished thesis.

Summary: The optimization of bonding was studied in the production of panels made from corn stalks. It was found that to utilize whole stalks for panel production, the microscopic waxy surface layer had to be removed to improve bonding effectiveness. To remove the waxy layer, the stalks were either sandblasted or carbonized by burning quickly in a very hot flame. Sandblasting and carbonizing stalks yielded panels which failed in bending before bond failure occurred when panels were loaded to ultimate load.

(Also see references 3, 190, and 491.)

Cement/Clay/Gypsum/ Plaster Materials

(See references 622 and 674.)

Molded Masses

Resins/Binders

526. Bornstein, L.F. 1971. Soft plywood. Patent, P.N.: US 3586576, I.D.: unknown.

Summary: This patent explains how corncobs and wheat flour are used in the production of a new type of plywood.

527. Demko, P.R.; Washabaugh, F.J.; Williams, R.H. 1977. Corrugating adhesive compositions containing thermoplastic polymer, thermosetting resin, and starch. Assignee: National Starch and Chemical Corp. Patent, P.N.: US 4018959, I.D.: 770419.

Summary: Water-resistant adhesives for corrugated boards are prepared from a mixture of vinyl acetate resin, a urea-formaldehyde copolymer resin, a starch (a waxy maize), water, and a metal salt catalyst.

528. Emerson, R.W. 1956. Molding compositions from lignocellulose condensates. Patent, P.N.: US 2765569, I.D.: unknown.

Summary: The reaction of cornstalks and flour with furfural and urea for the production of molding compositions is explained.

529. Kikuchi, K.; Miyake, K.; Suzuke, O. 1975. Adhesives for corrugated boards. Assignee: Honen Oil Co. Ltd. Patent, P.N.: JP 50034576, I.D.: 751110. [Japanese].

Summary: Manufacture of stable adhesives for corrugated boards involved pasting of starch with 0.1 to 1 percent NaOH and 20 to 35 percent water or of corn or wheat flour with 0.1 to 1 percent NaOH, ≤ 1 percent $NaHSO_3$, and 20 to 35 percent water. After preparation, the adhesive had a viscosity of 342 cP, changing only to 314 cP after pumping, and adhesive strength (corrugated board) of 3.0 MPa.

530. Rudy, N.J. 1985. Integrally bonded compositions of cellulosics and byproducts thereof directly from wet sawdust and the like. Patent, P.N.: US 4496718, I.D.: 850129.

Summary: Integrally bonded board was manufactured by hot-compressing wet sawdust containing an oxidizing reagent, such as NaClO, Cl, Br, or cyranuric acid, and optionally a carbohydrate, such as corn starch, wheat flour, sucrose, or soy protein.

Miscellaneous
General Information/Reviews

531. Anonymous. 1943. Industrial uses of corncobs. Chemurgic Digest. 2(7): 49, 52-53.

Summary: This paper reviews the possibilities of industrial utilization of corncobs.

532. Aronovsky, S.I. 1951. Using residues to conserve resources. 1950-1951 Yearbook of agriculture. Washington, DC: United States Department of Agriculture. Yearbook Separate 2283.
(no abstract available)

533. Lathrop, E.C. 1947. Corncobs enter industry. 1943-1947 Yearbook of agriculture. Washington, DC: United States Department of Agriculture. Yearbook Separate 1974.
(no abstract available)

534. USDA Northern Regional Research Laboratory. 1953. Corncobs–Their composition, availability, agricultural and industrial uses. AICC-177. USDA, Northern Regional Research Laboratory.
(no abstract available)

535. U.S. Senate. 1957. Report to the Congress from the Commission on increased industrial use of agricultural products. Doc. 45. United States Senate, 85th Congress.
(no abstract available)

Cotton [Seed Hull/Husk, Stalk]

Panel Board
Particleboard

536. Gurjar, R.M. 1993. Effect of different binders on properties of particle board from cotton seed hulls with emphasis on water repellency. Bioresource Technology. 43(2): 177-178.

Summary: Boards were prepared from cotton seed hulls with urea- and phenol-formaldehyde resin binders in different amounts. The optimum binder and percent usage was found to be 5 percent phenol formaldehyde.

537. Mahdavi, E. 1970. Economic and technical aspects of harvesting cotton stalks for the production of particle board. United Nations Industrial Development Organization Doc. (UNIDO) ID/WG.83/11. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 7 p.

Summary: Cotton stalks are used for the production of particleboard at a plant near Gorgan, Iran. A brief description is given of the harvesting method used to collect and store cotton stalk, and of the manufacturing process of particleboard at the plant. Since boards made from cotton stalks show a dark brown color and moderate strength, at least 50 percent of the stalks are substituted for poplar chips to improve appearance and physical properties.

538. Maurer, Z.O.; Babakhanov, G.A.; Shipilevskaya, S.B.; Tulyaganov, B.K. 1987. Modification of urea-formaldehyde resin by halo-containing compounds and its effect on properties of particleboard manufactured from cotton stems. Povysh. Kachestva Kompozits. Polimer. Mater. s Primeneniem Otkhodov Pr-va za Schet Fiz. i Khim. ikh Aktivatsii: Tashkent: 4-8. [Russian].
(no abstract available)

539. Pandey, S.N.; Mehta, S.A.K. 1980. Particle boards from cotton stalks. Research and Industry. 25(6): 67-70.

Summary: This paper discusses a process that uses cotton plant stalk and other agricultural wastes in various

particleboards. Also, the characteristics and uses of the particleboards are discussed. The relevance of the process to the rural economy is also covered.

540. Pandey, S.N.; Mehta, S.A.K.; Tamhankar, S.H.V. 1979. Particle boards from cotton plant stalks. Assignee: Indian Council of Agricultural Research. Patent, P.N.: IN 145886, I.D.: 790113.

Summary: Particleboards are obtained by treating cotton-stalk particles with aqueous solutions of ammonium chloride and urea-formaldehyde condensate and then hot-pressing mats of such particles. Stalk particles are sprayed with 5 percent ammonium chloride and urea-formaldehyde solution to provide 8 percent urea-formaldehyde resin content, dried at 60°C to 27 percent moisture content, cold pressed to form a mat, and pressed for 4 min at 150°C and 2.0 to 2.5 MPa to give a particleboard with 0.71 g/cm^3 density, 8.1 percent moisture content, 2.9 MPa tensile strength, 6.6 MPa modulus of rupture, and 38 percent water absorption upon 2 h of soaking.

(Also see references 53, 83, 484, 1075, and 1077.)

Fiberboard/Hardboard

541. Fadl, N.A.; Heikal, S.O.; El-Shinnawy, N.A.; Moussa, M.A. 1980. Hardboard from cooked rice blended with cotton stalks. Indian Pulp and Paper. 35(1): 19-22.

Summary: Rice straw and cotton stalks were separately pulped by the Asplund steam process or by the soda process (3 percent NaOH), and the pulps blended in various proportions The bending strength of the blended boards cooked with soda was better than that of rice boards. Water resistance was improved for blended Asplund pulp boards.

542. Fadl, N.A.; Sefain, M.Z.; Rakha, M. 1978. Hardening of cotton stalks hardboard. Indian Pulp and Paper. 33(2): 3-4.
(no abstract available)

543. Ishanov, M.M.; Tushpulatov, Y.T.; Biryukov, M.V. [and others]. 1988. Method of producing fiberboards from Guza-Pai cotton stalks. Assignee: VNIIdrev. Patent, P.N.: SU 1442588, I.D.: 881207. [Russian].

Summary: This patent explains a method that includes chip formation, soaking at an elevated temperature, refining, mat formation, and drying. Improved bending strength is achieved if, prior to soaking, the chips are subjected to impulse pressing in a hot press to form briquettes with a density of 0.50 to 0.13 g/cm^3. The moisture content and dimensions of the chips are 7 to 25 percent and 25 to 35 mm, respectively.

544. Mobarak, F.; Nada, A.A.M.A. 1975. Fibreboard from exotic raw materials. 2. Hardboard from undebarked cotton stalks. Journal of Applied Chemistry and Biotechnology. 25(9): 659-662.

Summary: Hardboard with acceptable properties was obtained by mechanical pulping of undebarked-cotton stalks soaked previously in water at room temperature. Pretreating the undebarked-cotton stalks with 10 to 15 percent NaOH or Ca(OH)^2 at atmospheric pressure for 4 h at 100°C, before mechanical defibration, resulted in considerable improvement in properties of the hardboard and less added resin requirement. The improvement due to chemical pretreatment is attributed to fiber softening. The semichemical pulps prepared from undebarked cotton stalks had remarkably high freeness compared with rice straw. Bending strength and water resistance were better than those obtained from rice straw and average samples of wood wastes.

545. Schroeder, F. 1982. Cotton stalk processing for fibreboard production by separating stalks into root and tops, with separate crushing of bast and wood and combining with tops. Assignee: (BAHR) Bigon-W Bahre Grete. Patent, P.N.: SU 952091, I.D.: 820815. [Russian].

Summary: This patent describes the process for uprooting cotton stalks and passing them through a vibration zone to separate into root, woody portion, and upper stalk portion. To upgrade feedstock for particleboard production, the roots and woody portion is divided again into bast and wood portions. The bast is combined with the uncrushed stalk tops, equal to one-third of the stalk length. Wood and bast fractions are crushed and dried separately, mixing to a residual moisture content of 6 percent. Then the bast and wood fractions are shaped individually to form rectangular parallel-piped bales, which are stacked close together so that the longitudinal axes between adjoining layers are at 90° to each other. This provides a balanced feedstock for a factory that produces particleboard.

546. Spencer, A.M.; Jacobson, A.; Sixt, K. 1954. Method of fiber liberation in cotton stalks and the pulp. Patent, P.N.: 2668110, I.D.: 540202.

Summary: Chopped cotton stalks are cooked with a wetting agent and dilute alkali at 121.1°C to 176.7°C for 5 to 15 min using a special type of digestor, and then disintegrated by nonabrasive beating. An asphaltic emulsion may be added to the suspension. The stock is then formed into products such as wallboard, roofing paper, and insulation.

547. Zur Burg, F.W. 1943. Cotton stalks for synthetic lumber. Paper Industry. 25(6): 12-15.

Summary: The feasibility of using cotton stalks as a raw material for building boards was studied. Pulping trials were made by cooking the chips in caustic soda under varying conditions or by beating them in a rod mill in the presence of water. The resulting pulp was formed into mats, pressed, and dried. The modulus of rupture of the boards ranged from 551.6 kPa to 3.4 MPa.

(Also see references 498, 845, and 858.)

Insulation Board

548. Anonymous. 1983. Flame-retardant, sound-proof boards manufacture involves blending cotton waste, reclaimed wool or synthetic fibre with glass fibre and spraying with binder resin composition. Assignee: (NIUT) Nippon Tkoushu Toryo. Document type: Patent, P.N.: JP 58118244, I.D.: 830714. [Japanese].

Summary: Cotton waste, reclaimed wool, and synthetic resin fiber (10 to 90 percent by weight) is blended with glass fiber (10 to 90 percent by weight) of average particle size up to 2 microns and the mixture is treated through an opener to provide a discontinuous fibrous material. The binder is comprised of phenol resin, thermosetting acrylic monomer copolymer, or polyethylene resin, and is used in amounts of 5 to 40 percent by weight of the production. The process provides molded soundproof products having high soundproof, heat resistance, and flame-retarding activity.

549. Luthhardt, M. 1971. Processing of cotton wastes into insulating sheets. Holztechnologie. 12(3): 131-136.
(no abstract available)

550. Seberini, M. 1969. Insulating boards. Patent, P.N.: CS 131432, I.D.: 690315. [Slovakian].

Summary: Lightweight insulation boards are made of waste sludges from pulp and paper manufacture and waste fibrous materials, such as cotton carding waste or sawdust, as fillers. The addition of 0.01 to 0.30 percent by weight rosin improves the strength of the products, and the addition of 0.05 to 0.75 percent, based on dry solids, of paraffin emulsion, improves the water resistance. Fungicide and a foaming agent for aeration of the mixture can be added during mixing prior to formation in a mold or an endless belt. Heavier constructional boards with good thermal-insulation properties are obtained by adding cement to the materials.

551. Spencer, A.M.; Jacobson, A. 1957. Fibrous board and sheet for insulation and other purposes of matted long cotton stalk fiber. Patent, P.N.: US 2794738, I.D.: 570604.

Summary: Board and paper were made from cotton-stalk fiber by chopping the stalks into short lengths, cooking them in 0.1 to 0.5 percent NaOH solution for 0.5 to 1.5 h at 137.9 kPa and 80°C to 100°C, gently beating the cooked fibers, and finally passing them to the boardmaking machinery.

(Also see references 546 and 1077.)

Cement/Gypsum/Plaster Board

(See references 175 and 1110.)

Plastic/Plastic-Bonded Board

552. Rosenthal, F. 1945. Radio-frequency heat for farm waste plastics. Pacific Plastics. 3(11): 38.

Summary: Laboratory experiments showed the advantage of using radio-frequency heating for plastic materials, especially wallboards, from farm wastes. The material tested had a composition of 83 percent cottonseed hulls and 17 percent phenolic resin. No cleavage of the molded product was observed.

Unknown Board

553. Forest Research Institute. 1976. Utilization of cotton stem and cotton waste for board and paper. Dehra Dun, Uttar Pradesh, India: Forest Research Institute. 16 p.
(no abstract available)

554. Malakhova, N.I.; Frank, A.Y. 1966. Cotton stalks as raw material for production of corrugated board. Sb. Tr. Ukraine Nauchno-Issled. Inst. Tsellyul-Bum. Prom-sti. 7: 60-71. [Russian].
(no abstract available)

555. Pandey, S.N.; Mehta, S.A.K. 1979. Industrial utilization of agricultural waste products: cotton plant stalk. Research and Industry. 24(2): 75-79.

Summary: This paper reviews the use of cotton stalks in the production of building boards, fillers, pulp, sugars, and chemicals; it contains 27 references.

(Also see references 3, 190, 197, 610, and 665.)

Cement/Clay/Gypsum/ Plaster Materials

556. Fujimasu, J.; Noda, K. 1990. Mortar compositions for fire-resistant building materials. Patent, P.N.: JP 02180741, I.D.: 900713. [Japanese].

Summary: A mortar comprised of cement mix, treated cotton waste, and inorganic aggregate (excluding asbestos) is produced. The cement mix contains 70 to 87 parts Portland cement, 1 to 5 parts alkali and/or alkali earth metal salt of lignosulfonic acid, 1 to 5 parts alkali and/or alkali earth metal bicarbonate, 1 to 5 parts alkali and/or alkali earth metal salt of stearic acid, and 10 to 25 parts $Ca(OH)_2$ (all parts by weight). The treated waste cotton is obtained by impregnating waste cotton with a solution containing a solution prepared by adding 20 to 50 percent by weight $(NH_4)3PO_4$ to 50 to 80 percent by weight water and allowing to stand for $\geq$ 12 h.

557. Taniguchi, I. 1978. Carbon dioxide hardened lime product. Assignee: Ibigawa Electric Industry Co. Ltd. P.N.: JP 53082836, I.D.: 780721. [Japanese].

Summary: A mixture containing lime, fibers, aggregate, and water is hardened with CO, by controlling reactor temperature from 70°C to 150°C to 40°C to 60°C to contain 10 to 30 percent moisture in 50 to 80 percent lime compact. The temperature is increased to 80°C to 100°C to contain

51 percent moisture in the compact. The beginning slurry contains $Ca(OH)_2$, perlite, asbestos, scrap cotton, and water.

(Also see references 197 and 912.)

Miscellaneous

Material Preparation Pulping/Storage Methods

(See reference 548.)

General Information/Reviews

558. Anonymous. 1975. Cotton stalks, a new building material. Algodon Mexico. 83: 56-57. [Spanish].
(no abstract available)

559. Guha, S.R.D.; Singh, M.M.; Sharma, Y.K.; Kumar, K.; Bhola, P.O. 1979. Utilization of cotton stem and cotton waste. Indian Forester. 105(1): 57-67.
(no abstract available)

Flax, Linseed [Shives, Straw]

Panel Board

Particleboard

560. Deppe, H.J.; Stashevski, A.M. 1974. Manufacture and testing of protected phenol-resin bonded flax particle boards. Holz als Roh- und Werkstoff. 32: 411-413. [German].

Summary: A method was developed to prepare phenolic resin-bonded flax particleboards with or without wood preservatives protecting against *Coniophora puteana* or *Poria vaillantii.* The physical and mechanical properties of the boards were determined. Mold fungus decreased the strength of nonprotected boards by more than 50 percent. Wood preservative, Xyligen 25°F, did not affect the crosslinking of alkali-hardening phenolic resin.

561. Dvorkin, L.I.; Pikovskii, LA.; Kovtun, A.M. 1988. Materials from flax shives. Stroitel'nye Materialy. 9: 16. [Russian].

Summary: The use of flax shives in the manufacture of Arbolite and binderless particleboards was discussed.

562. Eisner, K.; Kolejàk, M. 1958. Building board from flax and hemp fibers. Drevo. 13(12): 356-360. [Polish].

Summary: Experimental boards were prepared from flax and 9 percent urea-formaldehyde resin binder. The mixture with 6 percent moisture content was pressed at 160°C for 6 min. The density of the boards was 0.60 to 0.65 g/cm^3; boards of lesser density (around 0.16 g/cm^3) can be produced. Hemp fibers required only 7.5 percent binder. Although flax and hemp boards resulted in higher swelling when exposed to water, they are more economical to produce.

563. Fahmy, Y.A.; Fadl, N.A. 1979. Acetylation in particle board making. Egyptian Journal of Chemistry. 20(4): 397-403.

Summary: Liquid-phase acetylation of flax straw in a mixture of Ac_2O, AcOH, and $HClO_4$, decreased the water resistance, swelling thickness, and bending strength of the resulting particleboard relative to that of nonacetylated boards.

564. Fadl, N.A.; Sefain, M.Z. 1977. Coating of finished flax particle boards with insoluble gelatin. Journal of Applied Chemistry and Biotechnology. 27(8): 389-392.

Summary: Coating finished flax particleboards with gelatin alone did not improve the resistance of boards to hot water, whereas coating with gelatin and hexamine using high temperature produced an insoluble gelatin film on the flax particles, which improved water resistance of the coated boards. Particleboards coated with 5 percent gelatin and a high concentration of hexamine (10 percent), improved water resistance to about 50 percent higher than that of uncoated samples. Higher amounts of gelatin (7.5 and 10 percent) gave a smaller improvement. Changes in thickness and density of the coated samples were also investigated.

56.5. Heller, L. 1978. Production defects in laminated and nonlaminated particle boards made from flax shives. Drevo. 33(4): 105-108. [Slovakian].
(no abstract available)

566. Klauditz, W.; Ulbricht, H.J.; Kratz, W. 1958. Production and properties of lightweight wood-shaving boards. Holz als Roh- und Werkstoff. 16(12): 459-466. [German].

Summary: Particleboards having densities of 0.3 to 0.5 g/cm^3 were prepared from softwoods, hardwoods, and flax straw. About 6.9 percent urea-formaldehyde resin was added as a binder. The boards showed strength properties that made them suitable for various commercial applications.

567. Lawniczak, M.; Nowak, K. 1962. The influence of hydrophobing impregnating agents on moisture-caused dimensional changes in wood-particle and flax-chaff boards. Holz als Roh- und Werkstoff. 20(2): 68-72. [German].

Summary: Wood-particle and flax-chaff boards were treated with two different paraffin-based commercial water-proofing agents in amounts of 0.5 percent. By this means, the 24-h thickness swelling in water could be reduced by around 56 percent in particleboard and 85 percent in flax-chaff boards. After 140 days of storage in moist air, water-proofed flax-chaff boards had swollen 60 percent less than untreated boards.

568. Lawniczak, M.; Nowak, K.; Raczkowski, J. 1962. Properties and uses of flax and hemp waste boards. Drevo. 17(1): 5-8. [Slovakian].

Summary: Chaff or waste from processing flax and hemp constitutes up to 50 percent of the weight of these materials. In Poland, a large amount of the chaff is used for manufacturing particleboards by the Linex-Verkor process. Results of tests to determine the mechanical and physical properties of commercial products of various densities were reported. The swelling and water-vapor sorption of chaff boards were lower than those of three-layer wood particleboards. The mechanical properties (bending and tensile strengths, hardness, and nail resistance) were comparable to those of wood particleboard of the same density.

569. Lawniczak, M.; Nowak, K.; Zielinski, S. 1961. Mechanical and technological properties of flaxboard. Holz als Roh- und Werkstoff. 19(7): 232-239. [German].

Summary: Flaxboards have mechanical and technological properties equal to those of wood particleboards of the same density. However, since no water repelling agents are used in the manufacture of flaxboard, the water absorption and linear thickness swelling of boards having a density of 0.60 and 0.65 g/cm^3 are greater than those of wood particleboard. The most important use of flaxboard is in the manufacture of furniture. Because of particularly high heat insulation capacities and sound absorptivity, flaxboards are increasingly used in the construction industry.

570. Lawniczak, M.; Raczkowski, J. 1962. The physical and mechanical properties of boards from flax waste. Derevoobrabatyrayushchaya Promyshlennost. 11(10): 27-28. [Russian].

Summary: Building boards made from flax shives were produced in Poland in two density ranges, 0.50 to 0.70 g/cm^3 and 0.30 to 0.40 g/cm^3, the latter used as insulation paneling. After thorough cleaning, the shives were formed into boards using thermosetting urea-formaldehyde resin as the binder. The water absorption of flaxboard is lower than that of wood particleboard and is further reduced by adding a recently developed water-proofing agent. The modulus of elasticity and bending strength are comparable to those of wood particleboard of the same density; however, the special advantages of flaxboards are their high thermal and sound-insulating properties.

571. Lawniczak, M.; Raczkowski, J. 1963. Particle boards made from flax and hemp shives. Drvna Industrija. 14(9/10): 139-146. [Croatian].

Summary: This paper describes the process used at the Vitasicama mill in Poland for producing particleboard from flax and hemp waste. Dust and fibers, about 25 percent of the raw material, are removed pneumatically before mixing the shives with urea-formaldehyde resin and a water-proofing agent. The mixture, having a moisture content of 12 percent, is formed into a mat and pressed at 140°C to 150°C. Pressing time depends on the thickness and density of the board. Boards with densities of 0.50 to 0.70 g/cm^3 are produced for use in structural applications and furniture. Small quantities of lighter boards (density of 0.30 to 0.40 g/cm^3) are also produced, yielding a suitable insulation material. The physical and mechanical properties of the hemp boards compared well with those of boards made from wood.

572. Lawniczak, M.; Raczkowski, J. 1964. The effect of gamma radiation on lignocellulose particle/urea-formaldehyde binder compositions. Holztechnologie. 5(Special issue): 39-42. [German].

Summary: Studies that involved the subjection of flax particleboard to Co$^{60}\gamma$-radiation showed that board static-bending strength, impact-bending strength, and hardness decreased with increasing radiation dose. Board hygroscopicity and thickness swelling were not affected significantly by the radiation. The effects of y-radiation on flax particleboard were similar to those of y-radiation on wood particleboard and wood.

573. Mestdagh, M.; Demeulemeester, M. 1970. The manufacture of phenolic-resin-bonded flax-particle board for the construction industry. Holz als Roh- und Werkstoff. 28(6): 209-214. [German].

Summary: The structure, chemical composition, and mechanical resistance of flax shives and flaxboards are discussed and compared with corresponding properties of wood particleboards. No significant differences preventing the production of flaxboards with phenolic resins was observed.

574. Nice, R.; Cremaschi, J. 1961. Quebracho tannin-formaldehyde adhesive for particle board. Revista Sociedal Quimica Mexico. 5(3): 98-103. [Spanish].

Summary: Manufacturing of particleboard from poplar wood and flax fibers using quebracho tannin formaldehyde adhesive as a binder resulted in board with properties approximating or superior to those of similar boards using urea-formaldehyde resin adhesives. The cost of the tannin formaldehyde adhesive is less than half of that of urea-formaldehyde resin adhesives.

575. Nowak, K.; Paprzycki, O. 1961. Testing of glue lines in bonding flaxboard with wood and other wood-based materials. Przemysl Drzewny. No. 8 [Polish].

Summary: In Poland, flaxboard is commonly used in furniture manufacturing, as flooring underlayment, and as roof sheathing material. For evaluating the adhesive bonding characteristics of flaxboard, shearing strength, and water resistance of glued joints including the following combinations were determined: flaxboard/flaxboard, flaxboard/pine wood, flaxboard/hard fiberboard. Protein glues, urea-formaldehyde resin, or phenol-formaldehyde resin were used as binder. The samples were tested untreated, after exposure to high air humidity for 30 days, and/or after submersion in water for 24 h. By far, the lowest strength was obtained with the flaxboard/hard fiberboard combination; other samples did not show much difference. Phenol-formaldehyde resin gave bonds of particularly high water resistance followed by urea-formaldehyde resin and casein glue.

576. Skory, H. 1969. Method of improving some physical properties of flaxboard. Przemysl Drzewny. 20(1): 12-13. [Polish].

Summary: The possibility of improving the water resistance of flaxboard by incorporating a special paraffin emulsion into the fibrous material was investigated. It was found that both water absorption and swelling in water decreased considerably with increasing paraffin content in the boards. Optimum values were obtained with boards containing 0.7 percent of the water proofing agent. Further increasing the paraffin content resulted in products of lower strength.

577. Swiderski, J. 1960. Technology for flaxboard manufacture. Holz als Roh- und Werkstoff. 18(7): 242-250. [German].

Summary: This paper provides a well illustrated description of the technology of flaxboard manufacture in terms of facilities and operations of a recently constructed mill in Poland. Compared with the manufacture of wood particleboards, the processing of flax shives requires no chipping, uses less drying power, and uses no press forms. Flaxboard production requires closer moisture control, twice as much performing pressure, and a more rugged hot press design relative to wood particleboard production.

578. Takats, P. 1978. Possibilities of joint utilization of flax shive and poplar cuttings for chipboard manufacturing. Faipar. 28(5): 145-146. [Hungarian].
(no abstract available)

579. Tomàsek, L. 1962. Flax shive particle boards. Drev. Vyber. 15(6): 49-54. [Slovakian].
(no abstract available)

580. Verbestel, J.B.; Kornblum, G. 1957. Particle boards from flax. Part I. Utilization of agricultural by-products. Part II. Industrial experience in the use of flax straw for the manufacture of particle boards. FAO/ECE/BOARD CONS/ Paper 4.16. Fiberboard and Particleboard. Report of an International consultation on insulation board, hardboard, and particleboard; Geneva, Switzerland.

Summary: Part I of this paper dealt with the availability and utilization of agricultural byproducts, especially of flax straw. Part 2 reviewed the industrial experience in the manufacture of flaxboards gained over more than 20 years.

581. Wood Technology Research Institute. 1964. Possible uses of flaxboards in the furniture industry. Final Rep. 04 30 01 h/AE-3-101/FK. Dresden, Germany: Wood Technology Research Institute. 80 p. [German].

Summary: This was an extensive study on the physical properties of flaxboards, their workability, and utilization in the furniture industry. The following items were investigated: hygroscopicity of the boards at different humidities, water absorption and thickness swelling after submersion in water, surface quality and coating, glued joints and loose joints, and suitability of the panels. Recommendations were given concerning the optimum utilization of flaxboard.

(Also see references 33, 34, 44, 53, 59, 70, 83, 660, 787, and 1148.)

Fiberboard/Hardboard

582. Barthel, R. 1961. Utilization of by-product flax shives for fiber boards. Faserforschung und Textiltechnik. 12(11): 534-547. [German].

Summary: Flax shives constitute about 37 percent of the harvested yield of the flax plant. Experiments demonstrated that fiberboards with satisfactory properties comparable to those of wood particleboards and fiberboards can be made from this agricultural waste. The manufacturing process included sorting and cleaning of the flax chaff, pressure-steaming, defibration in a disk mill, sheeting of the processed shives by a wet process, and molding in a hot press with or without the addition of phenol-formaldehyde resin adhesive into fiberboards ranging in density from less than 0.25 to 1.0 g/cm^3.

583. Bularca, M. 1985. Research on the utilization of acacia wood, willow wood, and some lignocellulosic materials (vine shoots and flax boon) as raw material for the production of wood fiber boards-wet process. Industria. Lemnului. 36(4): 193-200. [Romanian].

Summary: Wood from fast-growing trees (acacia and willow) and other lignocellulosic materials (vine shoots and flax boon) were studied to determine their feasibility as raw materials for the manufacture of fiberboard. Tests were conducted to determine the physical and chemical characteristics of these raw materials, followed by pilot plant tests to determine tests for optimum grinding, defibering, and refining parameters for producing wood fiberboards with mechanical and physical characteristics that meet standard requirements.

584. Lüdtke, M. 1939. The utilization of the waste products from flax and hemp retting. Melliand Textilberichte. 20(4): 253-256. [German].

Summary: Possibilities for using waste products from flax and hemp retting are discussed. None of the industrial applications considered is practical, including the manufacture of insulation board and fiberboard.

585. Morze, Z.; Kinastowski, S.; Lecka, J.; Kozlowski, R. 1982. Impregnated decorative paper for finishing the surface of flax fiberboards. Prace Instytutu Krajowych Wlokien Naturalnych. 27: 273-281. [Polish].

Summary: This paper relates how a patterned paper with good chemical and mechanical resistances for finishing fiberboards is obtained from paper impregnated with urea-formaldehyde resin that has been modified with acrylic resin.

586. Narayanamurti, D.; Singh, J. 1962. Note on hardboards from linseed fibre. Indian Pulp and Paper. 17(5): 302.

Summary: Linseed (flax) fibers were pulped with varying concentrations of NaOH, defibered in a Condux mill, and pressed into board. Difficulties in the defibration of the long-fibered material were eliminated by cutting the linseed fibers to shorter lengths. The properties of the tempered boards proved satisfactory.

587. Verbestel, J.B. 1968. Treatment of flax particles for use in fiberboard manufacture. Patent, P.N.: BE 702968, I.D.: 680201. [Dutch].

Summary: Flax particles are brought to 110 percent moisture content before being pulverized for use in the manufacture of fiberboard. The fibers are then dried to their original 13 percent moisture content before being mixed with phenolic resin and pressed into boards at a high temperature. Boards prepared from the particles ground at a high-moisture content have a greater tensile strength and swelling resistance in water than boards prepared from particles ground without being moistened. In the process, 40 kg of flax particles containing 13 percent moisture content was brought to 110 percent moisture content, ground in a hamkermill, covered with a solution of 400 g urea-formaldehyde resin/ 2 kg of flax particles, and pressed for 11 min at 140°C. The resin contained a catalyst and a paraffin emulsion. Tensile strength of the panel was 725.6 kPa, and the swelling after 2 h in water was 6.2 percent, compared with 387.3 kPa and 9.6 percent for control panels prepared from particles beaten at 13 percent moisture content.

(Also see references 137, 660, 865, and 866.)

Insulation Board

588. Abramushkina, E.A. 1976. Study of the resistance of antiseptic-protected insulating peat and flax scutch boards. Biokorroz., Biopovrezhdeniya, Obrastaniya, Mater. Vses. Shk., 1st meeting date: 1975: 217-218. [Russian].

Summary: Addition of 0.5 percent by weight Na_2SiF_6 and 0.5 percent by weight NaF mixture, 0.8 percent NaF, or 1 percent borax during manufacture of flax scutch board offered complete protection during a 2-month exposure of the board samples to *Caniophora cerebella* cultures. Addition of 1.2 percent Na_2SiF_6 to peat during manufacture of peat board also offered complete protection from the fungus.

589. Derbentsava, F.F.; Derbentsava, N.A.; Kaplan, D.M.; Vladyka, L.I. 1952. Manufacture of insulating building material from flax scutch. Vestsi Akademii Navuk Beloruskai Soviet Socialist Republic. 1: 55-62. [Belorussian].

Summary: Flax scutch was ground and chemically treated, yielding a material of low water and moisture absorbency, which is used as insulating board.

590. Gradovich, V.A. 1963. Prospects for the expansion of the manufacture of constructional boards from flax waste. Proizv. Stroit. Izdelii iz Plastmass, Sb.: 73-80. [Russian].

Summary: A process for manufacturing insulation boards from flax chaff is described. The chaff is beaten to a freeness of 14°SR, sized with a rosin-paraffin size, and mixed with 0.2 percent fungicide (Na_2SiF_6). The fibrous suspension (consistency of 1 to 1.2 percent) is formed into sheets, pressed, and dried. The finished products have a density of 0.18 to 0.22 g/cm^3, a bending strength of 588.4 kPa to 1.2 MPa, a 2 h maximum water absorption of 20 percent, and a heat conductivity of 0.047 kcal/m/h/°C.

591. Mueller, M.E. 1952. Insulation board. Patent, P.N.: US 2608492, I.D.: 520826.

Summary: Flax shives or hemp from unretted plants are reduced in a beater at 51.7°C to 65.6°C. The pulp is formed into a sheet, pressed at 65.6°C to 93.3°C and a pressure of 689.5 kPa to 1.4 MPa, and then dried at 93.3°C to 121.1°C. The resulting board can be used as wallboard, for interior woodwork, or for building insulation.

592. Pietrzykowski, J.; Lawniczak, A. 1962. Utilization of flax waste for the production of insulating boards. Przemysl Wlokienniczy. No. 6. [Polish].
(no abstract available)

593. Skrigan, A.I.; Shishko, A.M.; Ileskin, G.V. 1958. Utilization of pinewood stumps and flax fibers for the manufacture of thermal insulation panels. Vestsi Akademii Navuk Belaruskai Soviet Socialist Republic, Seryia Fizika-Tekhnichnykh Navuk. 1: 89-93. [Belorussian].

Summary: The addition of 25 percent flax fibers to stump wood improved the strength properties and increased the hardness of insulation board. Joint beating of wood and flax fibers was recommended. The properties of the board complied with standard requirements.

594. Williams, T.I. 1949. Waste converted into valuable products: new uses for linseed straw. Indian Pulp and Paper. 4(1): 20, 24.

Summary: Flax straw can be used for building board, insulating material, and paper.

(Also see references 512, 569, 570, 571, 584, and 660.)

Cement/Gypsum/Plaster Board

595. Dvorkin, L.I.; Mironenko, A.V.; Shestakov, V.L.; Kovtun, A.M. 1987. Composites from phosphogypsum. Stroitel'nye Materialy Konstruktsii. 4: 15. [Russian].

Summary: A binder prepared from 85 percent phosphogypsum and 15 percent flax shives hardened at

130°C to 150°C for 4 to 8 h exhibited compressive strength of 19.2 MPa. Abrolite prepared from the binder and a flax-shive filler (27 percent by weight) with an average density of 0.79 g/cm^3 exhibited a compressive strength of 5.7 MPa.

596. Dvorkin, L.I.; Pikovskii, I.A.; Kovtun, A.M. 1989. Manufacture of building articles-by forming panels from Portland cement, flax chaff, and water, filling space between with wood filler, and vibro-compacting. Assignee: (UWAT-) Ukr Water Supply En. Patent, P.N.: SU 1502410, I.D.: 890823. [Russian].

Summary: Higher quality wood-filled building materials are obtained using a mixture containing (in parts by weight): 1 to 1.1 Portland cement, 0.040 to 0.065 flax or oakum chaff, and 0.30 to 0.35 water. The mixture is pressed under 0.5 to 1 MPa to a thickness of 15 to 20 mm. The panels are then positioned vertically, and the filler placed in the gap. Vibrocompacting and repeated pressing with a punch filled with cavity formers, is followed by hardening.

597. Mihashi, S. 1988. Fireproof boards. Assignee: Nippon Zeon Co. Ltd. Patent, P.N.: JP 63017039, I.D.: 880125. [Japanese].

Summary: Fireproof boards are prepared from a mixture of a water-soluble silicate, flax, inorganic hardener, inorganic microballoons, cement, and inorganic aggregates. The mixture is cast in a mold having an asbestos sheet, cured for 10 h, and dried for approximately 8 h at 50°C. The boards passed a nailing test and a thermal deformation test.

598. Shashkel, P.P.; Gurba, N.A.; Kalechits, A.K.; Zhavrid, S.S.; Bashlakov, P.E. 1979. Polymer-mineral mixture. Assignee: Institute of construction and Architecture, Belorussian Soviet Socialist Republic. Patent, P.N.: SU 642267, I.D.: 790115. [Belorussian].

Summary: The impact toughness of a polymer-mineral mixture was increased by adding 2.5 to 3 percent by weight hydrolyzed lignin, 3 to 7 percent by weight flax shives or chopped-basaltic fiber to a mixture containing 30 to 31.5 percent by weight urea resin, 44.5 to 47 percent by weight phosphogypsum hemihydrate, and the balance being water.

599. Thole, V. 1992. Bending-strength of gypsum-bonded particleboards using flax-waste as an additive. Holz als Roh- und Werkstoff. 50(7/8): 327.
(no abstract available)

(Also see reference 399, 400, and 1110.)

Plastic/Plastic-Bonded Board

600. Ishikawa, T. 1977. Cellular polyurethane building materials. Patent, P.N.: JP 52063296, I.D.: 770525. [Japanese].

Summary: Building materials are prepared by molding mixtures containing nylon fibers or flax and optionally containing perlite or borax fireproofing agent and optionally laminating the foams with asbestos paper. The resulting foam (cellular in composition) has good compressive and flexural strength.

601. Tabata, T. 1977. Flax-reinforced fire-resistant cellular polyurethanes. Assignee: Akira Ishikawa. Patent, P.N.: JP 52127970, I.D.: 771027. [Japanese].

Summary: Fire-resistant polyurethane foams, useful for building materials, were prepared by impregnating flax ropes with an inorganic compound expandable at high temperatures and foaming polyurethane compositions containing the ropes. The flax cords were immersed in melted Na metaborate until 500 percent pickup, dried, spray coated with a polyurethane, and foamed to give a cellular panel.

(Also see reference 400.)

Roofing Board

602. Nozynski, W. 1962. Testing of flaxboard roofing. Institute of Building Technique (Poland) No. 10. [Polish].
(no abstract available)

Unknown Board

603. Anonymous. 1961. Flaxboard production in Belgium-the new Wielexco mill. Board Practice. 4(12): 286-289.
(no abstract available)

604. Anonymous. 1974. Manufacture for impregnating wood-fibre panels--containing flax oil, tall oil and dibutylphthalate. Assignee: Cellulose Paper Ind Res. Patent, P.N.: SU 423632, I.D.: 741115. [Russian].

Summary: High-quality material used in furniture manufacturing, building, railway, and aero industries is less expensive when the impregnating mixture contains 18 to 20 percent by weight flax oil and 70 to 75 percent by weight dibutylphthalate. The impregnation is carried out at 120°C to 130°C for 3.5 h. The finished product has higher impact strength than that material impregnated with a well known mixture containing additional castor oil and differing amounts of the remaining components.

605. Flemming, H. 1966. Extreme material combinations exemplified by glass-fiber-reinforced flax shive boards. Holztechnologie. 7(3): 185-189. [German].

Summary: Following a review of material combinations, particularly glass-fiber combinations, used as construction materials, data were presented on the properties of a glass fiber/flax shive board laminate. The laminate is of a particular use in the construction of house trailers, freight trailers, and other such uses.

606. Frackowiak, A.; Koslowski, R. 1963. Properties of flaxboard. Report 11. Poznan, Poland: Institute of Bast Fibre

Industries. [Polish].
(no abstract available)

607. Frackowiak, A.; Lawniczak, M. 1961. The effect of the waterproofing impregnating agent GSE-10 on some properties of flax waste boards. Przemysl Drzewny. 12(11): 8-9. [Polish].

Summary: A new waterproofing agent developed at the Institute of Wood Technology in Poznan reduced the hygroscopicity of flax waste boards by 30 percent and swelling by 40 percent, and increased bending strength greatly.

608. Heller, L. 1976. Laboratory quality control of chemicals, semiproducts, and laminated flaxboards. Drevo. 31(9): 277-278. [Slovakian].
(no abstract available)

609. Horikoshi, K. 1990. Nonflammable building boards from wooden materials and cement. Patent, P.N.: JP 02034544, I.D.: 900205. [Japanese].

Summary: Wooden materials selected from excelsior, wood chips, pulp, bamboo, and flax are dipped in a solution containing alkali metal silicate, colloidal SiO_2, and/or SiO_2 gel, coated with a binder and a combustion inhibitor, cast or press molded, and hardened to obtain nonflammable building boards.

610. Inyutin, V.I.; Baranov, Y.D.; Matvetsov, V.I. 1983. Composition for producing structural products. Assignee: Belorussian Institute of Railroad Transport Engineering. Patent, P.N.: SU 1021667, I.D.: 830607. [Belorussian].

Summary: Building materials with high compressive and bending strengths are prepared from 17.5 to 22.5 percent by weight phenol-formaldehyde resol resin, 7.5 to 12.5 percent by weight epoxy diam resin, 22.5 to 27.5 percent by weight wastes from flax or cotton fabrics, and 37.5 to 52.5 percent by weight phosphogypsum hemihydrate.

611. Matejak, M. 1980. Sorption properties of flax and hemp shive boards. Holzforschung und Holzverwertung. 32(3): 67-69. [German; English summary].

Summary: Sorption isotherms were determined for flax and hemp boards made with urea-formaldehyde resin immediately after manufacture and after five climatic cycles. Increases in hygroscopicity during adsorption and a partial decrease during desorption were observed. There was an increase in the internal surface of the boards as a result of flaws developing in the cell walls with changes in humidity, with a consequent increase in deposition of moisture.

612. Nowak, K.; Paprzycki, O.; Czechowski, W. 1962. Effect of density on some physical and mechanical properties of flaxboard. Przemysl Wlokienniczy. 5. [Polish].
(no abstract available)

613. Saunderson, H.H. 1944. The industrial utilization of plant and animal products: Province of Manitoba. Report prepared for the Post-War Reconstruction Committee of the Government of Manitoba. Manitoba: University of Manitoba. 60 p.

Summary: The use of flax straw and other straws for the production of panel boards is briefly discussed.

614. Sinek, J. 1961. Linex boards from flax waste. Tech. Nov. 9(48): 5. [Slovakian].

Summary: A plant for manufacturing building boards from flax waste is under construction in Vesela, Czechoslovakia. The manufacturing process is described and the applications of the Linex boards in construction are discussed and illustrated.

615. Sizova, E.M.; Iakovenko, T.N. 1977. Pressing boards from (fiber flax) shive on rapidly hardening resins. Len i konoplia. 10: 36-37. [Russian].
(no abstract available)

616. Truc, R. 1972. Some experience with the use of laminated flaxboards for furniture. Drevo. 27(5): 131-133, 141. [Slovakian].
(no abstract available)

617. Verbestel, J.B. 1957. Structural board. Patent, P.N.: US 2798019, I.D.: 570702.

Summary: A high strength, dimensionally stable, fungus resistant building board is formed by a dry process from fiber-free flax shives bonded with resin, such as phenol formaldehyde, and consolidated under heat and pressure.

(Also see references 3, 190, 400, 401, 591, 594, 665, and **796.)**

Cement/Clay/Gypsum/ Plaster Materials

618. Bukus, K. 1978. Solidifying compositions for building industry. Patent, P.N.: HU 14627, I.D.: 780328. [Hungarian].

Summary: Clays containing CaO (pH $\geq$ 8) were heated at 100°C to 900°C ground, homogenized with fillers, such as coal-dust ash, cinder, black ground-flax straw, sawdust, or ground reed, optionally cement, and aqueous $Ca(OH)_2$ to pH of 11. Final building composition is a plastic mass of pH 11.

619. Coutts, R.S.P. 1983. Flax fibres as a reinforcement in cement mortars. International Journal of Cement Composites and Lightweight Concrete. 5: 257-262.
(no abstract available)

620. Kober, H. 1983. Reinforcing fibres for mineral building material comprising flax stems opened and impregnated with lime water. Assignee: (KOBE/) Kober H. Patent, P.N.: US 4369201, I.D.: 830118.

Summary: Flax-stem fibers are cut to length and opened along the capillaries, then dried, impregnated with a suspension of lime in water, dried again, then saturated with a solution of soluble glass containing formaldehyde. Fibers are used as reinforcement of pipes, boards, and profiles with angle moldings. The fibers are used as a replacement for asbestos. The lime mineralizes the fibers so that they have the same physical properties of asbestos without the toxicity, and they are especially resistant to industrial gases, fungi, insect attack, and putrefaction, Additionally, fibers have a high resistance to fire.

621. Krasnov, A.M.; Popov, V.N.; Kropotova, E.V.; Bezgina, O.S. 1991. Raw mixtures for manufacture of arbolite. Assignee: Mari Polytechnic Institute. Patent, P.N.: SU 1618737, I.D.: 910107. [Russian].

Summary: Flax waste is used as an additional component to increase construction capability of a material prepared with Portland cement, gypsum, and water.

622. Sestak, S.; Sestak, K. 1990. Manufacture of multicomponent building material. Patent, P.N.: CS 264914, I.D.: 900613. [Slovakian].

Summary: A material is manufactured by mixing sawdust with 60 to 65 percent by weight of the total amount with the required amount of water, optionally adding 10 to 30 percent by weight (based on weight of water) slaked lime or synthetic latex, adding fly ash while continuously mixing, additionally adding cement after mixing for more than 30 s, and adding the remainder of the water after mixing 10 s. Sawdust may be replaced by other fibrous materials such as chaff, flax powder, crushed hay, crushed cornstalks, and powdered reed. The material can be used for the manufacture of prefabricated elements, monoliths, or as mortar for plastering, bricklaying, or spraying.

623. Yanoshkin, V.F.; Berdichevskii, R.E. 1990. Gypsum blocks for exterior and interior walls. Stroitel'nye Materialy Konstruktsii. 5: 21. [Russian].

Summary: Blocks suitable for construction of load-bearing walls of buildings are manufactured from a $\leq$0.80 g/cm^3 gypsum binder, $\leq$0.12 g/cm^3 aggregates (sawdust, flax shives, or rice husks), and 0.30 g/cm^3 of plasticizer.

(Also see reference 210.)

Molded Masses

Refractory Materials

624. Anonymous. 1982. Refractory heat-resistant boards. Assignee: Shinagawa Refractories Co. Ltd. Patent, P.N.: JP 57022191, I.D.: 820205. [Japanese].

Summary: Refractory aggregates are mixed with organic fiber and a suitable amount of aqueous H_2SO_4 solution, molded, and dried. The mixture contains 65 parts MgO, 35 parts SiO_2, 1 part glass fiber, 2 parts flax yarn, 2 parts wood fiber, and 25 parts 5 percent aqueous H_2SO_4 solution, resulting in heat-resistant boards having a bending strength of 2.9 MPa.

625. Nikolaev, N.E.; Agishina, L.N.; Lokosov, V.G. 1988. Moulding composition for producing refractory panels-containing aluminum-chromium phosphate binder, urea, sulphuric acid as fireproofing component, and flax, hemp or wood processing waste. Assignee: (WOOD=) Wood Process Ind. Patent, P.N.: SU 1388406, I.D.: 880415. [Russian].

Summary: The use of sulfuric acid as a fireproofing component, and flax, hemp, or wood processing waste as filler in the mixture for producing refractory panels, increases the efficiency of the preparation. The mixture contains (in percent by weight): 5 to 13 percent Al-Cr phosphate binder, 4 to 8 percent urea, 2 to 4 percent sulfuric acid, and 75 to 89 percent wastes. The panels are made by hot pressing.

Resins/Binders

626. Kepes, J., Nemeth, L.; Kolozsi, A.; Balazs, I. 1985. Phenolic resin moldings. Assignee: Lenfono es Szovoipari Vallalat and Vllamosszigetelo es Muanyaggyar. Patent, P.N.: HU 37159, I.D.: 851128. [Hungarian].

Summary: Moldings used especially for electrical insulators are prepared from phenolic resins and reinforcements. A 50:50 mixture of Bakelite and flax tow was air dried for 2 days at 90°C to 100°C, then molded under high pressure to give electrical insulators.

Miscellaneous

Economics

(See references 34 and 59.)

Loose Insulation

(See reference 221.)

General Information/Reviews

627. Hadnagy, J. 1964. Examination of some problems in flaxboard production technology. Faipar Kutatasok. Vol. 2. Budapest, Hungary. p. 77. [Hungarian].
(no abstract available)

Foliage [Needles, Leaves]

Panel Board

Particleboard

628. Chow, P. 1973. New uses found for discarded Christmas trees. Illinois Research. 15(3): 18.

Summary: Scotch pine Christmas trees were processed through a wood chipper and hammermilled using a 1.27-cm screen. Boards were comprised of wood, bark, and branches (80 percent by weight) and needles (20 percent by weight). Urea-formaldehyde resin and wax were added prior to pressing. Boards (0.635 cm) with an average density of 0.79 g/cm^3 resulted after pressing exhibiting modulus of rupture of 6.6 MPa, modulus of elasticity of 1.59 GPa, and internal bond of 813.6 kPa. After 24 h of water soaking, thickness swell was 10 percent.

629. Chow, P.; Fox, H.W. 1973. Recycling used Christmas trees into decorative panels. American Christmas Tree Journal. 17(1): 15-18.

Summary: Boards of 0.635 and 0.9525 cm thickness were produced using discarded Christmas trees. Boards were comprised of wood, bark, and branches (80 percent by weight) and needles (20 percent by weight). Boards of 0.635 cm thickness had an average density of 0.80 g/cm^3, a modulus of rupture of 6.8 MPa, a modulus of elasticity of 1.65 GPa, and an internal bond of 834.3 kPa. Boards of 0.9525 cm thickness had an average density of 0.78 g/cm^3, a modulus of rupture of 6.5 MPa, a modulus of elasticity of 1.52 GPa, and an internal bond of 792.9 kPa.

630. Howard, E.T. 1974. Needleboards-an exploratory study. Forest Products Journal. 24(5): 50-51.

Summary: Medium-density hot-pressed boards were prepared from slash pine needles that had been either flattened, benzene-soaked, flattened and benzene-soaked, mercerized, or given no treatment. None of the boards had satisfactory properties for conventional uses. Mercerization improved bending strength and internal bond of the boards, but stiffness and dimensional stability were poor. All other boards were found to be poorly bonded.

Insulation Board

(See reference 8.)

Molded Masses

Resins/Binders

631. Chow, S. 1977. Foliage as adhesive extender: a progress report. In: Proceedings of the 11th Washington State University symposium on particleboard; 1990 March; Pullman, WA. Pullman, WA: Washington State University: 89-98.

Summary: Tree foliage (from Douglas-fir, western hemlock, western redcedar, white spruce, lodgepole pine, Scots pine, and red alder), dried and pulverized, is useful as an extender and filler for wood adhesives. The tree foliage exhibited good adhesive properties and could also act as a replacement for the phenolic adhesive; both liquid and powdered phenol-formaldehyde resins gave similar encouraging results. However, further work in durability of the foliage using resin needs to be done.

Grasses

Panel Board

Particleboard

632. Kordsacbia, O.; Baum, N.; Patt, R. 1992. Elephant grass-a potential raw material for the pulp and paper industry. Papier. 46(6): 257-264. [German].

Summary: Due to the high yield per hectare obtainable under the climatic conditions in Germany, elephant grass (*Miscanthus sinensis*) is regarded as a future raw material for the pulp and paper industry. To present the actual state of knowledge, information about this raw material is summarized and results of the authors' studies on cooking of elephant grass and pulp bleaching are given. The material can be delignified rather easily using the alkaline sulfite process with the addition of anthraquinone. Pulps with good strengths were obtained in high yields and can be chlorine free bleached to high brightness without impairing the pulp strength. The results are compared to those achieved with poplars from short rotation plantations. The special problems associated with processing annual plants were discussed.

633. Narayanamurti, D.; Singh, K. 1963. Boards from Phragmites karka. Indian Pulp and Paper. 17(7): 437.

Summary: The manufacture of thermodyne disks, chip boards, and fiberboards from Phragmites karka material and the properties of the products were described. The chip boards (10 percent urea-formaldehyde resin) had a density of 0.565 to 0.741 g/cm^3 and a tensile strength of 7.2 to 9.8 MPa. High strength fiberboards were produced from $Ca(OH)_2$-cooked pulps, while boards with good moisture resistance were produced with NaOH cooking. Linseed oil tempering improved both properties considerably, more so than just simple oven tempering.

Fiberboard/Hardboard

634. Narayanamurti, D.; Singh, K. 1962. Note on hardboards from Kans grass (*Saccharum spontaneum*). Indian Pulp and Paper. 17(5): 301.

Summary: Hardboards of satisfactory properties were made experimentally from Kans grass by pulping the grass with caustic soda (0.05 and 0.5 percent), lime (0.1 and 0.3 percent), or water, all mixed with the grass in a 1:20 ratio and boiled for 2 h. The 0.3 percent lime treatment produced the best board with a modulus or rupture of 53.2 MPa, but gave the lowest pulp yield (45 percent).

635. Singh, M.M.; Rana, R.S.; Sekhar, A.C. 1964. Pressed boards from Ulla grass (*Themida arundinacia*). Indian Pulp and Paper. 19(7): 443, 445-447.

Summary: Ulla grass was processed (chopped, screened, soaked, and steamed), defibered in an Asplund defibrator, washed, and pressed into fiberboard at 3.4 MPa for 5 min.

The board was subsequently dried at 130°C and a pressure of 3.1 MPa for 2 h. Strength properties of the boards obtained compared favorably with those of commercial fiberboards. The effect of steaming and defibering time on the board properties was discussed.

(Also see references 266 and 633.)

Cement/Gypsum/Plaster Board

636. Schubert, B.; Simatupang, M.H. 1992. Suitability of *Miscanthus sinensis* for manufacturing of cement particleboards. Holz als Roh- und Werkstoff. 50(12): 492.
(no abstract available)

Roofing Board

637. Ayyar, TSR.; Mirihagalla, P.K. 1980. Elephant grass fibres as reinforcement in roofing sheets. Appropriate Technology. 6: 8-10.
(no abstract available)

Unknown Board

(See references 190 and 289.)

Cement/Clay/Gypsum/ Plaster Materials

(See reference 674.)

Miscellaneous

Economics

(See reference 231.)

Material Preparation/Pulping/Storage Methods

(See references 231 and 242.)

General Information/Reviews

638. Elbassam, N.; Dambroth, M.; Jacks, I. 1992. Utilisation of *Miscanthus sinensis* as energy and industrial material. Landbauforschung-Volkenrode. 42(3): 199-205.

Summary: This paper stated that *Miscanthus sinensis* “Giganteus” represents an essential part in the frame of consideration of utilization of raw material of plant origin. The annual yield capacity of this plant exceeds all native species, including woods. The authors assume that this grass will become a major source of raw material for industrial and energy use in the near future.

Material Used in Natural State

(See reference 387.)

Groundnut Shell [Unspecified Nuts]

Panel Board

Particleboard

639. Chittenden, A.E; Palmer, E.R. 1962. The production of particle board from groundnut shells. Board Practice. 5(6): 102-105.

Summary: Single-layer particleboards were produced experimentally using groundnut shells and urea-formaldehyde resin. The range of strength characteristics from the several densities and resin content levels was quite wide. Very fine particles (passing a BS 22-mesh sieve, 0.6985-mm aperature) were excluded as they used excessive resin. A board of about 0.64 g/cm^3 density was chosen as a typical sample. Pressures used to produce boards of densities from 0.56 to 0.80 g/cm^3 ranged from 0.06 to 0.22 g/cm^3. A cost summary was included based on West African prices. Samples were compared with British Standard 2604. Data were tabulated by resin content and density for various characteristics.

640. Chittenden, A.E.; Palmer, E.R. 1964. The production of particle board from groundnut shells. Board Practice. 7(8): 183-187.

Summary: Particleboards were made experimentally from groundnut shells. The fraction of shells retained on a 0.4763-cm sieve was used as the core and an equal weight fraction that passed through the sieve was used as the surface layers. The effects of different resin formulations, modifications of the manufacturing technique, additions of fungicides and wax, and other parameters were investigated. The tests were conducted on boards having a density of 0.64 g/cm^3 and containing 8 percent urea-formaldehyde resin. Variations of manufacturing techniques and changes in resin formulations had little effect on board strength. Pressing without a frame resulted in boards of better strength properties than when using a frame. The most effective fungicide tested was Na-pentachlorophenate. Adding wax improved the dimensional stability of the boards when stored at high humidities, but had only little effect on water absorption when the board was immersed in water.

641. Chittenden, A.E.; Palmer, E.R. 1965. The production of particle board from groundnut shells. Board Practice. 8(3): 75-82.

Summary: Investigation of full scale producing particleboard from groundnut shells showed that a conventional plant designed for use with wood particles required modification, particularly in the methods used for removing extraneous materials and dust, and in eliminating processing steps where groundnut shells could be reduced to powder. Details of a plant taking these factors into account were presented. Boards produced were tested for strength, water absorption,

aging effects, and the like, and the results were tabulated. Tungsten carbide-tipped saws were required to trim the boards. The economics of using groundnut shells for particleboard manufacture were also discussed.

642. Digard, R. 1967. Particle boards from groundnut shells. Oltagineux. 22(6): 405-407. [French].

Summary: The article described a successful attempt at producing particleboard out of groundnut shells. After shredding and removing dust and cleaning, the particles were mixed with a thermosetting resin and preformed. Hot pressing is done continuously. The boards obtained showed satisfactory strength properties and were highly resistant to termites and molds. A board factory needs an annual supply of at least 2,500 t of shells.

643. Jain, N.C.; Gupta, R.C.; Jain, D.K. 1967. Particle boards from groundnut shells. Indian Pulp and Paper. 22(6): 345-346, 359.

Summary: Laboratory experiments on the manufacture of particleboards from groundnut shells were reported. The shells were freed of dust, sprayed with a suitable resin, formed into a mat, cold pressed, and then hot pressed. No sizing agent was added. The time and temperature of pressing depended on the type of binder used and the thickness of the board. The physical and mechanical properties of the board were satisfactory, except that water absorption was rather high. The data were tabulated.

644. Mars, P.A. 1970. An enquiry into the feasibility of producing particle board from groundnut husks in India. Rep. G55. London, England: Tropical Products Institute (TPI). 73 p.
(no abstract available)

645. Narayanamurti, D.; Raghunatha Rao, D.M. 1969. Particle boards from groundnut shell. Paintindia. 19(7): 35.
(no abstract available)

646. Tropical Products Institute. 1962. Notes on the design factors in the production of a particle board plant (using groundnut shells). Rep. 29. London, England: Tropical Products Institute (TPI).
(no abstract available)

(Also see references 44, 53, 83, 484, 493, and 647.)

Fiberboard/Hardboard

647. Jain, N.C.; Gupta, R.C.; Bajaj, S.C.; Singh, D.D. 1964. Utilization of groundnut shells. Indian Pulp and Paper. 18(8): 477-480.

Summary: This paper presents the results of investigations on the use of groundnut shells for hardboards, particleboards, and building boards, and as a filler extender in synthetic resins.

(Also see references 122 and 862.)

Insulation Board

(See reference 493.)

Cement/Gypsum/Plaster Board

(See references 885 and 886.)

Unknown Board

(See reference 886.)

Molded Masses

Resins/Binders

(See reference 647.)

Miscellaneous

Economics

(See reference 641.)

General Information/Reviews

648. Narayanamurti, D.; Krishna, D.S.; Mukunda, M.S.; Raghunatha Rao, D.M. 1965. Utilisation of groundnut shells. Popular Plastics. 9(7): 28.
(no abstract available)

Material Used in Natural State

Hemp

Panel Board

Particleboard

649. Bentsianova, I.Y.; Veksler, G.M.; Markov, L.R.; Melamed, S.N.; Petrienko, P.M. 1962. The manufacture of wood-particle board from hemp scutch. Derevoobrabatyrayushchaya Promyshlennost. 11(4): 9-10. [Russian].

Summary: The report describes a manufacturing process for wood particleboard from wood alone, wood and hemp (and/or flax) scutch, or from scutch alone. In the case of mixed boards, the internal layer was made of wood particles; the outside layers of hemp scutch were cleaned of fibers and dust. Urea- or phenol-formaldehyde resins were used as binders, and the boards were molded at 135°C to 140°C at a pressure of 1.4 to 2.0 MPa. This process is soon to be introduced at one of the large furniture plants of the Ukraine.

650. Kolosvary, G. 1965. Increasing the water resistance of wood-particle and hemp waste boards by preliminary thermal treatment of the particles. Faipar. 15(2): 46-49. [Hungarian].

Summary: Hemp waste and poplar wood particles were heated to 160°C. 200°C, 210°C, and 235°C by means of a

stream of hot gas. Particleboards made from the pretreated materials showed lower water absorption and lower thickness swelling after soaking in water or after exposure to super-saturated water vapor for 10 days than did boards obtained from untreated materials. Both types of boards exhibited similar strength properties.

(Also see references 33, 34, 53, 59, 83, and 571.)

Fiberboard/Hardboard

(See reference 498.)

Insulation Board

(See references 512 and 571.)

Unknown Board

(See references 3, 190, 401, and 665.)

Cement/Clay/Gypsum/ Plaster Materials

(See references 210, 400, 611, and 912.)

Molded Masses

Refractory Materials

(See reference 625.)

Miscellaneous

Economics

(See references 34 and 59.)

General Information/Reviews

651. Anonymous. 1962. The hemp plant--cultivation, retting, mechanized preparation, and uses of hemp; prospects for hemp culture. Ciba Review. 5: 2-32.

Summary: The article covers all areas of the hemp plant, its fibrous production, and its uses.

Jute [Stalk]

Panel Board

Particleboard

652. Banerjee, S.P.; Saha, P.K. 1964. Particle board from jute stick. Contribution to the annual report of the Technological Research Laboratories for 1962-1963. Calcutta, India: Indian Central Jute Committee. 4 p.

Summary: This article describes the manufacture and properties of particleboards from jute sticks.

653. Bhaduri, S.K.; Day, A.; Mondal, S.B.; Sen, S.K. 1992. Degraded gum from ramie in binder composition for jute-stick particle board. Bioresource Technology. 40(1): 87-89.

Summary: Degraded gum, obtained from the waste liquor after degumming of decorticated ramie with hot dilute alkali, can replace one-third of the urea-formaldehyde resin required for making jute-stick particleboard.

654. Pandey, S.N.; Das, R.N.; Day, A. 1990. Particle board from jute stick and its lamination-a new process. Research and Industry. 35(4): 227-229.

Summary: Production of particleboards from jute stick waste left after extraction of fiber was investigated. The surface lamination of the board with unsaturated polyester resin and effect of the lamination on the physical properties of the board were also studied.

(Also see references 33, 34, 53, 57, 59, 83, and 660.)

Fiberboard/Hardboard

655. Anonymous. 1962. Hardboard from jute stick. Far Eastern Economic Review. 36(8): 434.

Summary: India has begun producing hard paperboard from jute sticks at two Calcutta paper mills. The board is claimed to be a superior quality product of high bursting strength and folding endurance, suitable for making box boards. The manufacture of building board from jute sticks has not yet been considered.

(Also see references 114, 660, and 670.)

Insulation Board

(See references 506 and 660.)

Cement/Gypsum/Plaster Board

(See references 886, 1014, and 1016.)

Plastic/Plastic-Bonded Board

656. Narayanamurti, D.; Singh, J. 1962. Plastic boards from jute sticks. Board Manufacture. 5: 199.
(no abstract available)

Roofing Board

657. Saha, P.L.; Basak, K.K. 1964. Asphalted roofing material from jute stick. Jute Bulletin. 27(1): 8-9.

Summary: A board made from about 52 percent jute stick pulp, 44 percent wastepaper, and 4 percent hosiery cuttings was recently developed by the Technical Research Laboratories of the Indian Central Jute Committee at Calcutta, India. The quality of the board, either untreated or after dipping in hot asphalt, compared favorably with similar imported boards. Board can be used as a roofing material after proper surfacing.

(Also see references 1014 and 1016.)

Unknown Board

658. Narayanamurti, D.; Kohli, R.C. 1961. Boards from jute sticks. Board Manufacture. 4: 122-123.
(no abstract available)

(Also see references 3 and 665.)

Cement/Clay/Gypsum/ Plaster Materials

(See references 210, 337, 338, 886, and 912.)

Miscellaneous

Economics

(See references 34 and 59.)

General Information/Reviews

659. Tapadar, D.C. 1964. Utilization of jute sticks for the manufacture of paper and board. IPPTA Souvenir:: 137-141.

Summary: India's jute stick supply is reviewed. The data cover the chemical composition and fiber dimensions. Suitable pulping processes and pulp characteristics are covered.

Kenaf [Stalk]

Panel Board

Particleboard

660. Atchison, J.E.; Collins, T.T. 1976. Historical development of the composition panelboard industry including use of non-wood plant fibers. In: TAPPI nonwood plant fiber pulping progress report 7. Atlanta, GA: TAPPI Press: 29-48.

Summary: The report reviews the origin and development of various sectors of the composition panelboard industry including insulation board, hardboard, particleboard, medium-density fiberboard or fiber-type particleboard, thin panelboard, and combinations of standard particles with fiberized materials. Nonwood materials covered include kenaf stalks, flax shives, jute stalks, bagasse, rice husks and straw, wheat straw, rye straw, oat straw, and barley straw.

661. Chow, P.; Bagby, M.O.; Youngquist, J.A. 1992. Furniture panels made from kenaf stalks, wood waste, and selected crop fiber residues. In: Proceedings of the 4th annual International Kenaf Association conference; 1992 February 5-7; Biloxi, MS. p. 28.

Summary: This study was conducted in two parts. Part one determined the effect of density levels (0.64 to 0.72 g/cm^3), resin type (urea formaldehyde and phenol formaldehyde), and resin content on the physical and mechanical properties of particleboard made from kenaf (*Hisbiscus cannabinus*) stalks. Board specimens were tested for modulus of rupture and modulus of elasticity in bending, internal bond, tensile stress parallel to grain, screw holding power, and linear expansion properties. The aim of part two was to produce furniture panel boards made from a mixture of kenaf stalk and plant fiber residue (wood wastes, cornstalks, corncobs, and sunflower seed hulls). Only the urea-formaldehyde resin (7 percent) was used in this study. The melamine laminate face and back were used as overlays on board specimens. Test results indicated that good particleboard and laminated furniture panel could be made from both kenaf stalks and a mixture of kenaf stalk and crop residue.

(Also see references 73, 83, and 487.)

Fiberboard/Hardboard

662. Bagby, M.O.; Clark, T.F. 1976. Kenaf for hardboards. TAPPI C.A. Rep. 67. Atlanta, GA: TAPPI Press: 9-13.

Summary: Frost-killed kenaf was evaluated as a hardboard raw material, and trial results demonstrated its use to be technically feasible. Boards with densities of 0.78 to 1.15 g/cm^3 had tensile strengths ranging from 20.5 to 76.9 MPa. The boards compared favorably with wood (loblolly pine) derived hardboards having densities of 1.02 g/cm^3 and tensile strengths of 35.0 MPa.

663. Ngatijo, B.; Priyadi, T.; Sujono, R. 1990. Manufacture of ceiling boards on a small industrial scale using kenaf pulp as fibrous material. Berita Selulosa. 26(3): 63-69. [Indonesian].

Summary: Ceiling board was prepared on a pilot-plant scale using kenaf as the fibrous material. Kenaf was pulped by the cold soda process with total alkali varying from 0 to 15 percent. The pulps obtained were used to make ceiling board of several compositions. The amount of total alkali and the composition of the ceiling board raw materials affected the physical properties of the board. The bending strength of a ceiling board having composition of 50 percent cement, 42 percent lime, and 8 percent pulp originating from a cooking process with 10 and 15 percent NaOH was similar to that of a board made of staple components. As the cement and lime contents were changed to 60 and 32 percent, respectively, the bending strength became greater than that of staple boards.

664. Youngquist, J.A.; Rowell, R.M.; Ross, N.; Chow, P. 1991. Dry-process hardboard made from pressurized refiner processed kenaf stalks. In: Proceedings of the 3d annual International Kenaf Association conference; 1991 February 28-March 2; Tulsa, OK. p. 25.

Summary: The physical and mechanical properties of 3.1-mm-thick, dry-process acetylated kenaf hardboards were

studied for the effects of fiber type (hammermilled versus pressurized refiner processed), resin content (two levels), and wax content (two levels). Modulus of elasticity, modulus of rupture, tensile stress parallel to the grain, thickness swelling, and water absorption of the hardboard specimens were determined. Test results indicated that all independent variables, which included fiber type, resin content, and wax content, significantly affected most properties of these dry-process hardboards made from kenaf stalks.

(Also see reference 660.)

Insulation Board

(See reference 660.)

Cement/Gypsum/Plaster Board

(See reference 663.)

Unknown Board

665. Niedermaier, F.P. 1976. Technology, engineering and machinery for manufacturing panelboard from non-wood materials. In: TAPPI nonwood plant fiber pulping progress report 7. Atlanta, GA: TAPPI Press: 49-66.

Summary: This paper presents an excellent review of nonwood fiber usage in the panelboard industry and covers processing, engineering considerations, and machine requirements for a wide range of fibrous materials. Nonwood materials covered include kenaf stalks, flax shives, hemp shives, jute stalks, sisal stalks, theil stalks, ramie stalks, bagasse, cotton stalks, bamboo stalks, reed, palm leaves and stalks, rice husks, and vine stalks.

(Also see reference 3.)

Miscellaneous

Material Preparation/Pulping/Storage Methods

(See reference 73.)

General Information/Reviews

666. Chow, P.; Youngquist, J.A. 1993. Selected literature review on the utilization of kenaf (1950-1992). In: Proceedings of the 1993 international kenaf conference; 1993 March 3-5; Fresno, CA: 91-96.

Summary: This paper is a literature review of 56 citations (35 with summaries) on using kenaf.

667. Clark, T.F.; Cunningham, R.L.; Lindenfeiser, L.A.; Wolff, I.A.; Cummins, D.G. 1970. Search for new fiber crops. XVI. Kenaf storage. In: TAPPI C.A. Rep. 34. Atlanta, GA: TAPPI Press: 107-132.

Summary: This paper describes methods of storing and preserving kenaf which allow year-round operation of a pulp or board mill.

668. Youngquist, J.A.; English, B.E.; Spelter, H.; Chow, P. 1993. Agricultural fibers in composition panels. In: Proceedings of the 27th international particleboard/composite materials symposium; 1993 March 30-April 1; Pullman, WA. Pullman, WA: Washington State University: 43 p.

Summary: A review was provided concerning the use of kenaf, bagasse, straw, cornstalks, corncobs, rice husks, and sunflower stalks and seed hulls in panel board production.

(Also see reference 659.)

Megass

Cement/Clay/Gypsum/Plaster Materials

669. Hess, A.A.; Buttice, M.L. 1990. Composite materials from vegetable fibres as agglomerated irregular micro-reinforcement and Portland cement used in pieces for low-cost housing. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 69-76.

Summary: This paper presents the results of a study on the physical and mechanical behavior of micro-concrete containing vegetable fibers as irregular reinforcement. The fiber studied was megass (the husk from *Sacharus officinarum*). Megass is used for making paper, cattle feed, or fuel. Specimens were produced and tested for flexural, compression, and indirect tension properties. It was found that nonstructural boards could be produced with Portland cement and megass mixtures that could be used as partitions and walls.

Mustard [Stalk]

Panel Board

Fiberboard/Hardboard

670. Narayanamurti, D.; Kohli, R.C. 1961. Hardboards from mustard stalks. Indian Pulp and Paper. 16(6): 379.

Summary: Hardboards were made from mustard stalks using lime or caustic soda as the cooking medium. The strength properties of the boards were inferior to those of boards made from jute sticks, and their moisture absorption was rather high. However, some of the boards were satisfactory. Lime-cooked material produced better boards.

Unknown Board

(See references 3 and 784.)

Oats [Hull, Straw]

Panel Board

Particleboard

(See reference 660.)

Fiberboard/Hardboard

(See reference 660.)

Insulation Board

(See reference 660.)

Unknown Board

671. Eger, E. 1951. Construction board. Patent, P.N.: US 2550143, I.D.: unknown.

Summary: The use of oat hulls in the construction of boards is discussed.

Molded Masses

Refractory Materials

(See reference 961.)

Miscellaneous

General Information/Reviews

(See reference 1003.)

Palm [Catolé Palm, Fruit Palm, Oil Palm]

Panel Board

Particleboard

672. Chittenden, A.E. 1973. Particle board from date palm (*Phoenix dactylifera*). London, England: Tropical Products Institute. 8 p.
(no abstract available)

673. Deppe, H.J.; Hoffmann, A. 1977. Germany's B.A.M. tests Catolé palm wood, finds it can make good particleboard. World Wood. 18(4): 36-37.

Summary: Catolé palm from southern Brazil was used for particleboard production and tested at the German Federal Institute for Materials Testing, resulting in positive results. Urea formaldehyde, phenol formaldehyde, isocyanate, and a urea/melamine/phenol formaldehyde mix were used as binders. Manufactured board thickness was 16 mm. Bending and internal-bond strengths ranged from 23 to 33 MPa and 0.59 to 0.85 MPa, respectively. Board thickness swell after 24 h of water soaking was never greater than 9 percent. Board moisture content averaged 10 percent.

(Also see references 53 and 83.)

Fiberboard/Hardboard

(See reference 860.)

Plastic/Plastic-Bonded Board

(See reference 1026.)

Unknown Board

(See references 3, 190, 665, and 1027.)

Cement/Clay/Gypsum/Plaster Materials

674. Cabrera, J.G.; Nwaubani, S.O. 1990. Experimental methods for the preparation of palm fruit and other natural fibres for use in reinforced cement composites. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 29-36.

Summary: This paper reviews methods of extracting oil, total carbohydrates, and alkali-soluble carbohydrates, and preparing palm fruit fibers, grass, sugarcane, and maize fibers for use as reinforcement for cement. Preliminary data of extraction experiments are included and a tentative set of requirements for acceptance of these natural fibers for use in cement composites was proposed.

675. Salam, S.A. 1982. Lightweight concrete made from palm oil shell aggregates and rice husk. In: Regional seminar on technology, utilization, and management of agricultural wastes. Malaysia: UPM.
(no abstract available)

676. Salam, S.A. 1984. Structural concrete using industrial wastes as aggregates, National seminar on management and utilization of industrial wastes. Malaysia: United Nation Educational Scientific and Cultural Organization-UPM.
(no abstract available)

677. Salam, S.A. 1987. Oil palm shell aggregate concrete for low-cost building. In: Building materials for low-income housing: Proceedings of a symposium; 1987 January 20-26; United Nations, Bangkok, Thailand. London, England: E. and F.N. Spon Ltd.: 40-46.

Summary: Oil palm shell was utilized as coarse aggregate for producing lightweight concrete, reducing the dead load significantly. Utilization of oil palm shell reduced the problem of disposing huge waste piles at oil palm factories,

and provided a significantly less costly building material to the market. Although organic, the shell will not deteriorate once encapsulated into the concrete. The concrete has better insulation properties than normal concrete and has been used successfully to make slabs, beams, and columns of buildings.

(Also see reference 456.)

Papyrus

Panel Board

Particleboard

678. McGovern, J.N. 1981. Bonding in papyrus-like mats from pith section of certain plants. In: Proceedings of pulping conference; Madison, WI: 55-60.

Summary: Papyrus-like, cross-laminated mats were made from the pith sections of 22 plants, including papyrus, cornstalk, sugarcane, and sunflower stalks. Chemical compositions and tensile-strength properties were determined for papyrus, cornstalk, and kung shu (rice paper tree), with the samples prepared by press drying under ambient and elevated temperatures, and the results were compared with similarly prepared sheets from a high-yield sweetgum-kraft pulp. The bonding in the mats made from pith section of these plants was of a papermaking type associated with their hemicelluloses. A medium-density fiberboard, made from cornstalks by chipping, coarse fiberizing, moist forming, and hot pressing, met strength standards for industrial-grade hardboard.

Fiberboard/Hardboard

(See references 678, 679, and 680.)

Insulation Board

679. Lewin, M.; Lengyel, A. 1957. Papyrus as a raw material for the production of insulation board and hardboard. Food and Agriculture Organization of the United Nations Doc. (FAO) FAO/ECE/BOARD CONS/Paper 4.14. Fiberboard and particleboard. Report of an international consultation on insulation board, hardboard, and particleboard. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

Summary: Insulating board and hardboard have been made from papyrus both on a laboratory scale and in a pilot plant run in Israel. The physical properties of the boards were satisfactory.

680. Lewin, M.; Lengyel, A. 1958. Papyrus as a raw material for the production of insulation and hardboard. Bulletin of the Research Council of Israel. 6C(3): 181-196.

Summary: Insulation board and hardboard were made from Israeli papyrus having 37.5 percent rind and 29.5 percent pith. Suitable pulps were obtained by cooking with water at 150°C and a fiber:liquor ratio of 1:1, and subsequently refined in disk refiners. The refined and screened pulp was sheeted on an Oliver forming cylinder at 3.048 m/min and dried at 165°C to 170°C in a Coe drier to give insulation board. For the manufacture of hardboard, the wet mat was hot pressed at 200°C and 9.8 MPa for 6 min. The boards met British Standard specifications.

681. McGovern, J.N. 1982. Bonding in papyrus and papyrus-like mats. Tappi. 65(5): 159-162.

Summary: Bonding in mats made from pith sections of *Cyperus papyrus,* cornstalk, and *Tetrapanex papyriferum* was a result of hemicellulose adhesion in the compacted, continuous network of parenchyma cells as implemented by press-drying. The woody fibrovascular bundles in parenchyma cells were nonbonding but added structural strength to the cross-laminated mats, and hot-press drying enhanced the mat strength in a mechanism similar to that for hardboard kraft pulps. A fiberboard made from moist, defibered cornstalks met strength standards for industrial grade hardboard.

Cement/Gypsum/Plaster Board

682. Al-Makssosi, K.S.J.; Kasir, W.A. 1990. Preliminary work to produce papyrus-cement composite board. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 193-198.

Summary: This paper presents the results of research examining the influence of papyrus particle size and board density on the mechanical and physical properties of papyrus-cement board. Boards were classified on the basis of two papyrus particle sizes and two boards densities. Testing according to ASTM D 1037, included bending, internal bond, compression parallel, water absorption, and thickness swelling. Moduli of rupture and elasticity were found to be better in boards with higher density. Internal bond and thickness swell were found to be best in boards with smaller particles regardless of the density. The combination of small particles and high board density yielded the highest values for maximum crushing strength.

Unknown Board

683. Barkworth, G.E.; Coomber, H.E. 1946. Papyrus from Palestine. Bulletin Imp. Institute. 44(4): 279-286 and Paper Maker. 114(1): 12-16.

Summary: Papyrus from Palestine was examined as a raw material for board and paper. Experimental results indicated that the manufacture of boards for cartons and containers, or a board for building purposes is promising.

(Also see references 3 and 190.)

Peanut [Hull, Shell]

Panel Board

Particleboard

684. Anonymous. 1944. Low-cost products from the lowly peanut hull. Modem Industry. 8(6): 48, 137.

Summary: This article reports that building boards and other products can be made from peanut hulls by crushing them and binding the particles together with latex or other adhesives. The boards have considerable strength and stiffness.

685. Anonymous. 1975. High strength building panels based on crushed peanut shells-bonded with urea-formaldehyde adhesive. Assignee: (THEB/) J Thebaut. Patent, P.N.: FR 2235793, I.D.: 750307. [French].

Summary: Strong self-supporting building and facing panels were made by coating crushed peanut shells with a binder, such as urea-formaldehyde resin, and a catalyst and curing the mass under heat and pressure into a panel. The resulting panels are free from layers and sites for internal rupture, and may be used as ceiling and wall paneling.

686. Chen. C.M. 1980. Alkali extracts from peanut shells and pecan cores-used in preparation of phenolic resin binders for plywood and particle boards. Assignee: (CHEN/) Chen, C. M. Patent, P.N.: US 4201699, I.D.: 800506.

Summary: Extracts are obtained by treatment with alkali to yield an aqueous solution or suspension containing $\geq$2 percent by weight protein, based on extracted organic materials. Extraction is with aqueous alkali at 20°C to 400°C. Phenolaldehyde resins are made from reaction of 1 part (based on dry weight) of the extract, with 0.1 to 1.6 parts aldehyde in an aqueous alkali system at 30°C up to reflux temperature until viscosity of 250 to 1500 cP at 25°C is achieved and are used as a partial or complete replacement for phenol in preparation of binders for manufacture of plywood, particleboards, and the like.

687. Chen, C.M. 1982. Bonding particleboards with the fast curing phenolic-agricultural residue extract copolymer resins. Holzforschung. 36(3): 109-116.

Summary: Fast-curing phenolic copolymer resins made of agricultural residue extracts were investigated in bonding homogeneous particleboard, oriented strandboard, and composite panels made of flakeboard cores with veneer faces. In bonding 1.6-cm homogeneous southern pine particleboards, copolymer resins of peanut hull or pecan pith extracts gave internal bond strengths of 1.4 MPa and a modulus of rupture in excess of 15.2 MPa with 5 min press times at 182°C. The resorcinol-catalyzed commercial control resins needed press times longer than 6 min to achieve similar qualities. For 1.3-cm three-layer oriented strandboards, these two copolymer resins reached a 392.2 kPa internal bond with a press time of 3 min at 180°C in comparison to a 294.2 kPa internal bond with a 4 min press time for a commercial phenol formaldehyde control resin.

688. Pablo, A.A.; Perez, E.B.; Ella, A.B. 1975. Development of particleboard on a pilot-plant and semi-commercial scale using plantation and secondary wood species and agricultural fibrous waste materials, 10: mixtures of peanut shells and wood particles. Los Banos, Philippines: Forest Products Research and Industries Development Commission, Laguna College of Forestry, University of the Philippines. 17 p.
(no abstract available)

(Also see reference 487.)

Fiberboard/Hardboard

(See references 857, 862, and 863.)

Plastic/Plastic-Bonded Board

689. Maldas, D.; Kokta, B.V.; Nizio, J.D. 1992. Performance of surface-modified nutshell flour in HDPE composites. International Journal of Polymeric Materials. 17(1/2): 1-16.

Summary: Nutshells of mesh sizes 100, 200, and 325 were modified by polymer grafting with 1 to 3 percent by weight maleic anhydride, 1 percent by weight of filler dicumyl peroxide, and 5 percent by weight of filler HDPE. The mechanical properties of both compression-molded and injection-molded composites containing HDPE and modified and unmodified nutshells were studied. The mechanical properties of modified nutshell-filled composites were generally higher than those of unmodified ones. Strength and modulus of modified nutshell-filled composites improved even compared to those composites made with unfilled polymer. Experimental results, as well as cost analysis, indicated that surface-modified nutshells are a potential reinforcing filler for thermoplastic composites.

690. Raj, R.G.; Kokta, B.V.; Nizio, J.D. 1992. Studies on mechanical properties of polyethylene-organic fiber. Journal of Applied Polymer Science. 45(1): 91-101.

Summary: Composites were made from polyethylene and organic fibers from peanut-shell and peanut-hull flour using a compression-molding technique. Studies of variation in molding temperature (140°C to 180°C), fiber concentration (0 to 40 percent by weight), and fiber mesh size (100,200, and 325) were correlated to the mechanical properties of the composites. In untreated nutshell composites, tensile strength decreased steadily as the concentration of the fiber increased, due to poor bonding between the untreated fiber and the polymer. Polyisocyanate was used as the adhesive system, and its affect on the mechanical properties of the composites was studied. The adhesive made a significant improvement in the tensile strength of the board but had no effect on the modulus of the composite.

Unknown Board

(See references 3, 182, and 517.)

Molded Masses

Plastics

691. Lightsey, G.R.; Mann, L.; Short, P.H. 1978. Evaluation of polypropylene/peanut-hull-flour composites. Plastics and Rubber: Materials and Applications. 3(2): 69-73.

Summary: Samples of peanut-hull flour from two commercial sources were tested as a filler in polypropylene. Infrared spectra of the peanut-hull flour surface indicated a primarily lignin-type, nonpolar surface. Composites of peanut-hull flour and polypropylene at up to 35 percent loading by weight of filler were injection-molded into test specimens and tested. Tensile strength was reduced at a loading level greater than 15 percent. Flexure strength is essentially unchanged at filler loading levels up to 25 percent while the flexure modulus is increased up to 35 percent at a high loading. The compatibility of peanut-hull flour with polypropylene is believed to result from the nonpolar, lignin-type filler surface.

Resins/Binders

692. Chen, C.M. 1980. Organic phenol extract compositions of peanut hull agricultural residues and method. Patent; P.N. US 4200723, I.D.: 800429.

Summary: Aldehyde condensation products with alkali extracts of peanut hulls and pecan pith are useful as bonding agents for plywood or particleboard. Thus, 160 g powdered peanut hull and 1,600 g of 5 percent aqueous NaOH were heated for 17 h at 90°C to 95°C and then filtered. The process was repeated several times, and the extracts were combined for resin preparation.

693. Chen, CM. 1980. Phenol-aldehyde resin composition containing peanut hull extract and aldehyde. Assignee: Chen, C. M. Patent, P.N.: US 4201700, I.D.: 800506.

Summary: Phenolic-resin compositions consisting of the condensation product of an aldehyde with alkali extracts of peanut hull and pecan pith were useful in adhesive compositions for plywood and particleboard. Thus, 160 g powdered peanut hull and 1,600 g of 5 percent aqueous NaOH were heated for 17 h at 90°C to 95°C and then filtered. The process was repeated several times, and the extracts were combined for resin preparation.

694. Chen, CM. 1981. Gluability of copolmer resins having higher replacement of phenol by agricultural residue extracts. Industrial Engineering Chemical Products Research and Development. 20(4): 704-708.

Summary: Phenolic resins with greater than 50 percent by weight of the standard phenol replaced by the NaOH extracts of peanut hulls and pecan nut piths were evaluated by gluing southern pine plywood and three-layer oriented strandboards. Evaluation of southern yellow pine gluelines indicated that the copolymer resins retained their fast curing characteristics even though 60 percent by weight of the standard phenol had been replaced by the extracts. In bonding the oriented strandboards, three copolymer resins with 60, 80, and 100 percent by weight of their standard phenol replaced by the peanut hull extracts were evaluated. The copolymer resin with 60 percent by weight of phenol replacement exhibited superior bonding qualities compared with commercial resin. The resins with 80 and 100 percent by weight phenol replacement were possibly precured during the redrying process after the strands were coated with resins due to the excessive moisture content in the mat.

(Also see reference 686, 687, and 993.)

Miscellaneous

Loose Insulation

695. Kaiser, W.L. 1986. Manufacturing insulation from peanut hulls by grinding and screening then using coarse for blown insulation and fine for panels. Assignee: (KAIS/) Kaiser, W. L. Patent, P.N.: US 4572815, I.D.: 860225.

Summary: Peanut hulls are ground to produce a minimum of fines by screening through a coarse screen of about 4 mesh/ 2.54 cm, regrinding the retained material, screening passing material with a medium screen of 8 mesh/2.54 cm, and using the retained material-which is about 50 percent of the initial amount-for blown insulation in building walls. Binder is added to material retained on the fine screen and the mixture used to form panels. Material passing the fine screen is mixed with binder and used to form a second grade of panel. Suggested binder is sodium silicate.

Pecan

Molded Masses

Resins/Binders

(See references 686, 687, 692, 693, and 694.)

Pineapple [Leaf]

Panel Board

Plastic/Plastic-Bonded Board

(See references 1025 and 1026.)

Unknown Board

(See reference 3.)

Cement/Clay/Gypsum/Plaster Materials

(See reference 338.)

Molded Masses

Rubbers

696. Bhattacharyya, T.B.; Biswas, A.K.; Chatterjee, J.; Pramanick, D. 1986. Short pineapple leaf reinforced rubber composites. Plastics and Rubber Processing and Applications. 6(2): 119-125.

Summary: Pineapple leaf fibers influence on natural rubber was studied with respect to fiber-rubber adhesion, anisotropy in physical properties, processing characteristics, aging resistance, and comparative changes in physical properties and processing characteristics between HAF black, reinforced rubber compound and pineapple-leaf fiber-reinforced rubber composites. The replacement of carbon black partly in pineapple leaf fiber decreased optimum cure time, tensile strength, and elongation at break, and increased shore A hardness significantly. Carbon-black pineapple leaf fiber reinforced rubber composites would be suitable where high hardness, low elongation, moderate tensile strength, and moderate flex resistance are required.

Plant/Vegetable Fiber [Unidentified]

Panel Board

Particleboard

697. Chittenden, A.E. 1970. Historical outline of past research on the production of boards from agricultural wastes and future trends. United Nations Industrial Development Organization Doc. (UNIDO) ID/WG.83/2 and Corr. 1. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 28 p.

Summary: This paper discussed the possibilities for using agricultural wastes as a raw material for the manufacture of fiberboards, particleboards, and similar products. A checklist of agricultural waste materials tested for board making, a table of the number and production capacity of plants using agricultural wastes for board production, and a bibliography including 128 references are appended.

698. Chow, P. 1975. Fibreboard sandwich panels from fibrous plant residues-made by one step pressing and heating stage. Patent, P.N.: US 3927235, I.D.: 751216.

Summary: Sandwich particleboard panels are comprised of an inner core layer formed in a one-stage heating and pressing step from a mat consisting of at least 50 percent exo-s-plant fibers of predominately smaller than 30-mesh Tyler screen size, total fiber dry weight basis; moisture content of 6 to 18 percent, total weight basis; and two face layers enclosing the inner core, containing as a major ingredient s-plant fibers bonded with an adhesive. Scrap fibrous plant material is used to replace expensive softwoods in the production of particleboards.

699. FAO. 1958. Fibreboard and particle board. Report of an international consultation on insulation board, hardboard, and particleboard; 1957 January 21-February 4; Geneva, Switzerland. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). 190 p.

Summary: The FAO report discussed product description, nomenclature, and definitions, raw materials (including nonwood fibrous raw materials), processes and equipment, economic aspects of production and marketing, application, and uses, and research needs. A survey of testing methods and a list of mills and trade associations are appended.

700. Kuczewski de Poray, M. 1979. Fermentation treatment of wood and agricultural wastes for manufacture of particle boards, etc. Patent, P.N.: FR 2421039, I.D.: 791026. [French].

Summary: Agricultural wastes or wood chips are partially fermented in an apparatus where the growth of microorganisms is controlled by air circulation that maintains the optimum temperature for growth to give particulate products that are crosslinkable by a binder for the manufacture of particleboards and similar products.

Fiberboard/Hardboard

701. Lasmarias, V.B. 1985. Process of producing water-resistant laminated hardboard. NSTA Technology Journal 10(3): 84-85.

Summary: The process involves pulping chips of wood or agricultural fibrous material in a defibrator in 892.3 to 931.6 kPa steam and refining the resulting pulp in a disk refiner to a freeness of 22 to 26 s. The refined pulp is then formed into sheets in a mold and cold pressed to approximately 65 percent moisture content. The overlay is prepared by mixing air-dried wood/agricultural waste and PVC formulation in a weight ratio of approximately 60:40 to 40:60. Approximately 60 g of the overlay are spread on top of the cold-pressed sheet, which is backed by a fire screen and a stainless steel caul plate at the bottom and on top of the overlay. The overlaid sheet is then hot pressed at 100°C to 200°C and a plate pressure of 70, 10, and 6.9 MPa for 9 to 12 min, cold pressed at 490.3 kPa for 3 min, and subjected to a curing period of 2 to 3 days to effect complete polymerization.

702. Lepeut, M. 1970. The dry process for the production of fibreboards. ID/WG.83/6. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 12 p. [French].

Summary: The advantages of the dry process for the production of fiberboard as to the wet process are outlined. Although experience is limited with raw materials other than wood, there should be no difficulties with agricultural wastes.

703. Lowgren, U. 1976. History and application of the Asplund defibrator for fiberboard production from non-wood materials. In: TAPPI nonwood plant fiber pulping progress rep. 7. Atlanta, GA: TAPPI Press: 67-70.
(no abstract available)

704. Narayanamurti, D. 1961. Fibre boards. Indian Pulp and Paper. 16(1): 29-50.

Summary: A review was given of the research conducted on the production of fiberboards from raw materials indigenous to India. The manufacturing processes used were described and statistics on the properties of fibrous materials and finished boards were presented.

705. Stillinger, J.R.; Wentworth, I. 1976. Bison endless systems for producing non-wood fiber panelboard. In: TAPPI nonwood plant fiber pulping progress rep. 7. Atlanta, GA: TAPPI Press: 71-84.
(no abstract available)

706. Vanbever, M. 1975. Process for manufacturing hot-pressed boards of plant fibers. Assignee: Solvay and Cie. Patent, P.N.: DE 2500410, I.D.: 750717. [German].

Summary: This patent describes a process for manufacturing hot pressed boards of plant fibers. The process involves forming a mat consisting of a mixture of 50 to 90 percent, by weight, of plant fibers and 10 to 50 percent of synthetic staple fibers, heating the mat to a temperature above softening point of the synthetic fibers, and pressing the hot mat.

(Also see references 697 and 699.)

Cement/Gypsum/Plaster Board

707. Elmendorf, A. 1943. Cement-fiber board. Patent, P.N.: US 2332703, I.D.: 431026.

Summary: This board consists of a skeleton-like porous slab formed from vegetable fibers coated with an inorganic cement.

708. Exner, G.; Dietrich, J. 1990. Fiber-reinforced, cement-bonded building materials. Assignee: Fulgurit Baustoffe GmbH. Patent, P.N.: DE 3902595, I.D.: 900503. [German].

Summary: Boards used as building materials are composed of natural fibers and/or inorganic and/or synthetic fibers. The boards have long service life, regardless of the type of fibers used.

709. Klar, G.V.; Vankov, P.I. 1967. "Arbolite" with a modified structure. Lesnaya Prom. 47(8): 27-28. [Russian].

Summary: Arbolite construction boards were made of Portland cement with a cellulosic filler, such as wood particles or milled agricultural residues. The mechanical strength was low for use under high load without additional reinforcement. Experiments were carried out to determine if filler particle orientation increased the mechanical properties of the Arbolite. Orientation increased the bending strength by over 50 percent, but reduced it in the transverse direction. Water absorption was not affected by filler orientation.

710. Sandermann, W. 1970. Technical processes for the production of wood-wood/cement boards and their adaptation for the utilization of agricultural wastes. United Nations Industrial Development Organization Document (UNIDO) ID/WG.83/4 and Corr. 1. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 21 p.

Summary: This report describes technical processes used in manufacturing cement-bonded boards and building blocks, and the availability of agricultural residues and their suitability for producing cement-bonded products. Certain fibrous materials contain cement-setting inhibitors, making the production of satisfactory boards difficult.

711. Sandermann, W.; Kohler, R. 1964. Studies on mineral-bonded wood products. IV. A rapid test to determine whether an industrial wood is suitable for admixture with cement. Holzforschung. 18(1/2): 53-59. [German].

Summary: Wood extractives, such as tannins, coloring materials, and carbohydrates, inhibit the setting of cement. It is impossible to make cement-bonded panels of satisfactory strength from wood or other fibrous material that contains a certain amount of these inhibiting agents. To determine which raw material could be used satisfactorily, a rapid test method was devised for measuring the heat of hydration of mixtures of wood meal, cement, and water. The woods well-suited for admixture with cement gave rise to maximum hydration temperatures of 60°C; useless woods gave temperatures below 50°C. The measuring device used is described in detail.

712. Swamy, R.N. 1990. Vegetable fibre reinforced cement composites-a false dream or a potential reality? In: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 3-8.

Summary: Coverage of plant fiber usage in the production of cement composites is described. The paper also covers the weaknesses of the fibers, such as low modulus, lack of interfacial bond strength, and long term stability.

713. Taneja, C.A. 1971. Fibrous gypsum plaster boards. Building Materials Note 11. Roorkee, India: Central Building Research Institute: 1-60.
(no abstract available)

714. UNIDO. 1988. Vegetable-fibre cement board. United Nations Industrial Development Organization (UNIDO) Doc. 10.13.57 p.
(no abstract available)

715. Zou, W.; Qiu, C.; Zheng, M.; Mingiu, Q. 1990. Plant fiber-cement composite boards and their preparation. Assignee: Shandong College of Building Material Industry. Patent, P.N.: CN 1038631, I.D.: 900110. [Chinese].

Summary: The patent describes composite boards made of (in percent by weight) 20 to 70 percent plant fibers, 30 to 80 percent cement, 50 to 70 percent water, 1 to 4 percent auxiliary reagent, and 3 to 10 percent adhesive. The raw material is hot pressed at 2.9 to 4.9 MPa and 70°C to 170°C for 4 to 10 min. Then it is stored in ambient conditions for 15 to 28 days or cold pressed at 1.6 to 2.9 MPa and ambient temperature for 15 to 28 days. The pressed composite boards are then cured at 50°C to 80°C for 12 to 18 h so that the water content in the boards is compatible with that of conventional concrete boards.

Roofing Board

716. Andersson, R. 1987. Roofing tiles made of mortar reinforced with natural fibres. Report 87074. Stockholm, Sweden: Swedish Cement and Concrete Research Institute, Consultant Section. 60 p.
(no abstract available)

717. Andersson, R.; Gram, H.E. 1986. Roofing sheets made of mortar reinforced with natural fibres. Report 8607. Stockholm, Sweden: Swedish Cement and Concrete Research Institute, Consultant Section. 32 p.
(no abstract available)

718. Gram, H.E. 1988. Natural fibre concrete roofing. In: Swamy, R.N., ed. Natural fibre reinforced cement and concrete. Glasgow, Scotland: Blackie and Son Ltd.: 256-285. Chapter 8.

Summary: The use of natural plant fibers for the production of concrete roofing materials is discussed. The report describes the properties of natural fiber concrete, production methods, various products, expected service-life loads, and product cost.

719. Lola, C.R. 1985. Fibre reinforced concrete roofing sheets. Technology Appraisal Report. Washington, DC: AT International, Save the Children Federation. 28 p.
(no abstract available)

720. Lola, C.R. 1986. Fibre reinforced concrete roofing sheets: a technology appraisal. In: Proceedings of the 10th triennial congress of CIB; 1986 September; Washington, DC: 2131-2139.
(no abstract available)

721. Parry, J.P.M. 1979. Low-cost handmade roof sheets of fibre-reinforced cement. Appropriate Technology. 5: 6-7.
(no abstract available)

722. Parry, J.P.M. 1984. Fibre cement roofing. The technical record of the development and overseas field trials between 1977-84 of the low cost building material of the future. Cradley Heath, United Kingdom: IT Workshops. 73 p.
(no abstract available)

723. Schilderman, T. 1990. From research to dissemination of fibre concrete roofing technology. In: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 204-213.

Summary: An overview of the use of plant fibers utilized in concrete roofing elements and economic data are provided. Additionally, the technology involved with decreasing the brittleness of the concrete through time is discussed.

Unknown Board

724. Agopyan, V. 1987. Fibre/agro-industrial by-products bearing walls-1st progress report. Sao Paulo, Brazil: IPT-IDRC. 35 p.
(no abstract available)

725. FAO. 1975. Review of agricultural residues utilization for production of panels. FO/WCWBP/75 Doc. 127. New Delhi, India: Food and Agriculture Organization of the United Nations (FAO) World Consultation on wood based panels.
(no abstract available)

726. Linto, L. 1978. Panels, paper, and paperboard from agricultural residues. Unasylva. 29(118): 12-17.
(no abstract available)

727. **Neusser, H.** 1970. Standards and quality control for panels made from agricultural wastes. United Nations Industrial Development Organization Doc. (UNIDO) ID/WG.83/7. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 26 p.

Summary: This article emphasizes the importance of effective production control in the manufacture of panels from wood and agricultural residues. The main properties to be controlled are specified, while considering different types of panels, and referring to ISO and various national testing methods and quality standards. Although production control is expensive, it can contribute to the profitability of the plant.

728. UNIDO. 1972. Production of panels from agricultural residues. Report of the Expert Working Group meeting; 1970 December; Vienna, Austria. United Nations Industrial Development Organization (UNIDO). Doc. ID/79 (WG.83/15/Rev. 1). New York: UN Publication Sales E.72.II.B.4.
(no abstract available)

729. Walters, C.S. 1971. Wood scientists make boards from plant residues, Urbana, IL: Illinois Research: 13(1): 11. (no abstract available)

(Also see references 749, 757, 758, 778, and 780.)

Cement/Clay/Gypsum/Plaster Materials

730. Agopyan, V.; Cincotto, M.A.; Derolle, A. 1989. Durability of vegetable fibre reinforced materials. In: CIB Congress 11, quality for building users throughout the world. Theme II, Vol. I. Paris, France: 353-363. (no abstract available)

731. Ali, A.A.A. 1982. Utilization of agricultural wastes as aggregates for low-cost construction materials. In: Proceedings of a seminar on the technology, utilization, and management of agricultural wastes; 1982 September 15-17; Serdang, Selangor, Malaysia: 127-142.

Summary: Preliminary investigation into using agricultural wastes as aggregates for special concrete, otherwise termed light-weight concrete, produced positive results. It is envisaged that special concrete can find applications in low-cost housing and farm structures.

732. Aziz, M.A.; Paramasivam, P.; Lee, S.L. 1981. Prospects for natural fibre reinforced concretes in construction. International Journal of Cement Composites and Lightweight Concrete. 3: 123-132. (no abstract available)

733. Aziz, M.A.; Paramasivam, P.; Lee, S.L. 1984. Concrete reinforced with natural fibres. In: Swamy, R.N., ed. New reinforced concretes. Glasgow, Scotland: Blackie and Son Ltd.: 106-140. (no abstract available)

734. Bergström, S.G.; Gram, H.E. 1984. Durability of alkali-sensitive fibres in concrete. International Journal of Cement Composites and Lightweight Concrete. 6(2): 75-80. (no abstract available)

735. Canovas, M.E.; Kawiche, G.M.; Selva, N.H. 1990. Possible ways of preventing deterioration of vegetable fibres in cement mortars. In: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 120-129.

Summary: The study of the intensive revision of the structure of vegetable fiber used in mortars to reduce brittleness with age is described. The study examined the use of impregnants as possible means to block water penetration in the fiber and their reactions with alkalis. Experimental results are also given.

736. Castro, J.; Naaman, A.E. 1981. Cement mortar reinforced with natural fibres. ACI Journal. 78: 69-78. (no abstract available)

737. Cook, D.J. 1980. Concrete and cement composites reinforced with natural fibres. In: Proceedings of symposium Concrete International: CI-80 Fibrous concrete; Lancaster, England: 99-114. (no abstract available)

738. Dove, L.P. 1945. Building materials from Portland cement and vegetable fiber. Corvallis, OR: Forest Research Laboratory, College of Forestry, Oregon State University: 24 p. (no abstract available)

739. Gram, H.E. 1983. Durability of natural fibres in concrete. Swedish Cement and Concrete Research Institute, S-100444. CBI FO 1.83. Stockholm, Sweden. 255 p. (no abstract available)

740. Gram, H.E.; Persson, H.; Skarendahl, A. 1984. Natural fibre concrete. SAREC Report R2: 1984. Stockholm, Sweden: Swedish Agency for Research Cooperation with Developing Countries. 139 p. (no abstract available)

741. Guimaraes, S.S. 1984. Experimental mixing and moulding with vegetable fibre reinforced cement composites. In: Ghavami, K.; Fang, H.Y., eds. Proceedings of the international conference on development of low-cost and energy saving construction materials; 1984 July; Rio de Janeiro, Brazil: 37-51. (no abstract available)

742. Guimaraes, S.S. 1987. Some experiments in vegetable fibre-cement composites. In: Building materials for low-income housing in Asia and the Pacific. Bangkok, Thailand: SCAP/RILEM/CIB: 167-175. (no abstract available)

743. Guthrie, B.M.; Torley, R.B. 1983. Composite materials made from plant fibers bonded with Portland cement and method of producing same. Assignee: Permawood International Corp. Utility, P.N.: US 4406703, I.D.: 830927.

Summary: This patent describes a method of producing composite building materials from a mixture of plant fibers bonded with Portland cement. Plant fibers, cement, and soluble silicates in certain proportions are mixed and heated under pressure for a short period to get a physically stable product that can be cured under atmospheric conditions to full strength. The plant fibers may initially be pretreated with an aqueous solution containing dichromate or permanganate ion prior to adding the cement to negate the adverse effects of set-inhibiting water-soluble compounds in the fiber. Other chemicals may be added to modify the reaction and improve the product.

744. Krishnamoorthy, S.; Ramaswamy, H.S. 1982. Fibre reinforced concrete with organic fibres. In: Proceedings of the national seminar on building materials-their science and technology; 1982 April 15-16; New Delhi, India: 2A(15): 1-5.
(no abstract available)

745. La Tegola, A.; Ombres, L. 1990. Limit state of crack widths in concrete structural elements reinforced with vegetable fibres. In: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 108-119.

Summary: A study of the behavior of concrete reinforced with vegetable fibers is described. Using vegetable fibers in concrete increased the concrete ductility. The presence of a residual resistance to traction even after cracking is shown. This study focused on the contribution of vegetable fibers in ordinary concrete in evaluating the limit state of crack widths.

746. Parameswaran, V.S. 1991. Fibre-reinforced concrete-a versatile construction material. Building and Environment. 26(3): 301-305.

Summary: Efforts are being made to achieve a breakthrough in construction technology. By optimizing the building material, labor, and time of the cost while improving prefabrication, composites, building systems, and management, the study aims to enhance the strength and performance of building components using various types of fibers, both organic and inorganic. Using naturally available fibers and industrial wastes may contribute to optimizing building materials.

747. Sarja, A. 1986. Structural concrete with wooden or other vegetable fibres. In: Use of vegetable plants and fibres as building materials. Joint symposium RILEM/CIB/NCCL; Baghdad, Iraq: C117-C126.
(no abstract available)

748. Singh, S.M. 1985. Alkali resistance of some vegetable fibres and their adhesion with Portland cement. Research and Industry. 30(2): 121-126.
(no abstract available)

749. Sobral, H.S. 1990. Vegetable plants and their fibres as building materials. In: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil. 374 p.

Summary: This proceedings of a symposium on the utilization of plant fibers for building materials is in book form. It covers products such as cement, concrete, building panels, roofing sheets, break walls, and water conduits.

750. Swamy, R.N., ed. 1988. Natural fibre reinforced cement and concrete. In: Concrete technology and design series. Glasgow, Scotland: Blackie and Son Ltd. 288 p. Vol. 5.

Summary: Using natural fiber for producing reinforced cement and concrete is described. The book chapters were written by various researchers. Each chapter is followed by extensive references.

751. Tezuka, Y.; Marques, J.C.; Crepaidi, A.; Dantas, F.A.S. 1984. Behaviour of natural fibers reinforced concrete. In: Ghavami, K.; Fang, H.Y., eds. Proceedings of the international conference on development of low-cost and energy saving construction materials; 1984 July; Rio de Janeiro, Brazil: 61-69.
(no abstract available)

752. Velparri, V.; Ramachandram, B.C.; Bhaskaram, T.A.; Pai, B.C.; Balasubramani, N. 1980. Alkali resistance of fibres in cement. Journal of Materials Science. 15: 1579-1584.
(no abstract available)

753. Yamamoto, T.; Suzuki, T. 1990. Building materials and their manufacture. Assignee: Tohoku Electric Power Co. Inc., Shimizu Construction Co. Ltd. Patent, P.N.: JP 02055253, I.D.: 900223. [Japanese].

Summary: Plants, plant fibers, coal ash, sand, and cement, gypsum, or lime are mixed with water and stirred for a predetermined period of time to produce building materials. These materials are lightweight, resistant to heat and corrosion, and may be used as aggregates.

Molded Masses

Plastics

754. Kropfhammer, G. 1974. Elements of construction from domestic, agricultural or forestry wastes. Patent, P.N.: BE 806455, I.D.: 740215.

Summary: Domestic, agricultural, or forestry wastes are disintegrated by treating with excess CaO to obtain fillers used for producing construction materials. The fillers are particularly suitable for combining with epoxy resins but can also be used with hydraulic cements; unsaturated polyesters; phenolic, amino, or acrylic resins; vinyl polymers; or bitumens.

Refractory Materials

755. Moret, C.; Panhelleux, G. 1991. Vegetable fiber-containing cellular refractory composites. Assignee: Aris S.A. Patent, P.N.: FR 2649095, I.D.: 9100104. [French].

Summary: Composites consisting of a foam and a binder consist of a vegetable component and a mineral binder. The composites are strong, fire and moisture resistant, have a low

density, and are especially suitable for replacing wood chipboard for shelving use in exhibitions.

Resins/Binders

(See reference 754.)

Rubbers

756. Shimomura, T.; Tanaka, Y.; Inagaki, K. 1991. Spinning polyolefin-plant fiber mixtures for reinforcing fibers for building materials. Assignee: Ube Nitto Kasei Co. Ltd. Patent, P.N.: JP 03224713, I.D.: 911003. [Japanese].

Summary: High-density fibers with high bending strength are prepared by spinning compositions comprised of 100 parts polyolefin-plant fiber mixtures and 1 to 3.5 parts silicone rubber at a die temperature of 80°C to 140°C. Final fiber density was 1.16 g/cm^3 with a bending strength of 63.2 MPa.

Miscellaneous

Economics

757. De Longeaux, M. 1970. Problems of marketing and promotion related to the introduction of panels from agricultural wastes into the markets of developed countries. United Nations Industrial Development Organization Document (UNIDO) ID/WG.83/3. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 29 p, [French].

Summary: The problem of introducing panels from agricultural residues into the market is to overcome the resistance of the consumer to the new product. Boards made from wood are considered superior to those made from annual plants. Therefore, the products should be excluded from the very beginning. This paper emphasizes the importance of a comprehensive market study and enumerates the main measures to be taken in developing countries to promote the utilization of locally produced panels, such as training salesmen, broadening local building codes and government specifications, and establishing demonstration centers.

758. UNIDO. 1972. Production of panels from agricultural residues. United Nations Industrial Development Organization (UNIDO) report of the Expert Working Group meeting; 1970 December 14-18; Vienna, Austria. New York: United Nations. 37 p.

Summary: The final report of the Expert Working Group meeting outlined the economic and technical aspects of producing panels from agricultural wastes. The report formulated the measures the developing countries must take to make full use of potential raw materials.

Material Preparation/Pulping/ Storage Methods

759. Atchison, J.E. 1963. Progress in preparation and pulping of agricultural residues. Indian Pulp and Paper. 17(12): 681-689 and 18(2): 159-171.

Summary: The collection, storage, and preservation of bulky agricultural residues are discussed. Also discussed are new mills in operation or under construction that use agricultural fibers, and the expanded use of pulp produced from agricultural fibers.

760. Lathrop, E.C.; Naffzier, T.R.; Mahon, H.I. 1955. Methods for separating pith-bearing plants into fiber and pith. Bull. ARS-71-4. United States Department of Agriculture.

Summary: Several practical and economical methods for effecting separation into fiber and pith have been developed from a study of depithing methods made at the Northern Research and Development Division, Peoria, Illinois.

General Information/Reviews

761. Anonymous. 1987. Building materials for low-income housing. In: Proceedings of a symposium held at the United Nations Building; 1987 January 20-26; Bangkok, Thailand. London, England: E. and F.N. Spon Ltd. 357 p.

Summary: The use of vegetable sources as raw material for building materials was discussed. In the proceedings, each paper was abstracted and references were included.

762. Chand, N.; Sood, S.; Rohatgi, P.K.; Satyanarayana, K.G. 1984. Resources, structure, properties, and uses of natural fibers of Madhya Pradesh. Journal of Scientific and Industrial Research. 43(9): 489-499.

Summary: This report is a review, with 64 references, of the structure and properties of natural fibers used for composites.

763. Chand, N.; Verma, K.K.; Saxena, M.; Khazanchi, A.C.; Rohatgi, P.K. 1984. Materials science of plant based materials of Madhya Pradesh. In: Proceedings of the international conference on low-cost housing for developing countries; 1984 November 12-17. Roorkee, India: Central Building Research Institute: 191-201.
(no abstract available)

764. Gallegos Vargas, H. 1986. Use of vegetable fibers as building materials in Peru. In: Proceedings of the symposium on the use of vegetable plants and fibres as building materials; 1986 October; Baghdad, Iraq: A25-A34.
(no abstract available)

765. Jetzer, R. 1977. Conversion of refuse into fibrous material. Assignee: Jetzer Engineering AG. Patent, P.N.: US 3989499, I.D.: unknown.

Summary: The patent describes a method of producing a fibrous material from household, agricultural, forestry, and/or commercial refuse containing a mix of substances with varying rates of decomposition.

766. Kick, C.G. 1980. Appropriate technology for building materials from agro-wastes and natural fibers. Report THA/CDT 80/2. St. Louis, MO: Department of Technology and Human Affairs, Center for Development Technology, Washington University. 200 p.

Summary: This paper presents a thorough review and analysis of technology currently available for the conversion of agricultural wastes into building materials. It includes analysis of urban versus rural materials and economic, environmental, political, social, and community factors, and an extensive bibliography containing 187 references.

767. Mohan, D. 1981. Keynote address on buildings. In: Proceedings of the conference on appropriate technology in civil engineering; 1980 April 14-16, London, England. London, England: Thomas Telford Ltd.: 91-93.
(no abstract available)

768. Pomeranz, Y. 1973. Industrial uses of cereals. In: Proceedings of the symposium on industrial uses of cereals, in conjunction with the 58th annual meeting of the American Association of Cereal Chemists. St. Paul, MN: American Association of Cereal Chemists. 483 p.

Summary: This book discusses the industrial uses of cereals, feed, fertilizer, panel products, and building materials.

769. Pomeranz, Y. 1973. Industrial utilization of cereals–annotated bibliography 1948-1972. In: Proceedings of the symposium on industrial uses of cereals, in conjunction with the 58th annual meeting of the American Association of Cereal Chemists. St. Paul, MN: American Association of Cereal Chemists: 418-477.

Summary: This annotated bibliography on the industrial (nonfood) uses of cereals does not contain publications on the use of starches or derivatives of starches. The papers are listed by author, alphabetically, in order of year of publication. The report contains 80 references on using cereals for the production of building materials and insulators.

770. Raouf, Z.A. 1986. Examples of building construction using reeds. In: Use of vegetable plants and their fibres as building materials: Proceedings of joint symposium RILEM/CIB/NCCL; Baghdad, Iraq.
(no abstract available)

771. Rivera Alés, N.; Mata de la Cruz, A.; Garcia, R. Rojas. 1986. Use of vegetable plants and their fibres as building materials. Havana, Cuba: Technical Center of Construction Materials. 9 p.
(no abstract available)

772. Samarai, M.A. 1990. First international symposium on the use of vegetable plants and their fibers as building materials. Baghdad, Iraq, 1986. In: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 9-18.

Summary: A review of the first international symposium on the use of vegetable plants and their fibers as building materials is given. A collection of the advantages and disadvantages of using plant fiber as building materials is presented.

773. Satyanarayana, K.G.; Kulkarni, A.G.; Rohatgi, P.K. 1981. Natural fibres as valuable resource for materials in the future of Kerala. In: Rohatgi, P.K.; Satyanaryana, K.G.; Mohan, S., eds. Materials science and technology in the future of Kerala. Kerala, India: RPL Trivandrum: 127-178.
(no abstract available)

774. Satyanarayana, K.G.; Sukumaran, K.; Ravikumar, K.K.; Bramhakumar, M.; Pillai, S.K.G.; [and others]. 1984. Possibility of using natural fibre composites as building materials. In: Proceedings of the international conference on low-cost housing for developing countries; 1984 November 12-17; Roorkee, India. Roorkee, India: Central Building Research Institute: 177-181.
(no abstract available)

775. Sosa, M.; Trebbi, J.C. 1986. Building with plants. In: Proceedings of the symposium on the use of vegetable plants and fibres as building materials; 1986 October; Baghdad, Iraq: A47-A50.
(no abstract available)

776. UNDESA. 1976. Use of agricultural and industrial wastes in low cost construction. New York: United Nations Department of Economic and Social Affairs. 56 p.
(no abstract available)

777. UNIDO. 1974. Information sources on building boards from wood and other fibrous materials. United Nations Industrial Development Organization (UNIDO) guides to information sources, no. 9. UNIDO/LIB/SER.D/9. New York: United Nations.
(no abstract available)

778. UNIDO. 1979. Information sources on bioconversion of agricultural wastes. United Nations Industrial Development Organization (UNIDO) guides to information sources, no. 33. ID/228 UNIDO/LIB/SER.D/33. New York: United Nations. 84 p.

Summary: A directory of information sources on the bioconversion of agricultural wastes into various products is described. Sources are not journal sources, but rather addresses of centers, agencies, and research laboratories that conduct research on bioconversion of agricultural wastes. Included are addresses of institutions that have produced building materials from agricultural wastes.

779. UNIDO. 1979. Information sources on the utilization of agricultural residues for the production of panels, pulp and paper. United Nations Industrial Development Organization (UNIDO) Guides to information sources, no. 35. ID/234 UNIDO/LIB/SER.D/35. New York: United Nations. 99 p.

Summary: A thorough coverage of institutions and research centers that have produced experimental building panels from agricultural residues is described. Books, periodicals, and papers are presented in chapter format.

780. Vanderhoek, N. 1992. Commercial evaluation of non-wood fibres. Search. 23(6): 179-180.
(no abstract available)

781. Wang, J.Z.; Dillard, D.A.; Kamke, F.A. 1991. Moisture effects in materials. Journal of Materials Science. 26(19): 5113-5126.

Summary: The paper reviews the transient moisture effects in various materials with emphasis on their viscoelastic properties and durability. Part one of the review is dedicated to the phenomenological aspects of the effects in materials such as whole wood, plywood, particleboard, fiberboard, paper, natural and synthetic fibers, and composite materials. Creep, creep recovery, dynamic response, and failure as influenced by various transient moisture conditions are discussed in relation to the materials system, the extent and rate of moisture change, loading modes, temperature levels, specimen sizes, type of solvent and preventive measures. Part two discussed mechanistic models. The main mechanisms discussed include hydrogen bonding, slip planes, crystallite slippage, and rotation.

782. Wood, I.M. 1992. Wood says non-wood would. Search. 23(7): 230.
(no abstract available)

(Also see references 696, 722, and 723.)

Poppy [Straw]

Panel Board
Fiberboard/Hardboard

783. Chawla, J.S. 1978. Poppy straw-a new source for fibre boards. Indian Pulp and Paper. 32(4): 3-4.

Summary: Soda cooking of poppy straw (*Papaver somniferum*) having 78 percent holocellulose and 20 percent lignin at 130°C to 140°C gave a 75 percent pulp yield. Pressing this pulp at 165°C and 4.9 MPa gave a fiberboard with a density of 1.0 g/cm^3. The board had high strength properties comparable with that of commercial boards.

784. Hammer, H. 1949. Experimental board manufacture with hitherto unevaluated fibrous substitutes. Wochbl. Papierfabrik. 77(6): 168-169. [German].

Summary: The possibilities of using poppy straw, mustard straw, potato tops, tomato tops, beet tops, and tobacco stalks for the production of paper board were discussed. Most of these residues yielded boards with satisfactory properties, but utilization is not promising due to problems in collection, transportation, and storage.

(Also see references 3 and 831.)

Potato

Panel Board
Unknown Board

(See reference 784.)

Ragweed

Panel Board
Particleboard

(See reference 489.)

Ramie

Panel Board
Particleboard

(See reference 83.)

Cement/Gypsum/Plaster Board

(See reference 1016.)

Roofing Board

(See reference 1016.)

Unknown Board

(See references 3 and 665.)

Rape [Straw]

Panel Board
Particleboard

785. Asheim, P. 1982. Rape straw for industrial purposes (experiences from the 1981 experimental year) (Chipboard manufacture, Denmark). Svensk Frotidning. 51(1): 7-8. [Swedish].
(no abstract available)

786. Kilanowski, W. 1970. Economic and technical aspects of the processing of rape straw into particle boards. United Nations Industrial Development Organization Document (UNIDO) ID/WG.83/13. United Nations Industrial Development Organization (UNIDG) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 16 p.
(no abstract available)

787, Wnuk, M. 1965. Properties of rape straw board produced in Poland. Holztechnologie. 6(1): 64-67. [German].

Summary: Rape straw was substituted for flax on an experimental basis in a commercial particleboard manufacturing line in Poland. Boards with a density below 0.60 g/cm^3 showed high thickness swelling and water absorption and were unsuitable for use in furniture. Boards with a density above 0.60 g/cm^3 had a bending strength lower than corresponding flax shive boards. Other properties of the boards, such as thermal conductivity, fungal resistance, screw holding capability, and workability were satisfactory. Disadvantages of using rape straw included higher resin consumption, lack of abundance of raw material, and difficulty of storing rape straw without decay occurring.

{Also see reference 44.)

Fiberboard/Hardboard

788. Büttner, M. 1965. Danger of decay of materials of wood and annual plants by fungi. Holztechnologie: 6(2): 123-127. [German].

Summary: Studies of the decay of rape straw fiberboards, European hardwood fiberboards, and various pine wood particleboards by fungi showed that, in general, all of the materials were susceptible to fungi attack. The importance of effective preservative treatments for particleboards and fiberboards is emphasized.

789. Lampert, H. 1959. Modification of the properties of hard fiberboards through unidimensional shaping. Zellstoff und Papier. 8(10): 378-380. [German].

Summary: The strength properties of low quality hardboards made from rape straw can be improved by appropriate aftertreatment with water, heat, and pressure. Rape straw fiberboards were stored in 17°C water for 1 to 230 min; the treatment increased the moisture content to 9 to 24 percent. Fiberboards were then pressed at 195°C and 3.9 MPa for 12 min. Bending strength increased by about 25 percent, whereas board thickness decreased from 4.5 to 3.5 mm. Best results were obtained at 15 percent moisture content.

790. Lampert, H. 1960. Manufacture of fiberboards from rape straw. Holztechnologie. 1(1): 15-22. [German].

Summary: A detailed description was given of the manufacture of fiberboard from rape straw, including handling, cleaning, and chopping of the raw material, pulping by the Asplund defibrator process at 175°C to 180°C, refining to 11°SR to 14°SR, and hot pressing at 180°C to 195°C and a final pressure of 3.9 MPa for 18 min. The effects of some operating variables on thickness swelling and bending strength were investigated. In addition, the morphological and chemical characteristics of rape straw and the changes of chemical composition during storage are reported.

Insulation Board

791. Kontek, W.; Lawniczak, I. 1959. The utilization of rape. straw in the manufacture of insulation board. Przemysl Drzewny. 10: 16-18. [Polish].

Summary: Preliminary experiments showed that the quality of insulation boards made from sawdust, shavings, and reed was improved by adding rape straw. Board containing rape fibers had lower water absorption and reduced swelling.

792. Lis, T. 1978. Insulation boards from rape straw. Budownictwo Rolnicze. 30(11): 27-28: [German].
(no abstract available)

793. Nieborowski, H. 1976. Insulation boards made out of rape straw. Budownictwo Rolnicze. 28(8/9): 44.
(no abstract available)

(Also see reference 871.)

Unknown Board

794. Saechtling, H. 1948. New procedures for the manufacture of building boards from cheap wood waste. Holzforschung. 2(1): 21-24. [German].

Summary: The development of adhesive properties from beating or grinding of wood waste was described, thus eliminating the need to add large amounts of binders. Other materials, such as rape straw, flax chaff, and heather, can be used provided that the procedure is adapted to the requirements of each special material. Physical-property data of the boards were given.

(Also see reference 3.)

Cement/Clay/Gypsum/Plaster Materials

(See reference 911.)

Miscellaneous
Economics

(See reference 786.)

Raspberry

Panel Board
Fiberboard/Hardboard

(See reference 498.)

Red Onion

Panel Board

Particleboard

(See reference 492.)

Reed [Stalk]

Panel Board

Particleboard

795. Al-Sudani, O.A.; Daoud, D.S.; Michael, S. 1988. Properties of particleboard from reed-type mixtures. Journal of Petroleum Research. 7(1): 197-208.

Summary: Particleboards were prepared with a target density of 0.64 g/cm^3 and 16-mm thickness from 5 mixtures of reed and cattail, using 8 percent urea-formaldehyde resin as the binder system. All mechanical and physical properties were highly influenced by the percentage of reed used. For example, as the reed content increased, the mechanical properties increased significantly, whereas the physical properties (thickness swell and water absorption) significantly decreased. At ≤50 percent reed content in the mixture, most properties of the panels met or exceeded the specifications.

796. Badanoiu, G.; Oradeanu, T. 1958. Utilization of reed residues for particle-board manufacture with synthetic binders. Celuloza Hirtie. 7(3): 103-107. [Romanian].

Summary: Comminuted reed wastes, remaining after acid treatment for production of furfural, were neutralized, dried to 6 to 10 percent moisture content, and mixed with 6 to 10 percent urea-formaldehyde resin binder and 6 percent paraffin sizing. The material was then pressed into boards at 140°C to 150°C and 980.6 kPa to 1.5 MPa for 10 to 20 min. The resulting particleboards had a density of 0.674 g/cm^3 and are comparable to wood particleboards in, their properties. Data on the consumption of water, heat, and electric energy were given.

797. Narayanamurti, D.; Singh, K. 1963. Utilization of dust from reeds of *Ochlandra travancorica,* Indian Pulp and Paper. 17(8): 487, 489.

Summary: Reed rejects from 20-mesh screen were used for the experimental manufacture of particleboard, fiberboard, sawdust board, and thermodyne disks. The particleboards were bonded with phenol-formaldehyde resin at 150°C and a pressure of 2.7 MPa for 12 min. For the production of fiberboards, the raw material was cooked with lime or NaOH, fiberized, and pressed at 5.1 MPa and 160°C for 25 min. The sawdust boards were prepared from a mixture of reed dust and activators (shellac). Most of the boards had satisfactory strength properties.

(Also see references 44 and 53.)

Fiberboard/Hardboard

798. Federowicz, G. 1958. Fiberboards from reed. Przeglad Papierniczy. 14(4): 125-126. [Polish].
(no abstract available)

(Also see references 797 and 858.)

insulation Board

799. Ambroziak, L. 1968. Insulating boards from reeds and polystyrene foam. Assignee: Biuro Dokumentacji Technicznej Przemyslu Terenowego. Patent, P.N.: PL 55425, I.D.: 680620. [Polish].

Summary: A loosely tied reed mat is placed between two layers of granulated expanded polystyrene in a mold. The mold is placed in an autoclave at 100°C to 109°C where the polystyrene expands and is bound to the reed. Before being included in polystyrene, the reed may be impregnated with soluble chemicals to provide necessary resistance to fire, fungi, and bacteria. The ready-made boards are painted with a fireproof agent.

800. Huminski, K.; Werba, K. 1956. Light panels and their manufacture. Patent, P.N.: PL 39112, I.D.: 560410. [Polish].

Summary: Light panels or tiles used in construction as heat and sound-insulating material are made from stems and leaves of reed. The manufacturing method consists of packing straightened stems and leaves into alternating crosswise and lengthwise layers, impregnating the material with a binder, and hot pressing into multiply sheets of various hardness and thickness.

801. Kolesnikov, E.A. 1963. Properties and utilization of powdered reed wastes. Khim. Pererabotka Drevesiny Sb. 30: 5-6. [Russian].

Summary: Morphological and chemical analysis was made of powdered reed waste obtained from a reed-processing board mill. The waste consisted of 7.4 percent fibers, 46.2 percent fine particles (0.1 to 2.5 mm), and 46.4 percent dust. The material was used for manufacturing insulation boards containing no binder. The experimental boards were of standard quality.

(Also see references 149, 1103, and 1104.)

Cement/Gypsum/Plaster Board

(See references 149 and 885.)

Plastic/Plastic-Bonded Board

802. Sauer, C.; Kern, M.; Burger, R.; Reguigne, G. 1987. Construction material for buildings has reed stems encased in plastics material to form matrix. Assignee: (TOUR-) Tourisme et Hotelle. Patent, P.N.: US 4690874, I.D.: 870901.

Summary: Reeds are processed by scoring them; the reeds are then placed in a rotary drum where the stems roll over one another, which rids them of their leaves, while the siliceous particle of the leaves score the naturally varnished epidermis of the stems. The reed stems are then enclosed in a plastic matrix. The matrix can be of polyurethane or polyester to prevent relative movement of the reed stems.

Roofing Board

803. Anonymous. 1976. Reed thatch roofing panels--of chipboard with reed thatch cemented on with polyester adhesive. Assignee: (HARM/) Harm H. Patent, P.N.: DE 2525777, I.D.: 761223. [German].

Summary: Reed thatch is cemented onto a panel, instead of being stitched directly onto roof battens. Panels are standard size, handled easily, and suitable for rafter intervals of 80 cm; chipboard is a suitable panel material. Waterproofing is provided by the polyester, or similar plastic, used as the adhesive. The reed thatch is between 5 and 10 cm thick. Pressure causes the edges to spill over the panel edge, so as to give the completed roof a homogeneous cohesive structure.

Unknown Board

804. Mudrik, V.I. 1960. Reed processing plants. Bumazh. Prom. 35(8): 6-10. [Russian].

Summary: Reed-processing plants are under construction in regions of the former USSR-where reed is abundant. The plant at Astrakhan will produce large amounts of semi-chemical pulp, board, corrugating medium, and 5 million m^2 of building board. A description is given of mechanized harvesting and transportation of reed, pulping processes, and board manufacture.

(Also see references 3, 190, 197, 289, 665, and 769.)

Cement/Clay/Gypsum/Plaster Materials

805. Zhu, B.; Zhu, S.; Zhu, B. 1991. Decorative construction material--contains cement, sandy gravel, sawdust, reed, coloring agent and additive. Assignee: (ZHUS/) Zhu Shaohua. Patent, P.N.: CN 1048210, I.D.: 910102. [Chinese].
(no abstract available)

(Also see references 197, 622, 808, and 911.)

Molded Masses
Refractory Materials

(See reference 963.)

Miscellaneous
Material Preparation/Pulping/ Storage Methods

(See reference 263.)

Material Used in Natural State

806. Al-Mohamadi, N.M. 1990. Effect of reed reinforcement on the behaviour of a trial embankment. In: Vegetable plants and their fibres as building materials: Proceedings of 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 214-223.

Summary: This paper investigates using bundled reeds as reinforcement along marshy areas of Iraqi highways. The field and analytical study showed that reed bundles were effective in reducing lateral strain by 14 percent. Finite element analysis showed that using reed reinforcement is equivalent to increasing the soil stiffness by 15 percent.

807. Al-Refeai, T.O. 1990. Reed fibers as reinforcement for dune sand. In: Vegetable plants and their fibres as building materials: Proceedings of 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador; Bahia, Brazil: 224-236.

Summary: A series of triaxial tests were performed to investigate the behavior of fiber-reinforced sand. Reed and glass fiber were chosen to observe the influence of variables associated with the fiber, namely, diameter, surface characteristics, aspect ratio, concentration, and stiffness, on the behavior of the fiber-reinforced sand. Results indicated that incorporation of the fibers could significantly increase the ultimate strength and stiffness of the sand. Strength increase was found proportional to the fiber concentration up to some limiting content. Increasing the aspect ratio, confining stress, and volume ratio, rougher surface, and not stiffer fibers, were the more effective in increasing strength of the sand.

808. Kadir, M.R.A. 1990. Use of vegetable plants in housing construction in Northern Iraq. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 314-318.

Summary: The report describes the use of vegetable plants, such as reeds, for producing roofing material and bricks in northern Iraq. Suggestions are given for improvement of the materials.

809. Samarai, M.A.; Al-Taey, M.J.; Sharma, R.C. 1986. Use and technique of reed for low cost housing in the marshes of Iraq. In: Use of vegetable plants and fibres as

building materials; Joint symposium RILEM/CIB/NCCL, Baghdad, Iraq.
(no abstract available)

(Also see references 384 and 387.)

Rice [Hull/Husk; Straw]

Panel Board

Particleboard

810. Anonymous. 1975. Resin-coated rice hulls and the production of composite articles therefrom. Assignee: Cor Tech Research Ltd. Patent, P.N.: GB 1403154, I.D.: 750813.

Summary: Boards were manufactured from cleaned ground or tumbled rice hulls and 10 percent by weight water-immiscible emulsifiable caustic-free phenol-formaldehyde copolymer. Fines-free tumbled hulls gave better products than did ground hulls. Final composite had an internal bond strength of 551.6 kPa, modulus of rupture of 13.1 MPa, and a density of 0.8 g/cm^3.

811. Anonymous. 1979. Utilization of rice hull (a byproduct of rice milling) for particleboard, cellophane, and viscose rayon manufacturing. Grains Journal. 3(3): 5-10.
(no abstract available)

812. Anonymous. 1982. Building materials. Assignee: Sanko Co. Ltd. Patent, P.N.: JP 57003949, I.D.: 820109. [Japanese].

Summary: Lightweight boards or moldings are prepared from thermoplastic or thermosetting resins and dry powdered rice hull which is used as filler.

813. Anonymous. 1987. Manufacture of moulded boards containing rice or wheat chaff-includes mixing chaff with prepolymer prepared from polyol and polyisocyanate and hardener comprising polyether-polyol and amino alcohol. Assignee: (NIPO) Nippon Polyurethane KK. Patent, P.N.: JP 87050286, I.D.: 871023. [Japanese].

Summary: Rice and/or wheat chaff (100 parts by weight) is blended with a binder consisting of (1) a polymer prepared from a polyol having two or more active hydrogen atoms and an organic polyisocyanate having terminal isocyanate groups, and (2) a hardening agent consisting of poly-etherpolyol containing two or more active hydrogen atoms (100 parts by weight) and an amino alcohol. The binder compositions provide a high adhesion between chaff particles containing waxy materials. The mixture is pressed at room-temperature to 180°C and at 2.0 to 5.9 MPa.

814. Antakova, V.N.; Glumova, V.A.; Medvedeva, G.V. 1979. Change in the chemical composition of rice straw in the production of board materials from it. Tekhnol. Drevesn. Plit i Plastikov, Sverdlovsk: 80-83. [Russian].
(no abstract available)

815. Bulakul, S. 1970. Economic and technical aspects of the utilization of cereal stalks for the production of panels. United Nations Industrial Development Organization Document (UNIDO) ID/WG.83/10. United Nations Industrial Development Organization (UNIDO) Expert Working Group meeting on the production of panels from agricultural residues; 1970 December 14-18; Vienna, Austria. 39 p.

Summary: Economic and technical aspects of producing straw slab by the “Stramit” process were discussed, including transportation and storage of raw materials, requirements of straw quality, manufacturing process, layout of the “Stramit” plant, cost factors, properties and applications of finished product, and marketing problems. The plant in Thailand uses rice straw exceeding a certain length as raw material. The manufacturing process is simple. It includes pressing of the straw into a continuous slab without the adding binder, covering the faces of the heated slab with paper liners, and cutting to size. The panels, having thickness of 50 mm, showed satisfactory strength properties, good heat and sound insulation values, and high fire resistance.

816. Casalina, S.L. 1972. Rigid, flexible, and composite solid objects having cellulose-containing rice hull particles and radiation-induced polymer. Patent, P.N.: US 3660223, I.D.: 680410.

Summary: Rice hull particle composites had higher strength than did sawdust composites. Rice hulls were ground, screened, pressed into small pieces, impregnated with Me methacrylate mixture, and irradiated for 3 h with 1 megard per hour γ-rays to give composites having improved fracture resistance. Flexibility of composites was improved by using parboiled rice hulls and Et acrylate instead of methacrylate.

817. Chandramouli, P. 1973. Comparative properties of rice husk board, particle board, and wafer board. Interim Rep. July 1973. Richmond, British Columbia, Canada: Cor Tech Research Ltd. Richmond. 39 p.
(no abstract available)

818. Chen, T.Y. 1979. Studies on the manufacture of particleboard from rice hull. K’o Hsueh Fa Chan Yueh K’an (National Science Council Monthly, ROC). 7(1): 32-45. [Chinese; English summary].

Summary: Rice hulls and a urea-formaldehyde or phenol-formaldehyde resin binder were used to prepare particleboards having good water-absorbing properties and low expansion. The particleboard mechanical properties could be improved by increasing density and amount of binder, or by mechanically treating the rice hulls and mixing them with wood particles. Bending strength was improved by laminating with wood.

819. Chen, T.Y. 1980. Studies on the manufacture of particleboard from rice hulls in industrial scale. K’o Hsueh Fa Chan Yueh K’an (National Science Council Monthly, ROC). 8(5): 456-462.[Chinese; English summary].

Summary: Particleboards were manufactured using rice hulls and wood particles as raw materials. The hulls were treated by chemical methods and evaluated. Baking treatment resulted in the best boards, while treatment with 1 percent solution of NaOH resulted in the poorest boards: Boards passed the DIN 68761 Standard for internal bond strength, thickness swell, and water absorption, but failed in bending strength. A veneer lamination of 0.8-mm-thick lauan on both surfaces of the board greatly improved its bending strength. Information on cost of transporting rice hull material to the plant was competitive with that of transporting wood particles.

820. Chentemirov, M.G.; Makhalov, L.S.; Chistyakov, A.M.; Kopeikin, V.A.; Gamza, L.B. [and others]. 1979. Articles of construction. Assignee: Kucherenko, V.A., Central Scientific-Research Institute of Building Structures. Patent, P.N.: SU 689848, I.D.: 791005. [Russian].

Summary: Articles produced using shredded rice straw treated with an alkali solution of a phosphate fireproofing composition at 140°C to 160°C and 0.2 to 0.4 MPa, pressed, and dried have decreased flammability and increased strength and water resistance.

821. Fujimoto, M.; Taguchi, N.; Hattori, S. 1988. Manufacture of chaff boards. Assignee: Oshika Shinko KK. Patent, P.N. JP 63118203, I.D.: 880523. [Japanese].

Summary: Chaff boards are prepared by spreading adhesive onto raw materials mainly containing chaff or its debris, forming, and pressing. The boards are said to have good cushion and sound insulation, and are useful as floor or construction panels. Coating 100 parts rice chaff with 80 parts of a mixture of SBR latex, 1 part antioxidant, 2 parts sulfur, 1.5 parts vulcanization accelerator, 15 parts TiO_2, and 3 parts crude MDI, forming a mat between two sheets of nonwoven fabrics, and hot pressing gave a sound insulating board.

822. Hancock, W.V.; Chandramouli, P. 1974. Comparative properties of rice-husk board, particle board, and wafer board. Journal of the Indian Academy of Wood Science. 5(1): 18-27.

Summary: Tests carried out with a limited number of laboratory-produced boards indicated that rice husks could be used to make a useful panel that used waste material. Properties of the rice husk board were similar to those of wood-based boards.

823. Petri, V.N.; Mel'nikova, M.E.; Antakova, V.N.; Akkerman, AS.; Yusupova, Z.A. 1977. Manufacture of boards from rice straw under industrial conditions. Mezhvuz. Sb., Ser. Tekhnol. Drev. Plit Plastikov. 4: 88-95. [Russian].

Summary: Research was carried out to obtain binderless particleboards from rice straw. Nondried straw was comminuted so that at least 70 percent of the particles passed through a screen with 2-mm openings. Optimum parameters for manufacturing unfaced and faced (with paper-resin film) boards showed that boards with good physicomechanical properties could be obtained at a pressure of 5 to 9 MPa. However, boards pressed at 5 MPa had a moisture content of 14 to 16 percent immediately after pressing and needed subsequent conditioning. Economic and technical parameters pertaining to manufacture of rice-straw board were discussed.

824. Vasishth, R.C. 1971. Water resistant composite board from rice husk. United Nations Industrial Development Organization Document (UNIDO) ID/WG/89/23. Joint United Nations Industrial Development Organization (UNIDO), Food and Agriculture Organization of the United Nations (FAO), ECAFE interregional seminar on industrial processing of rice; 1971 October 28; Madras, India. Vienna, Austria: United Nations Industrial Development Organization (UNIDO). 9 p.

Summary: Rice husks are generally considered unsuitable for producing particleboard due to their high silica content, short fiber length, and low resistance to alkali. Studies demonstrated that satisfactory boards could be produced from rice husks if specially prepared phenol-formaldehyde resin was used as binder. Rice husks were sprayed with 8 percent by weight of the new resin, formed into a mat, and pressed at 154°C to 210°C for 8 to 20 min. For boards of 1.59 cm thickness, pressing times of 7 min at 210°C, or 12 min at 177°C, were adequate. Some physical properties of the boards were reported.

825. Vasishth, R.C. 1972. Preliminary cost study of rice husk composite board plants. Vancouver, British Columbia, Canada: Columbia Engineering International Ltd. 9 p. Vol. 3.
(no abstract available)

826. Vasishth, R.C. 1973. Composite boards from rice hulls. Richmond, British Columbia, Canada: Cor Tech Research Ltd. 9 p. Vol. 3.
(no abstract available)

827. Vasishth, R.C. 1974. Manufacture of composite boards from rice husks using batchwise, labour-oriented plant: Feasibility study-India. Richmond, British Columbia, Canada: Cor Tech Research Ltd. 50 p. Vol. 1.
(no abstract available)

828. Vasishth, R.C. 1974. Resin coated rice hulls and compositions containing them. Assignee: Cor Tech Research Ltd. Patent, P.N.: US 3850677, I.D.: 741126.

Summary: Composite articles having good internal bond strength and rupture modulus were molded from compositions containing cleaned dust-free rice hulls coated with an alkali-free phenol-formaldehyde copolymer. Rice hulls that had been tumbled and the fines removed through a 40-mesh screen were sprayed with 10 percent phenol formaldehyde and 20 percent (based on resin) *p*-toluenesulfonic acid catalyst in a stream of hot air. The resin-impregnated hulls

were molded into 1.6-cm-thick sheets having an internal bond strength of 517.1 kPa and a modulus of rupture of 12.4 MPa according to ASTM D 1037-64 testing standards.

829. Vasishth, R.C.; Chandramouli, P. 1975. New panel boards from rice husks and other agricultural by-products. Food and Agriculture Organization of the United Nations Document (FAO) FAO/WCWBP/75 Doc. 30. Background paper to world consultation on wood based panels. New Delhi, India. 11 p.
(no abstract available)

830. Viswanathan, T.; Smith, M.; Palmer, H. 1987. Rice hull-reinforced building boards using formaldehyde-free adhesive resins derived from whey. Journal of Elastomers and Plastics. 19(2): 99-108.

Summary: This paper reports on the feasibility of producing rice hull-reinforced particleboards using resins derived from whey permeate. Results indicated that low-quality boards may be prepared using unground rice hulls, but may be improved by grinding the rice hulls and/or adding saw dust to the formulation. The proposed use of whey permeate favors replacing formaldehyde-based resins used in the forest products building board industry, in addition to conserving nonrenewable energy sources in the form of petroleum and natural gas.

(Also see references 53, 493, 494, 660, and 877.)

Fiberboard/Hardboard

831. Bains, B.S.; Chawla, J.S. 1977. Studies on fire retardant compositions for fiber and paper board. Holzforschung und Holzverwertung. 29(6): 126-130. [German; English summary].

Summary: Tests for flame penetration and flammability for hardboards made from chemimechanical pulp of pine needles, rice and poppy straw, and paperboard impregnated or coated with flame retardants indicated that treated materials are more fire resistant than untreated ones. The NaCl as a hygroscopic material was an effective fire retardant at high concentrations only. Borax and $(NH_4)_2HPO_4$ produced twice the char in the ignition period of tested materials, but the time of flame and char penetration depended on the nature of the material and the efficiency of the fire retardants used.

832. Fadl; N.A.; El-Kalyoubi, S.F.; Rakha, M. 1987. Effect of pressing pressure of the first stage on the properties of rice-straw hardboard. Research and Industry. 32(2): 107-111.

Summary: In hardboard manufacture, the wet-process pressing method is most commonly used. A three-phase pressing cycle is normally employed. The effect of variation in the pressing pressure during the first phase of the pressing cycle on the properties of rice-straw hardboard was studied. The specific pressure used in this stage is a very important factor that influences the properties of the finished hardboard. Appreciable improvement in the properties of the fiberboard was noticed when pressing pressure was increased. A specific pressure of about 5.9 MPa is sufficient to impart desirable properties to the finished board.

833. Fadl, N.A.; El-Meadawy, S.A.; El-Awady, N.; Rakha, M. 1982. Effect of radiation and monomers on the properties of rice straw hardboard. Indian Pulp and Paper. 37(1): 2-7.

Summary: Bending strength of Me methavrylate-impregnated hardboard from rice straw pulp increased approximately 24 percent with increasing y-radiation dose at 0 to 4.8 Mrad. Water absorption and swelling were scarcely affected.

834. Fadl, N.A.; El-Shinnawy, N-A.; Heikal, S.O.; Mousa, N.A. 1979. Hardboard from cooked and blended rice straw and bagasse. Indian Pulp and Paper. 34(3): 19-21.

Summary: Mixing bagasse and rice straw (soda or Asphund process) pulps improved bending strength, water absorption, and thickness swelling of resulting hardboards. The improvements became more pronounced as the ratio of bagasse pulp was increased. Soda pulp blends gave greater increases in these properties than did Asplund water pulp blends. Rice straw/bagasse blends were better than rice straw/cotton stalk blends.

835. Fadl, N.A.; El-Shinnawy, N.A.; Rakha, M. 1985. Effect of ammonia and thermal treatment on rice straw hardboard. Research and Industry. 30(2): 127-133.

Summary: Absorbed nitrogen content increased with increased time of ammonia treatment of thermomechanical pulp (TMP) from rice straw, and was higher in NH_4OH treatment than NH, treatment. Hardboard made of NH_3-modified TMP showed a remarkable improvement in bending strength, which increased with increasing treatment time-and reached a maximum after 2 days treatment. Since elimination of SiO_2 from TMP was higher in the case of NH_4OH treatment, boards made from NH_4OH-treated TMP had higher strength than boards made from NH,-treated TMP. The NH_4OH-treated samples showed remarkable increase in water absorption. The absorption increased progressively with increased treatment time in the absence of thermal treatment of board. With thermal treatment the water absorption decreased after 4 days. Samples of NH_3-treated TMP showed slight change in thickness swelling, especially without thermal treatment.

836. Fadl, N.A.; Nada, A.A.M.A.; Rakha, M. 1984. Effect of defibration degree and hardening on the properties of rice-straw hardboard. Research and Industry. 29(4): 288-292.

Summary: The degree of defibration plays a significant role in improving the physical and mechanical properties of rice-straw hardboards. Hardboard properties are improved with

decreasing coarse fiber content. The optimum coarse fiber ratio which imparted desired properties to the board, ranged between 11 and 22 percent. Properties improved when defribration was combined with thermal treatment and resin.

837. Fadl, N.A.; Rakha, M. 1980. Effect of fire-retardant materials on properties of rice straw hardboard. Indian Pulp and Paper. 35(3): 15-19.

Summary: Hardboard samples were prepared without resin from rice-straw pulp. Fire-retardant materials (20, percent solutions) used in the study were ammonium phosphate, 60 percent borax/40 percent boric acid, 50 percent borax/35 percent boric acid/15 percent ammonium phosphate and zinc amine. All fire retardants improved the water resistance of the boards while reducing their bending strength. Ammonium phosphate was the best fire retardant tested in terms of shortening flame duration (to 0 at 3.7 percent concentration) and afterglow of the board (to 0 at 5.0 percent concentration).

838. Fadl, N.A.; Rakha, M. 1983. Effect of addition of linseed oil and heat treatment on properties of rice straw hardboard with and without resin. Acta Polymeica: 34(3): 169-170.

Summary: Adding emulsified linseed oil to rice-straw pulp improved water resistance of the finished hardboard. Without thermal treatment, this improvement increases with oil content, but with loss of board strength. However, a subsequent thermal treatment improves strength and water

839. Fadl, N.A; Rakha, M. 1983. Effect of precipitated wax emulsion and thermal treatment on rice-straw hardboard. Research and Industry. 28(4): 258-263.

Summary: Rice-straw pulp (92 percent dry solids, 14 percent ash, 12 percent silica; and 21 percent pentosans) was prepared by steaming rice straw at 200°C for 20 s, followed by mechanical defibration. The pulp was treated with paraffin wax emulsion (containing 10 percent oleic acid and saponifed with ammonia solution) in the presence or absence of 3 percent phenol-formaldehyde resin binder. Sulfuric acid or alum was used to precipitate the emulsion on the fibers. Hardboards were prepared in a small pilot press. Water resistance and bending strength of the boards were improved by adding 2 percent alum-precipitated wax emulsion in the absence of phenol-formaldehyde resin. Thermal treatment also improved the water absorption, probably by reducing hygroscopic materials.

840. Fadl, N.A,; Rakha, M. 1983. Effect of rosin addition and thermal treatment on rice straw hardboard. Acta Polymerica. 34(2): 123-124.

Summary: The effect of rosin addition and thermal treatment at 150°C on bending strength, water absorption, and thickness swell of hardboard from thermomechanical pulp of rice straw was studied. The rosin addition and thermal treatment decreased the bending strength but-improved the water absorption and thickness swell of the hardboard. Simultaneous addition of phenol-formaldehyde copolymer also decreased the effect of rosin.

841. Fadl, N.A.; Rakha M. 1983. Effects of various synthetic resins on hardboard from rice straw. Zellstoff Papier. 32(3): 121-124. [German].

Summary: Untreated hardboard from rice straw was impregnated with various resins, which improved all properties measured. Phenol-formaldehyde resin gave the least improvement and is not recommended since it darkens the board. Novolac, an intermediate product of phenol-formaldehyde manufacture, was the best impregnant, improving strength and moisture resistance. Melamine-formaldehyde resin improved the latter better than did Novolac, but gave less strength improvement. Urea-formaldehyde resin yielded moderate improvement of moisture resistance and very slight improvement of bending stiffness.

842. Fadl, N.A.; Rakha, M. 1984. Effect of cooking temperature and hardening on properties of rice straw hardboards manufactured by Asplund process. Cellulose Chemistry and Technology. 18(4): 431-435.

Summary: Cooking temperature (experimentally varied from room temperature to 250°C) was found to be the most important factor governing the quality of hardboards produced from rice straw by the Asplund process (autoclaving for 20 s, followed by stone refining to a coarse fiber content of approximately 20 percent). Temperature should be high enough to soften the middle lamella and permit easy fiber separation. The best cooking conditions for Egyptian rice straw were 185°C to 195°C for 20 s. Heat treatment of the finished board is recommended to impart improved physical: and mechanical properties.

843. Fadl, N.A.; Rakha, M. 1990. Effect of defibration and hardening on the properties of rice straw hardboards. Four P News (Pulp, Paper, Printing, and Packaging). 2(4): 4-7.

Summary: Rice straw, the main lignocellulosic raw material in Egypt, used in industry mostly for fiberboard making, produces fiberboard of inferior quality to that made from wood. This is due to the high percentage of nonfibrous materials and technical difficulties in processing. This study investigated the effect of the degree of defibration (ratio of coarse to fine) of the pulp on the properties of the finished hardboard before and after hardening and pressed with and without resin. Details of the experiment included the preparation of the pulp, determination of coarse materials, preparation of hardboard hand sheets, thermal treatment (hardening), and physical and mechanical properties.

844. Fadl, N.A.; Sefain, M.Z. 1984. Hardboard from retted rice straw and cotton stalks. Research and Industry. 29(2): 95-99.

Summary: Chemical analysis of rice-straw and cotton stalks, after retting for different periods, showed that retting had a negligible effect. However, retted-rice straw contains a higher silica and lower lignin content than that of retted-cotton stalks. The effect of retting on bending strength, water resistance, and thickness swelling of hardboard prepared from rice straw and cotton stalks was studied. Retting opera-tion improves bending strength and water resistance of rice-straw boards; it decreases bending strength of cotton-stalk board.

845. Fadl, N.A.; Sefain, M.Z.; Rakha, M. 1977. Effect of blending waste paper with some indigenous agricultural residues on the properties of hardboard. Indian Pulp and Paper. 32(1): 11-13.

Summary: Blending rice-straw and cotton-stalk pulps with waste-paper pulp improved bending strength, water resistance, and density of the resulting hardboard. Blending bagasse pulp with waste-newspaper pulp decreased bending strength and water resistance. The addition of a phenol-formaldehyde copolymer to the waste pulp blends improved strength and water absorbency characteristics of the hardboard produced.

846. Fadl, N.A.; Sefain, M.Z.; Rakha, M. 1977. Effect of thermal treatment on Egyptian rice straw hardboard. Journal of Applied Chemistry and Biotechnology. 27(2): 93-98.

Summary: Bending strength fell with an increase in heating time and temperature for hardboard samples containing 51.5 percent resin. Hardboards containing 3 percent resin showed initial improvement in bending strength after heating at 140°C 160°C, and 180°C. Heating all samples at 200°C reduced bending strength. Water resistance was improved by heating.

847. Kluge, Z.E.; Lielpeteri, U.Y.A.; Ziendinsh, I.O. 1979. Hot pressed rice straw panels production-includes treating straw with steam prior to being modified with ammonia and pressed. Assignee: Kluge, Z.E., Lielpeteri, U.Y.A., Ziendinsh, I.O. Patent, P.N.: SU 656868, I.D.: 790418 [Russian].

Summary: A method for producing panels from vegetable raw materials which can be press-formed, by modifying the raw materials with ammonia, shaping, and hot pressing, is discussed. The physical and mechanical properties are improved and the production technology is simplified by treating the raw material with steam prior to modification with the ammonia. The treatment temperature is 140°C to 250°C.

848. Kluge, Z.E.; Tsekulina, L.V.; Savel'eva: T.G. 1978. Manufacture of hardboards from rice straw. Tekhnol. Modif. Drev.: 55-63. [Russian].

Summary: The experimental production of rice-straw hardboards was carried out by a two-stage process. The first stage, which increases the thermosetting properties of the straw, involved heat treatment with superheated steam at 167°C for 90 min, drying at 60°C, and the addition of 5 percent ammonia. The second stage, carried out under varying conditions to determine the optimum, included pressing at 160°C to 180°C and 7 MPa for 2 to 4 min/mm of board thickness. Straw moisture content was 6 to 12 percent. Density, static bending strength, and 24 h water absorption and swelling of the boards were determined. Results are presented in the form of regression coefficients and discussed. The optimum conditions (checked under pilot-plant conditions) included a straw moisture content of 9 to 10 percent, a pressing temperature of 180°C, and a pressing time of 2 min/mm of board thickness. Manufactured boards had a density of 1.15 g/cm^3, static bending strength of 22.8 MPa, 2-h water absorption of 13 percent, and swelling of 7.4 percent.

849. Korshunova, N.I.; Perekhozhikh, G.I. 1977. Infrared spectroscopy of rice straw used as a raw material for the manufacture of fiber boards. Tekhnol. Drev. Plit. Plast. 4: 114-121. [Russian].

Summary: Molded rice-straw fiberboards have a considerably lower content of OH, MeO, and CO groups than untreated rice straw, as evidenced by the attenuation of IR peaks at 2,800 to 3,600, 1,100, 1,160, 1,250, and 1,375 cm^{-1}. The attenuation of peaks at 800, 1,250, and 1,425 cm^{-1} is attributed to demethylation of lignin during molding of rice-straw fiberboards.

850. Madan, R.N. 1981. Production of strawboard pulps from agricultural residues. Holzforschung und Holzverwertung. 33(3): 50-51. [German; English summary].

Summary: Rice and wheat straws and bagasse were each pulped with caustic soda, lime, soda ash, or combinations thereof. Yields were satisfactory and the strength of boards made from the pulps exceeded Indian specifications.

851. Mobarak, F.; Nada, A.A.M.A.; Fahmy, Y. 1975. Fibreboard from exotic raw materials. 1. Hardboard from rice straw pulps. Journal of Applied Chemistry and Biotechnology. 25(9): 653-658.

Summary: Mechanical and semichemical pulping methods were investigated to determine the suitability of making rice-straw hardboard. It was found that adding a relatively high amount of resin (2 to 3 percent) was essential if hardboard was to be made from mechanically prepared rice-straw pulps. Mild chemical treatment of the mechanical straw pulp by sodium hydroxide at optimum conditions reduced the amount of resin needed to improve bending strength and water resistance of the board considerably. Treatment with calcium hydroxide or sulphuric acid was, generally, less successful.

852. Rakha, M.; Fadl, N.A.; Shukry, N. 1985. Blending rice straw pulp with some Egyptian flora. Research and Industry. 30(2): 102-106.

Summary: Blending rice-straw thermomechanical pulp (TMP) with TMP from *Helianthus tuberosus* (sunflower) or *Conyza descroides* gave hardboard with improved bending strength and water resistance properties, whereas that from *Imperata cylindrica* deteriorated the physical and mechanical properties of the resulting board. The improvement or deterioration of the properties of hardboards were rather pronounced in the absence phenolic-resin binder. The ratio of TMP blended played a significant role in the properties of the resulting boards.

853. Sarkaria, T.C.; Iyengar, MS. 1968. Hardboard and tiles from agriculture residues. Assignee: Council of Scientific and Industrial Research, India. Patent, P.N.: IN 101714, I.D.: 680615.

Summary: Sawdust or rice husk was sieved (36 mesh), air dried, mixed 5 to 10 min with 20 percent by its weight water, and molded at 160°C at 7.9 MPa for 1 h to give boards with tensile strength of 10.8 to 12.3 MPa, compression strength of 12.7 to 14.2 MPa, average density of 1.27 g/cm^3, and water absorption of 17 to 18 percent after 7 days of soaking. Urea- and H_2SO_4 were added for waterproofing the product.

854. Sefain, M.Z.; Fadl, N.A.; Rakha, M.M. 1984. Impregnation of rice straw hardboards. Holzforschung. 38(6): 353-355.

Summary: Details of experiments performed to impregnate hardboards with emulsified paraffin wax, resin, boiled linseed oil, and unsaturated high fatty acid are given. The physical and mechanical properties of the finished boards were investigated and the rates of change shown. Emulsified paraffin wax and resin generally harmed the boards manufactured, whereas drying oil and oleic acid improved the hardboards properties.

855. Sefain, M.Z.; Fadl, N.A.; Rakha, M. 1984. Influence of pressing time in fiber board making. Research and Industry. 29(4): 269-272.

Summary: In a three-stage pressing cycle, the pressure was 26.5, 4.9 to 5.9, and 26.5 MPa, respectively. The pressing time affected the bending strength, water absorption, and thickness swelling of phenolic resin-bonded fiberboard made from rice-straw pulp. For fiberboard with 3-mm thickness, the most favorable pressing condition was 40 s for the first stage, 4 min for the second stage, and 2 min for the third stage.

856. Sefain, M.Z.; Fadl, N.A.; Rakha, M. 1984. Thermal studies of hardboard impregnated with different resins. Research and Industry. 29(1): 39-42.

Summary: The physical and mechanical properties of rice-straw hardboards impregnated with melamine-formaldehyde copolymer, phenol-formaldehyde copolymer, urea-formaldehyde copolymer, or novolak resin, and heat treated at 100°C to 190°C for 1 to 5 h, were discussed. Novolak resin was the most effective in improving bending strength of rice-straw hardboards, even though it hardened at relatively low temperatures. From an economic viewpoint, a higher temperature (190°C for 30 mm) was recommended, since it resulted in maximum improvement in mechanical properties. Melamine-formaldehyde copolymer was the most suitable resin for improving water absorption and thickness swelling properties of the boards.

857. Shen, G. 1987. Making composites from lignocellulosic materials by partial hydrolysis. Patent, P.N.: CN 85105958, I.D.: 870225. [Chinese].

Summary: Composites are prepared without additional binders by a process that includes treating dispersed cellulosic materials with steam at high temperatures to depolymerize and hydrolyze hemicellulose to give free sugars, sugar condensates, dehydrated carbohydrates, and the like, molding the steam-treated materials, and thermosetting. Lignocellulosics include rice husks, wheat straw, and peanut shell.

858. Shurky, N.; Fadl, N.A.; El-Kalyoubi, S.F. 1992. Improving the properties of rice straw hardboard by blending with other raw materials. Research and Industry. 37(3): 161-164.

Summary: The effect of blending Egyptian rice-straw pulp with different pulp, namely, bagasse, reeds, cotton stalks, barley straw, and wood wastes, on the physical and mechanical properties of the finished hardboards was investigated. Two concentrations of phenol-formaldehyde resin (1.5 and 3 percent) were used. In the presence of 3 Percent resin content, the properties of all unblended and blended boards were superior to those boards containing 1.5 percent resin. A clear relationship was found between the pentosan content of the different pulps and the bending strengths of the finished boards. Lack of pentosans render the board more brittle, while its abundance imparts flexibility to the board and improves its bending strength. Blending rice-straw pulp with bagasse pulp caused the optimum improvement in the bending strength of the finished board. A noticeable improvement in the thickness swelling was observed on blending rice-straw pulp with pulps from reeds and wood wastes.

859. Shukry, N.; Fadl, A.; Rakha, M. 1992. Effect of second and third phases of pressing pressure on properties of rice-straw hardboard. Research and Industry. 37(1): 25-28.

Summary: Rice straw hardboard properties were greatly influenced by the second phase pressing pressure. Specific pressure of 2.0 to 3.9 MPa was sufficient to impart the desired properties to the board. The third phase leads to improvement in water resistance only. Abstract contained no specifics on the pressing phases.

860. Smith, D.C.; Pommerening, J. 1982. Straw into gold: MDF from non-traditional fibers. Unpublished report. Seattle, WA: Washington Iron Works. 20 p.

Summary: High quality medium density fiberboard (MDF) was successfully produced from rice straw, bagasse, palm fronds, and coconut trees. Extensive experimentation on a pilot-plant scale was developed in materials handling, processing, and pressing techniques for converting these under-developed resources into premium grade panels. Boards generally exceeded the ANSI specifications. Extensive data are provided.

861. Vasishth, R.C. 1975. Composite rice hull-resin articles. Assignee: Cor Tech Research Ltd. Patent, P.N.: US 3930089, I.D.: 751230.

Summary: Lightweight (0.48 to 0.80 g/cm^3) composite boards were made by compressing tumbled, sieved, and phenol-formaldehyde impregnated rice hulls at 1.1 to 3.4 MPa and 176.7°C to 232.2°C The rice hulls were tumbled to break up pods, sieved to remove fines passing through a 40-mesh sieve, sprayed with 100 percent alkali-free phenol-formaldehyde resin containing 20 percent catalyst, and compressed into 1.6-cm boards. Internal bond strength and modulus of rupture of boards containing 10 percent phenol-formaldehyde resin were 172.4 to 586.1 kPa and 5.5 to 13.1 MPa, respectively.

862. Williamson, R.V. 1953. Lignocellulose pressure-molded product. Assignee: USA, as represented by the Secretary of Agriculture. Patent, P.N.: US 2645587, I.D.: 530714.

Summary: Lignocellulosic material (rice hulls, nutshells, straw, corncobs, peanut shells, bagasse, flax shives), in finely divided form, is heated to 93.3°C to 148.9°C in essential absence of oxygen until the evolution of smoke or fumes ceases. The treated material is mixed with thermoplastic resins and molded under high pressure and elevated temperatures in a platen press. The product has excellent flexural and impact strength and relatively low water absorption.

863. Williamson, R.V.; Lathrop, E.C. 1951. Hardboard from agricultural residues. Modern Plastics. 28(8): 126, 128, 130, 187.

Summary: The possibility of using rice hulls, peanut shells, and flax shives for producing hardboard was investigated. Mixtures of the ground residues and a rosin by-product resin or phenol-formaldehyde resin and pine gum were pressed at high temperatures yielding boards with good strength and water resistance. Because of their superior physical properties, most of the study was devoted to boards made from peanut shells.

864. Wood Technology Research Institute. 1961. Investigations on the manufacture of hardboards from rice straw. Final report AE-1-41/0 Dresden, Germany: Wood Technology Research Institute. 30 p. [German].

Summary: In the manufacture of hardboard from rice straw, thorough cleaning of the raw material and careful defibration is essential to the development of optimum physical properties of the end product. Experimental boards were produced on a laboratory scale by the wet process using 3 percent by weight synthetic resin as an additional binder. After heat treatment at 160°C for 2 h, the boards exhibited satisfactory physical properties complying with standard specifications. Trials on a full commercial scale gave less satisfactory results, however.

(Also see references 115, 122, 497, 544, 660, 875, and 876.)

insulation Board

865. Anonymous. 1960. Tecpan—a new “home-grown” building material will solve South Korea’s housing problems. Industrial and Engineering Chemistry. 52(4): 28-29A.

Summary: Studies are described of the manufacture of building boards from rice straw using sodium silicate as a binder. Panels of varying thicknesses and sizes can be produced. The material is light but structural strength is high. It is resistant to vermin and moisture and has insulating and sound-proofing qualities.

866. Bencsik, I.; Boros, A.; Csala, G.; Dessewffy, O.; Szabo, G.; Vago, G. 1981. Process for manufacturing insulation panels using fibrous agricultural wastes and a binder. Patent, P.N.: FR 2490142, I.D.: 820319. [French].

Summary: The process is characterized by the use of rice husks or similar materials as a basic raw material for insulation panels.

867. Bencsik, I.; Boros, A.; Csala, G.; Dessewffy, O.; Szaho, G.; Vago, G. 1986. Manufacture of insulating building panels involves pressing mix of fiberized rice hulls filler and resin binder. Assignee: (TWEN-) 23 Sz Allami Epitoi, (SZAM-) Szamu Allami Epitoi, (TWEA) 23 August Intr. Patent, P.N.: IT 1139168, I.D.: 860924. [Italian].

Summary: The patent is for a thermal and sound insulation for buildings that contains plant fiber material. The insulation is in the form of a bound plate. The plate consists of plant fibers, which are cut up and dewaxed, as well as waste material, especially rice shell material, which contains silicic acid. The plate also contains perlite and/or asbestos or straw material. The binding material is preferably a resin.

868. Fadl, N.A.; Rakha, M. 1984. Influence of pH of phenol-formaldehyde resin and thermal treatment on the properties of hardboard. Holz als Roh- und Werkstoff. 42(2): 59-62.

Summary: Hardboard made from mechanical pulp of rice straw showed remarkable improvement in bending strength, water absorption, and thickness swell properties when the pH of the pulp was adjusted to 3.3 to 5.8 by means of diluted H_2SO_4 and $Al_2(SO_4)_3$. Strength decreased by 56 to 65 percent when pH was lowered from 3.5-5 to 2.0-3.9. The rate of improvement was greater when $Al_2(SO_4)_3$ was used for adjusting pH. Thermal treatment resulted in greater improvement in the physical and mechanical properties of the hardboard at lower H^+ concentrations.

869. Gamza, L.B.; Korol'kov, A.P. 1983. Fibrous thermally insulating plates based on organophosphate. Proizvod. Primen. Fosfatnykh Mater. Stroit: 17-30. [Russian].

Summary: Low-toxicity thermal insulating panels for industrial building roofs were made of mineral wool and organophosphate binder consisting of urea resin and sodium polyphosphate curing agent. The bulk density of the panels was 0.20 to 0.21 g/cm^3, thermal conductivity 0.052 W/m-k, compressive strength 0.118 to 0.125 MPa, moisture content 0.3 percent, water absorption capacity 12.6 to 18 percent, and binder content 8.3 to 9 percent. The replacement of mineral wool by self-binding NaOH-treated rice straw is discussed.

870. Guha, S.R.D.; Mathur, G.M.; Gupta, V.K.; Sekhar, A.C. 1964. Insulating board from rice straw. Indian Pulp and Paper. 19(10): 633, 635.

Summary: Insulating boards were produced on a laboratory scale from. rice straw by the Asplund process. Test results indicated that boards with satisfactory properties can be manufactured from this raw material.

871. Juhasz, K.; Polhammer, E.; Horvath, I.; Nacsa, J. 1986. Building elements. Assignee: 23 Sz. Allami Epitoipari Vallalat. Patent, P.N.: GB 2175294, I.D.: 861126.

Summary: Low cost, heat-insulating building panels are manufactured from vegetable matter (such as rice husk or straw, rape, and/or sugarcane) having a waxy surface, siliceous binding materials, and sufficient water to cause setting of the resulting mixture. Patent provides detailed processing and preparation material.

872. Mariani, E. 1963. Insulating materials. Assignee: Societa Novabric. Document type: Patent, P.N.: IT 652049, I.D.: 630125. [Italian].

Summary: Thermal and acoustic insulating material was prepared from the hydrolyzed husks of cereals, preferably rice, and clay by roasting the aqueous paste in a rotating furnace at 850°C to 1,100°C in the presence of 1 to 2 percent sodium or potassium nitrate, and then grinding in a hammermill to <10-mm diameter. The product was used either as an additive to mortar or as raw material for prefabricated panels.

873. Razzaque, M.A. 1969. Manufacture of insulation-type boards from Golpata and rice-stalk. Forest-Dale News. 2(1): 50-57.

Summary: The lamina and pith of the leaf stalk of Nip fruticans were suitable for board manufacture of any type. Only the outer layer of the leaf stalk yielded pulps suitable for making good quality boards of intermediate density.

874. Salas, J.; Veras, J. 1986. Insulating panels with rice husk. International Journal for Housing Science and Its Applications. 10(1): 1-12.

Summary: The report presents quantitative results of tests carried out on 7.5- by 15.0-cm cylindrical test pieces and full-sized panels with a cement and rice husk, produced by appropriate technologies. The results are summarized and analyzed with a view to providing a possible alternative for substituting other insulating materials, which are generally imported, in developing countries.

875. Senno, N. 1980. Heat-insulating boards. Patent, P.N.: JP 55067555, I.D.: 800521. [Japanese].

Summary: Calcium hydroxide is reacted with polyvinyl, mixed with rice hull or other plant fibers, molded, and hardened.

876. Shukla, B.D. 1983. Engineering properties of rice husk boards. Agricultural Mechanization in Asia, Africa, and Latin America. 14(3): 52-58.

Summary: Three successful processes for the production of rice husk boards were developed and described. Four types of rice husk boards, namely insulation board, binderless board, sodium silicate bonded board, and resin bonded board, were investigated. Different engineering properties of the rice husk boards were tested and compared with the recommendations of the Indian Standard Institution, British Standards, American Society for Testing and Materials, and other published literature. A 5,080-kg per day capacity plant for the production of resin bonded rice husk board was also designed for India, and the cost of production was estimated.

877. Shukla, B.D.; Ojha, T.P.; Gupta, C.P. 1985. Measurement of properties of rice husk boards. Agricultural Mechanization in Asia, Africa, and Latin America. 16(2): 53-60.

Summary: Tests indicate that husk boards, depending on their density and strength, can be used like insulation boards, particleboards, and hardboards. Procedures and apparatus for the measurement of physical and mechanical properties of rice husk boards are described. Air permeability, thermal conductivity, and specific heat measurement procedures are described.

878. Shukla, B.D.; Ojha, T.P.; Gupta, C.P. 1985. Measurement of properties of rice husk boards: Part II, Thermal properties. Agricultural Mechanization in Asia, Africa, and Latin America. 16(2): 53-60.

Summary: The procedures and development of apparatus for measuring the air permeability, thermal conductivity, and specific heat of rice husk boards are described. The results are compared with the recommendation of the Indian Standard Institute and other published literature. The suitability of rice husk boards for insulation purposes was studied.

879. Takashima, M. 1975. Heat-insulating board for covering the top surface of a feeder head. Assignee: Aikoh Co. Ltd. Patent, P.N.: US 3923526, I.D.: 751202.

Summary: Insulating board was made from 18 percent flake graphite, 6 percent aluminum, 12 percent FeO, 33 percent aluminum ash, 7 percent cellulosic material from paper, 5 percent slag wool, 10 percent carbonized rice husks, 3 percent KNO_3, and 6 percent phenol-formaldehyde resin. The average yield of ingots cast with this material formulation was improved 1.4 percent over conventional boards.

(Also see references 493, 494, 660, and 1154.)

Cement/Gypsum/Plaster Board

880. Anonymous. 1983. Lightweight building materials with high strength and heat resistance. Assignee: Nichias Corp. Patent, P.N.: JP 58140361, I.D.: 830820. [Japanese].

Summary: A slurry containing burnt rice hulls, bentonite binder, and inorganic fibers is molded, dried, and optionally fired. The resulting lightweight material has a density of 0.57 g/cm^3, bending strength of 392.2 kPa, and low shrinkage.

881. Kanetake, K. 1986. Wallboards from rice hulls. Patent, P.N.: JP 61236640, I.D.: 861021. [Japanese].

Summary: Rice hulls are mixed with cement, chamotte, and heat-resistant fiber, and then aerated, molded, and hardened.

882. Kisoiti, H. 1939. Artificial slates. Patent, P.N.: JP 128357, I.D.: 390118. [Japanese].

Summary: Hemp cloth is immersed in a gelatin solution at low temperature and dried. A paste of MgO, $MgCO_3$, ground rock, rice hull, $MgCl_2$, gelatin solution, and a small amount of organic acids with or without pigments is coated on both sides of base material and pressed. The material may be treated with sodium silicate and formalin solution and dried.

883. Kojima, H. 1986. Nonflammable building materials. Patent, P.N.: JP 61242937, I.D.: 861029. [Japanese].

Summary: Nonflammable building materials are produced from rice hull ash, water glass, or cement, and, optionally, lightweight aggregates by kneading with water, press-molding, and hardening. Resulting boards have a high weathering resistance and high strength.

884. Nishi, T. 1925. Wall-board compositions. Patent, P.N.: GB 239437, I.D.: 250217.

Summary: Rice husks are used with plaster, cement, and lime as fillers.

885. Perl, J. 1950. Composition and production of building units. Patent, P.N.: US 2504579, I.D.: 500418.

Summary: Building blocks, sheets, and boards are prepared by combining cellulosic materials, which include wood fiber, sawdust, straw, reeds, rice husk, or nut shells with a hydraulic binder such as Portland cement. These products are durable, stone-like, lightweight, high in insulative value, excellent in volume stability, and capable of being cut with saws. The durability in volume stability is attributed to a preliminary treatment with ammonia or NH_4OH instead of the conventional NaOH, which results in a regenerated cellulose that expands and contracts with wetting and drying.

886. Rai, M. 1978. Low cost building materials using industrial and agricultural wastes. International Journal for Housing Science and Its Applications. 2(3): 213-221.

Summary: Cement and cementitious materials, reactive pozzolanas, composite boards, roofing sheets, flooring tiles, and water- and weatherproof coatings made of industrial wastes and agricultural wastes such as rice husks, coconut husks, jute sticks, and groundnut shells have been made at the Central Building Research Institute in India. The processes have been licensed to various industries.

887. Roffael, V.E.; Sattler, H. 1991. Studies on the interaction between lignocellulosics straw pulps and cement-bonded fiberboard. Holzforschung. 45(6): 445-454. [German].

Summary: The interaction between kraft rice straw pulps and cement was studied in cement-bonded fiberboards. Results indicate that the presence of alkali-soluble carbohydrates greatly reduced the physical and mechanical properties of the boards. Cement degraded the pulp as the boards aged, leading to a continuous increase in the amount of soluble carbohydrates.

888. Salas, J.; Alvarez, M.; Veras, J. 1988. Rice husk concrete for light weight panels. Batiment International/ Building Research and Practice. 21(l): 45-49. [French; English summary].

Summary: A project by the Eduardo Torroja Institute in Madrid has focused on the mechanical performance of lightweight panels based on concrete made with rice husks treated with lime. The 6-cm-thick components measure 90 by 60 cm and are hand-formed in accord with methods that are suitable for developing countries. The results from flexure and axial compression on a short series of tests of these components are described.

889. Shukla, KS.; Jain, V.K.; Pant, R.C.; Kumar, S. 1984. Suitability of lignocellulosic materials for the manufacture of cement bonded wood-wood boards. Journal of the Timber Development Association of India. 30(3): 16-23.

Summary: The suitability of lignocellulosic materials was determined for the production of cement-bonded wood-flour boards. Of the lignocellulosic materials, rice husk cement mixes developed adequate strength.

890. Simatupang, M.H. 1988. Cement-bonded particleboards and their manufacture. Patent, P.N.: DE 3711496, I.D.: 881013. (German].

Summary: Particleboards (preferably containing wood chips), a hydraulically hardened, Portland cement-containing binder, and additives (optional) contain rice husk ashes.

Abstract gives detailed information on the composition and production of the particleboard. The rice husk ashes act as a hardener for the adhesive system employed in board production.

891. Yen, T. 1978. Study on the rice hull cementboard. K'o Hsueh Fa Ghan Yueh K'an (National Science Council Monthly, ROC). 6(10): 928-938. [Chinese; English summary].

Summary: Coarse grain (raw material) and tine grain (2.0-mm) rice hulls were utilized in the manufacture of cementboard. Test results showed that rice hull is suitable for use in the production of the board. To increase the strength of the cementboard, it was recommended that using the optimal mortar content, consolidation method, or water cement ratio should be used. Increasing the mortar content was the most effective method to achieve higher strength properties.

(Also see references 176, 930, and 1016.)

Plastic/Plastic-Bonded Board

892. Honda, Y. 1950. Water-resistant pressed board. Patent, P.N.: JP 2118, I.D.: 500719. [Japanese].

Summary: Cork or rice hulls with a polyvinyl acetate emulsion are heat-pressed and then treated with formaldehyde gas at 80 to 90 percent humidity.

893. Isobe, K. 1975. Boards from rice hulls. Assignee: Shimoyama, Taizo. Patent, P.N. JP 75138070, I.D.: 751104. [Japanese].

Summary: Mixtures of rice hulls and powdered polyethylene are hot-pressed to give boards having a bulk density of 0.20 to 0.75. Rice hulls (500 g) containing 12 percent water, 100 g of 1 percent aqueous sodium lauryl sulfate, and 100 g of 200-mesh polyethylene were pressed for 3 min at 140°C and 29.4 kPa to give a 25mm board having a density of 0.25 g/cm^3.

894. Jain, N.C.; Gupta, R.C.; Bajaj, S.C. 1964. Plastic board from paddy husk. Research and Industry. 9(3): 67-69.

Summary: Thermal hydrolysis of rice husk in the presence of various chemicals and under different cooking conditions and duration of cooking resulted in boards with superior strength when treatment included cresol, followed by PhOH and PhOH + $Na_2S_2O_3 \cdot 5H_2O$. $PhNH_2$ gave boards with the lowest water absorption. A cooking period of 30 min at 195°C gave boards of optimum strength and minimum water absorption. Replacing 20 to 30 percent of the rice husk with jute sticks and adding 10 percent PhOH and/or PhOH + $Na_2S_2O_3 \cdot 5H_2O$ (based on the weight of the rice husks and jute sticks) gave boards of higher strength (35 percent) and satisfactory properties.

895. Mitchell, M.R.; Varnell, W.R. 1971. Building material made of a mixture of polyester resin and rice hulls. Assignee: Concrete Development Corp. Utility, P.N.: US 3554941, I.D.: 710112.

Summary: A mixture of rice hulls and polyester resin, which preferably includes fine organic particles in the 0.001 to 20 µm range to increase the strength of the product, is used to produce a building material. The rice hulls, which may be either whole or ground, or a mixture of both, are thoroughly coated with resin or polyester resin cement, and bonded together to make a solid product that is strong, durable, inexpensive, lightweight, acid-resistant, and a good electrical, thermal, and sound insulator. The product is ideal for molding articles such as drain boards, wall tiles, shingles, corrugated sheets, siding, roofing, deck panels, silo doors, and frames.

896. Ohtsuka, M.; Uchihara, S. 1970. Straw and chaff molding. Assignee: Otsuka Chemical Drugs Co. Ltd. Patent, P.N.: JP 48022346., I.D.: 700528. [Japanese].

Summary: Vinyl monomer-impregnated chaff and rice straw layers were molded to give laminates useful as construction materials. One-thousand parts air-dried chaff (15 percent water content) were impregnated for 7 min at 200-mm Hg with a mixture of styrene, unsaturated polyester, azobisisobutyronitrile, and polyethylene glycol. One-hundred parts air-dried rice straw were similarly impregnated and the two compositions were heated for 4 h at 65°C at 196.1 kPa. Layers of resinified chaff and rice straw 4 mm thick were heat pressed together for 15 min at 180°C at 1.5 MPa to give a molding having a density of 0.70 g/cm^3.

Roofing Board

(See reference 1016.)

Unknown Board

897. Anonymous. 1975. Conglomerate of rice skin and synthetic resin-production method and use in manufacture of panels and other materials. Assignee: (CIDA/) Cidade J. Patent, P.N.: PT 62226, I.D.: 750331.
(no abstract available)

898. Anonymous. 1981. Composition containing rice hull, for use as construction material–containing fibrous material, starch and/or amino and phenol resins. Assignee: (OKUR) Okura Industrial KK. Patent, P.N.: JP 81013622, I.D.: 810330. [Japanese].

Summary: A composition containing rice hull is produced by adding adequate fibrous material to rice hull, wet starch, and amino or phenol resins. The rice hull mixture is then molded by heating at 160°C under a pressure of 98.1 kPa for 10 min to give a 20-mm board.

899. Anonymous. 1985. Panels production using rice adhesive paste. Assignee: (SADE-) Sadepan SAS. Patent, P.N.: IT 1082947, I.D.: 850521. [Italian].
(no abstract available)

900. Correa, A.P. 1988. Building materials from urea and rice hulls and/or sawdust. Patent, P.N.: BR 8601471, I.D.: 880517. [Portuguese].

Summary: Posts, beams, boards, and moldings are prepared from a mixture of urea compounds, rice hulls, and/or sawdust, and a small amount of water by molding and heating at 100°C.

901. Jain, N.C.; Gupta, R.C.; Bajaj, S.C. 1964. Building board from paddy husk. Board Manufacture. 7(3): 72.
(no abstract available)

902. Shcherbako, A.S.; Gurevich, A.A.; Podchufaro, V.S. 1978. Light heat insulating materials-containing aluminum chromium-phosphate binder, rice straw as tiller and finely divided asbestos. Assignee: (MOFO=) Most Forest Tech. Patent, P.N.: SU 624908, I.D.: 780811. [Russian].

Summary: A mixture contains (in percent by weight) 16 to 17 percent finely divided asbestos, 45 to 47 percent rice straw as organic filler, and 36 to 38 percent aluminum chromium-phosphate binder. The rice straw reduces the temperature of the subsequent heat treatment and the amount of pressure necessary to produce lightweight building material.

903. Staackmann, M. 1970. Feasibility of new utilization of rice hulls. Cereal Science Today. 15: Abstract 72.

Summary: The report reviews ashed rice hulls in structural materials and boards for buildings.

904. Van der Kamp, B.J.; Gokhale, A.A. 1974. Resistance of rice husk board to decay fungi: Comparison to wood. Journal of the Indian Academy of Wood Science. 5(2): 106-107.
(no abstract available)

905. Vasishth, R.C. 1974. Project proposal: Rice husk board manufacture in Malaysia. Prepared for Mara, Malaysia. Richmond, British Columbia, Canada: Cor Tech Research Ltd. 50 p.
(no abstract available)

(Also see references 3, 182, 197, and 665.)

Cement/Clay/Gypsum/Plaster Materials

906. Abdellatif, A. 1971. Burning and other treatment of rice hulls to be used in cement mixtures. Patent, P.N.: FR 2070383, I.D.: 711015. [French].

Summary: Three modifications to the original method (Patent FR 1535495) are described. The maximum ratio of oxygen to rice is increased to 0.4 m^3/kg, the moist mix is pelletized or extruded at low pressure, and up to three wet-dry cycles are applied to the aged material. The product has a bulk density of 0.5 and superior thermal and acoustic insulating properties.

907. Anonymous. 1946. Building blocks from waste. Chemurgic Digest. 5(10): 346.

Summary: The use of rice hulls in producing building blocks is discussed.

908. Anonymous. 1974. Building blocks from rice hulls. Appropriate Technology Document Bulletin. 1(1): 12-13.
(no abstract available)

909. Anonymous. 1974. Material of construction from organic waste material containing silica and pentosan. Assignee: American Organic Silicate Corp. Patent, P.N.: FR 2226373, I.D.: 741115.

Summary: Furan resin obtained from rice husks or wheat straw and ashes obtained by the incineration of the acid-treated organic waste material, controlled to produce an appropriate amount of ash, are mixed to give, after heat treatment, an optionally expanded aggregate for building purposes. The patent presents detailed information about the processing of the aggregate.

910. Anonymous. 1975. Cement from paddy husk ash. Appropriate Technology Document Bulletin. 2(1): 3-5.
(no abstract available)

911. Anonymous. 1986. Construction elements. Assignee: 23 Sz. Allami Epitoipari Vallalat. Patent, P.N.: NL 8501539, I.D.: 861216. [Dutch].

Summary: Construction materials from fibrous vegetable materials (such as rice husks, rice straw, rape, or reed) are mixed with a siliceous binder and water and then formed. Manufacture entails mixing only part of the amount of total water required with the vegetable materials, which contain a dissolved bonding-improving agent, mixing the melted material with the siliceous material, adding the balance of water, and letting the mixture harden. Material is very similar to plaster in texture and properties.

912. Behera, H. 1951. Fabricated cement articles. Patent, P.N.: IN 40868, I.D.: 510110.

Summary: Hydraulic cement mixed with pulps and fibers of vegetable matter is made plastic with water and molded into desired pattern in a skeleton with holes and gaps and constructed from materials like bamboo, cane, and reed. The amount of pulp and fibers in the mixture may be 2 to 12.5 percent of the cement by weight in the dry state. Pulps and fibers are obtained from paper pulps, waste papers, waste cardboards, cotton, jute, hemp, coir, manila, sawdust, rice husk, and straw. Roofing tiles, writing boards, slates, containers, and dishes can be manufactured from the cement.

913. Chittenden, A.E.; Flaws, L. J. 1964. The use of rice hulls as aggregate in lightweight concrete. Tropical Science. 6(4): 187-199.

Summary: Rice husks can be used successfully as an aggregate in the preparation of lightweight concrete. For nonload bearing internal partitions, it is sufficient to press the mix by hand. When the concrete is to be used for load-bearing outdoor structures, the mix must be compressed during setting and the concrete rendered. The cement/husk ratio was varied from 2:1 to 10:1, corresponding to a density range of the concrete of 0.40 to 1.84 p/cm^3. It appeared that with a density approaching 1.60 g/cm^3, the concrete had adequate strength for most structural purposes.

914. Christen, M. 1970. Silicocalcareous construction elements. Patent, P.N.: FR 1587389, I.D.: 700320. [French].

Summary: A mixture of sand and a saturated solution of chalk is autoclaved at 200°C under 1.5 atm pressure for 90 min. The mixture is then ground and 100 parts is mixed with 3 to 10 parts of calcined rice husks and 7 to 10 parts of chalk. The resultant mixture is then added to about 10 percent by weight of water and an aqueous solution of a strong base. The total mixture contains 5 percent rice husk. The mixture is molded into bricks and treated in an autoclave at 200°C under 15 atm for 4 h. The bricks have a compression resistance of from 29.4 to 34.3 MPa.

915. Chvatal, T. 1972. Increasing the freeze resistance of concrete. Patent, P.N.: Austrian 302149, I.D.: 721010.

Summary: The freeze resistance of concrete, especially concrete exposed to high mechanical stress during manufacturing processes, is increased by adding a mixture of 4 to 30 percent rice hull ash (based on the volume of cement paste) of a particle size $\leq$ 0.2 mm.

916. Cook, D.J. 1985. Rice husk ash cements: their development and application. Vienna, Austria: United Nations Industrial Development Organization (UNIDO): 1-100.
(no abstract available)

917. Cook, D.J.; Pama, R.P.; Damer, S.A. 1976. The behavior of concrete and cement paste containing rice husk ash. In: Proceeding of the conference on hydraulic cement pastes: their structural properties; 1976. Slough, England: Cement Concrete Association: 268-282.

Summary: The use of rice husk ash to replace 10 to 67 percent Portland cement was studied in cement pastes and concrete. For pastes, the bleeding rate decreased with increased additions, but shrinkage and swelling increased. Cement replacement by 530 percent ash did not significantly influence later strength. For concrete, replacement of $\leq$20 percent by weight cement significantly reduced both initial and later strength, but did not significantly affect shrinkage, swelling, and creep.

918. Cook, DJ.; Pama, R.P.; Paul, B.K. 1987. Rice husk ash-lime-cement mixes for use in masonry units. Building and Environment. 12: 281-288.
(no abstract available)

919. Cook, DJ.; Suwanvitaya, P. 1983. Properties and behavior of lime-rice husk ash cements. American Concrete Institute, 79 (fly ash, silica fume, slag and other mineral byproducts for concrete). 2: 831-845.

Summary: The use of rice husks for pozzolanic materials is described. The behavior of lime-rice husk ash mixes is examined in terms of strength, shrinkage, durability, and microstructure. Although maximum strengths are achieved with low lime mixes, lime leaching could seriously impair the durability and the long-term strength of these mixes. It is proposed that the optimum lime:rice husk ash ratio should be about 1:1.

920. Dass, A. 1978. Pozzolanic behavior of rice husk ash, developing countries viewpoint. UDC 691.34. Thailand: AIT: 301-311.
(no abstract available)

921. Dass, A. 1983. Pozzolanic of rice husk ash. In: Building Materials and Components. The 9th International Council for Building Research Studies and Documentation Congress CIB83: 4: 85-96.
(no abstract available)

922. El-Wahed, M.G.A. 1991. Electrical behaviour of blended cement made of rice huck ash. Journal of Materials Science Letters. 10(1): 35-38.
(no abstract available)

923. Farias, J.S.A.; Recena, F.A.P. 1990. Study for Brazilian rice husk ash cement. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia; Brazil: 360-369.

Summary: The report describes procedures for preparing rice husk ash cement for application on low cost civil construction. A variety of rice husk ash cement mixes produced during laboratory work are described.

924. Fujimoto, M.; Taguchi, N.; Hattori, S. 1988. Chaff panels with good sound and vibration damping. Assignee: Oshika Shinko KK. Patent, P.N.: JP 63118337, I.D.: 880523. [Japanese].

Summary: Chaff panels to be used in construction and automobiles are prepared by (1) kneading powdered chaff with foamable natural and diene rubber latexes, vulcanization agents, and delayed gelation agents, (2) casting on substrates, and (3) gelling. A foamed, compounded latex of 70:30 natural rubber-SBR is kneaded (100 parts) with

50 parts chaff for 3 h, cast on a nonwoven cloth-covered metal plate, heated by far IR at 120°C for 1.5 min, gelled, cold-pressed, and vulcanized at 120°C for 0.5 h to give a panel with good sound and vibration damping.

925. Gavieta, R.C. 1991. Mass housing based on traditional design and indigenous materials for passive cooling in the tropical urban climate of the Philippines. Energy and Buildings. 16(3/4): 925-932.

Summary: The Bahay Kubo (nipa hut) and the Bahay na Bato (stone house) were the subjects of study regarding traditional design for passive cooling. Coca-timber, rice hull ash, ordinary Portland cement, and bamboo were the indigeuous materials chosen because of their excellent thermal qualities. The combination of traditional design and indigenous materials resulted in houses with an acceptable internal bioclimatic environment, which are economically affordable and are appealing for low-income families in the tropical urban areas. Maximum benefits from natural ventilation and sun shading were achieved by collating wind direction and speed data, solar charts, and elements of the Filipino house. The use of building materials that are low cost but are thermally congruent for passive cooling in urban areas enhanced affordability for mass housing.

926. Hara, N. 1988. Utilization of rice husk ash for calcium silicate light-weight building materials. Kobutsugaku Zasshi. 18(6): 405-415. [Japanese].

Summary: The report reviews chemical, physical, and mineralogical properties of rice husk ash and manufacturing, mechanical, and thermal characteristics of calcium silicate hydrate for insulating materials from rice husk ash, CaO, and/or $Ca(OH)_2$ by a hydrothermal process.

927. Hara, N.; Yamada, H.; Inoue, K.; Tsunematsu, S.; Noma, H. 1989. Hydrothermal reactivity of rice husk ash and its use for calcium silicate products. American Concrete Institute, SP, 114, (fly ash, silica fume, slag, natural pozzolans concrete). 1: 499-516.

Summary: The use of rice husk ash as a siliceous material for calcium silicate products manufactured by hydrothermal reaction was examined. Characteristics of rice husk ash are favorable to the formation of well-grown xonotlite, which forms bodies of insulating materials. Trial products with bulk densities of 0.11 to 0.41 g/cm^3 prepared from rice husk ash using glass fiber as reinforcement not only satisfied all the requirements in the industrial standards, but also gave 1.4 to 2 times higher bending strength than commercial products prepared from conventional siliceous materials.

928. Ikpong, A.A.; Okpata, D.C. 1992. Strength characteristics of medium workability ordinary Portland cement-rice husk ash concrete. Building and Environment. 27(1): 105-111.

Summary: The report describes the strength of medium workability concrete when rice husk ash replaces some ordinary Portland cement. The strengths investigated were 20, 25, 30, and 40 MPa. Compressive strength results obtained for 28-day strengths of up to 30 MPa show that the designed strengths were achieved for up to 40 percent replacement of cement with rice husk ash. For the mixes designed for 40 MPa, the designed strength could not be achieved at 28 days, indicating that strength values greater than 30 MPa may not be achieved in this time framework. Mathematical relationships giving mix design parameters for ordinary Portland cement/rice husk ash concrete are also established.

929. James, J.; Rao, M.S. 1992. Rice-husk-ash cement-a review. Journal of Scientific and Industrial Research. 51(5): 383-393.

Summary: The use of silica from rice husk for the production of various materials, including rice husk ash-lime binder, has gained significance. In this context, the decomposition of husk, the properties of the silica ash (including its crystallization), and the ash-lime reaction are reviewed. The mechanism of ash-lime reaction is controlled mostly by the development of osmotic pressure. For lime-deficient ash-lime mixtures, the reaction is complete in the initial few days and therefore no strength development is observed for such mortars in the later stages. The use of optimum ash-lime ratio is recommended for obtaining consistently good performance for the mortar. A method for the determining this ratio is also discussed. Paper includes 109 references.

930. Karapanos, T.; Mavropoulos, T. 1982. Flowable mixture of water, filler, and binding materials as well as its application to forming and pouring building elements with insulating properties, and a building element in the form of a slab, block, or panel. Patent, P.N.: EU 49733, I.D.: 820421. [German].

Summary: Structural materials, such as walls, tiles, and blocks, with good insulating properties against heat, cold, moisture, and pedestrian traffic noise are prepared from flowable masses consisting primarily of expanded perlite and rice husks, along with materials like pumice, sawdust, sand, and cement.

931. Kulakova, E.G.; Proskura, I.F.; Litvinov, P.K. 1968. Increase in brick quality and mechanization of labor-consuming processes at the Kerch Structural Materials Plant. Stroitel'nye Materialy, Detali Izdeliya. 10: 106-110. [Russian].

Summary: To improve the drying and firing properties of brick, 12 percent by volume sawdust (percent by volume boiler slag), 20 percent by volume rice hull, and 70°C water were added to brick batches.

932. Masood, I.; Mehrotra, S.P. 1981. Rice husk ash based lime cement. Research and Industry. 26(1): 4-8.

Summary: A cementitious binder with properties comparable to that of ordinary Portland cement was prepared from lime

and rice husk ash as a pozzolan. A tobermorite-like gel and gelatinous SiO_2 were found in the hydration products. The strength of the binder increased with increased curing time. The binder was used for mortars, plasters, and the prepara-. tion of stone-masonry blocks.

933. Mehta, P.K. 1977. Properties of blended cements made from rice husk ash. Journal of the American Concrete Institute. 74(9): 440-442.
(no abstract available)

934. Mehta, P.K.; Pitt, N. 1976. Energy and industrial materials from crop residues. Resource Recovery and Conservation. 2(1): 23-38.

Summary: Crop residues such as rice hulls and rice straw can be a valuable resource for the recovery of energy and useful industrial products. By a special process, combustion of rice hulls produces a reactive silica ash which is used for making acid-resistant hydraulic cement and reinforcing filler for rubber. Properties of the hydraulic cement and the rubber filler made from rice hull ash are described.

935. Mehta, P.K.; Polivka, M. 1976. Use of highly active pozzolans for reducing expansion in concretes containing reactive aggregates. Symposium on living with marginal aggregates; 1975; England. Philadelphia, PA: American Society for Testing and Materials (ASTM) Special Technical Publications: 25-35.

Summary: Mortar containing 5, 10, 15, or 20 percent rice hull ash or calcined shale with a high alkali cement was prepared at a water: cement ratio of 0:5. The addition of 5, 10, 15, and 20 Percent rice hull ash reduced concrete expansion by 52.2, 90.4, 97.4, and 98.6 percent, respectively. With 10 percent rice hull ash, the water demand increased by 5 percent; the 3- and 7-day compressive strength was unaffected and the 28-day compressive strength increased by 18 percent.

936. Palli, A. 1955. Artificial cement. Patent, P.N.: IT 516459, I.D.: unknown. [Italian].

Summary: Rice hulls are utilized in the production of an artificial cement.

937. Pitt, N. 1972. Siliceous ashes. Assignee: Structural Materials. Patent, P.N.: US 3959007, I.D.: 720728.

Summary: A process and apparatus have been developed for incineration of organic material (especially rice hulls and rice straw) to produce siliceous ashes that can be used to make hydraulic cements. The process consists of exposing the material to elevated temperatures $\leq$843.3°C in an excess of air in a cylindrical furnace. The amorphous silica ash (28 percent SiO_2) can be withdrawn from the bottom of the furnace; when ground with 20 to 30 percent by weight quicklime or cement, the ash gives a high-strength cement:

938. Qurashi, M.M.; Ahsanullah, A.K.M. 1959. The properties of heat-insulating building materials II. The thermal conductivity of binary mixtures with particular reference to cellular concrete. Pakistan Journal of Science and Industrial Research. 2(1): 1-9.

Summary: Comparisons of experimental data of thermal conditions of mixtures of cement and rice husk ash to theoretically derived formulas governing thermal conditions of porous materials led to derivation of a law based on an improved model for a homogeneous mixture of two substances, which is in excellent agreement with experimental data. Derivation of the formula and verification on cellular concrete, cork, and rice husk ash are given.

939. Reiser, H. 1934. Clay product suitable for light bricks. Patent, P.N.: US 1945232, I.D.: 340130.

Summary: The residue obtained by burning rice hulls is mixed (preferably in proportions of 20 to 80 percent) with brick or potter’s clay.

940. Sabrah, B.A.; El-Didamony, E.; El-Rabieh, M.M. 1989. Ceramic studies of the clay/rice husk/slag system and its suitability for brick making. Interbric. 5: 24-27.
(no abstract available)

941. Salam, S.A. 1985. Composite beams using rice husk concrete and timber. Journal of Institute of Jurutera Malays. 37: 40-50.

Summary: A theoretical and experimental study was carried out to determine the flexural and shear strengths of T-beams made up of rice husk concrete flanges and timber ribs. Two rows of lo-mm-diameter bolts were used as shear connectors and Light Red Meranti timber was used for the tests. The spacing of bolts along the span was different throughout each beam to test the validity of the proposed method of design. Of the four composite beams tested to failure, there was virtually no slip at the interface of timber and concrete in two beams that had sufficient shear connector. The theoretical ultimate loads calculated on the basis of strength properties of the materials and strain compatibility show a reasonable agreement with experimental loads.

942. Secondi, A. 1960. Building materials from rice hulls. Patent, P.N.: DE 1075493, I.D.: unknown. [German].

Summary: Rice hulls are used in the production of cement articles to be used in construction.

943. Shah, A. 1972. Chemurgy and developing nations with specific reference to the production of furfural and compost fertilizer or insulation bricks. Presented at IRC working party on agricultural engineering aspects of rice production, storage and processing, 7th session; 1972; Bangkok, Thailand. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). 27 p.
(no abstract available)

944. Shimizu, G.; Jorillo, P. 1990. Study on the use of rough and unground ash from an open heaped-up burned rice husk as a partial cement substitute. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RlLEM); 1990 September 17-21; Salvador, Bahia, Brazil: 321-333.

Summary: Various replacement ratios of rice ash to cement were made and four grades of concrete were produced experimentally. Three different degrees of ash fineness were introduced to HG1 and LG series. Mechanical properties were measured at four different curing ages (including fresh) to evaluate the effect of the rice ash to concrete. At a proportion of 80:20 by volume (or 87:13 by weight), the compressive strength of a low-grade RHA concrete was 93 to 100 percent that of plain Portland cement. The equations for the tensile property did not significantly vary compared with other experimental equations for plain Portland cement concrete.

945. Smith, R.G. 1984. Rice husk ash cement: progress in development and application: a report on site visits to India, Nepal and Pakistan. London, England: Intermediate Technology. 45 p.

Summary: The book describes the use of rice husk ash in the production of cement.

946. Smith, R.G. 1984. Rice husk ash cement small scale production for low cost housing. In: Proceedings of international conference on low cost housing for developing countries; Roorkee, India: 687-695.
(no abstract available)

947. Smith, R.G.; Kamwanja, G.A. 1986. The use of rice husk for making a cementitious material. In: Use of vegetable plants and fibres as building materials; joint symposium RILEM/CIB/NCCL; Baghdad, Iraq: E85-E94.
(no abstract available)

948. Tosi, V. 1955. Rice bran preparation for kneading with cement binders. Patent, P.N.: IT 526360, I.D.: unknown. [Italian].
(no abstract available)

949. Venditti, G.; Venditti, J. 1972. Gypsum-based composition for making construction elements. Patent, P.N.: FR 2133255, I.D.: 721229. [French].

Summary: A mixture of 30 to 50 percent by weight plaster, 50 to 70 percent by weight aggregate, and 2 to 5 percent by weight sizing is used for a lightweight construction material of superior thermal and sound insulating properties. The sizing is vegetable, animal, cellulosic, and vinyl. Pumice, fly ash, aerated concrete, expanded clay, and rice straw ace used as the aggregate.

(Also see references 197, 210, 622, 623, 872, and 886.)

Molded Masses
Plastics

958. Anonymous. 1990. Preparation of moldings for the cultivation of plants. Assignee: Klasmann-Werke GmbH. Patent, P.N.: DE 3828346, I.D.: 900329. [German].

Summary: Moldings, which can be disposed of easily, consist of rice hulls bonded by inert, organic materials, especially polyurethane foams. Rice hulls are stirred with water until they form a crumbly mass, mixed (1 L) with 30 g isocyanate prepolymer and water, placed in a mold enclosed on three sides, covered with a lid, and unmolded after a few minutes to give a molding varying from moist to dry, depending on the amount of water added.

951. Chand, N.; Dan, T.K.; Verma, S.; Rohatgi, P.K. 1987. Rice husk ash filled-polyester resin composites. Journal of Materials Science Letters. 6(6): 733-735.

Summary: Rice husk ash-polyester composites or different volume fractions are described in this study. Tensile and impact properties of the composites were evaluated. The effect of the addition of the filler on the properties of polyester are discussed based on the fractographs obtained from scanning electron microscopy. Composites of rice husk ash fired at different temperatures with polyester resin were successfully developed. Addition of tiller (rice husk ash) decreased the tensile strength of the composites. Firing temperature did not affect the ultimate tensile strength of the composites.

952. Dudkin, M.S.; Shkantova, N.G.; Kestel'man, N.Y.; Ruzer, V.V. 1974. Use of rice husks as fillers for plastics. Khimica i Khimicheskaya Tekhnologiya (Minsk). 7: 182-188. [Russian].

Summary: Rice husks were mixed with Bakelite lacquer to give plastic construction materials by heat pressing at 140°C to 180°C. Panels prepared from husk-filled Bakelite had a density of 0.75 g/cm^3. The water and water-vapor absorption of such panels was significantly lower than that of similar particleboard panels. The water absorption of the husk panels decreased with increasing binder content or on using NaOH-treated husks. The mechanical properties of the husk panels were superior to those of the particleboard panels. The rigidity of the husk panels increased with increasing binder content. The oil absorption of the husk panels and the effect of moisture content on the deformability were also studied.

953. Ohashi, Y. 1975. Resin blocks made of polyesters. Patent, P.N.: JP 50014747, I.D.: 750217. [Japanese].

Summary: Rice bran was used as the aggregate in polyester building blocks.

954. Takano, A.; Ozawa, K.; Hayashi, M. 1975. Injection molding of wood substitutes. Assignee: Asahi Dow Ltd. Patent, P.N.: JP 50142663, I.D.: 751117. [Japanese].

Summary: Compositions of 20 to 80 percent by weight polystyrene and 20 to 80 percent by weight sawdust or rice hull powder are injected into molds containing wood parts to give moldings having wood surfaces. A lauan wood cabinet molded with a 50:50 mixture of polystyrene and sawdust at 180°C and 11.8 MPa had good dimensional stability after five cycles of 8 h in dry air at 60°C and 8 h in air at 40°C and relative humidity of 90 percent. When sawdust was omitted, a similar cabinet developed cracks and warped during testing.

955. Willis, S.; King, T.S. 1981. Surface-modified organic particulate as extenders in thermoplastics. Plastic Compounds. 4(2): 46, 48-50.

Summary: Rice hulls, surface treated with coupling and wetting agents and used as fillers in polyolefins, reduced the weight of finished parts, increased stiffness in polypropylene, decreased warpage and shrinkage, decreased cycle times in some processes, decreased feed for thick-walled parts, decreased melting and molding temperatures, improved mold release, increased stiffness and sealability in low-density film, increased ease of handling, increased paint adhesion in polypropylene parts, and increased blowing agent functionality.

Refractory Materials

956. Agarwal, R.K. 1963. Refractory materials. Patent, P.N.: IN 74582, I.D.: 630119.

Summary: Refractory blocks were produced by combining 100 parts rice husks ash and 2 to 16 parts lime, adding 1 to 5 parts of sodium silicate as a 1 to 5 percent aqueous solution, molding and drying the wet mix, and finally firing the mix at 676.7°C. The fired material can be powdered and used in mortars.

957. Anonymous. 1953. Microporous, refractory, heat-insulating material. Assignee: Aktein-Ziegelei Allschwil. Patent, P.N.: Swiss 292726, I.D.: 531116.

Summary: A refractory, heat-insulating material is manufactured by burning rice hulls slowly and completely, controlling the oxygen supply so as not to hinder conversion of the SiO_2 of the ash into tridymite and cristobalite. At least one trivalent metal silicate is added to the ash, such as those from aluminum or iron. The mixture is shaped and calcined at 950°C to 1450°C. The product is stable to cold and hot water, to water vapor, and to acid vapors. It is light, strong, and acid resistant.

958. Anonymous. 1971. Composite materials containing fibers. Assignee: Foseco Trading A. Patent, P.N.: FR 2053972, I.D.: 710521. [French].

Summary: Sound- and heat-insulating composites were prepared by filling an oriented fabric with a particulate refractory material and needling the laminate. A carded rayon fabric was spread with layers of paper, calcimined rice grains, muslin, and a second rayon layer, and consolidated by needling to give a flexible composite, which was sprayed with colloidal silica and used as a feed head in contact with molten steel.

959. Anonymous. 1981. White ash production from rice husks-for use in fireproof building materials. Assignee: (REFR-) Refratechn Albert. Patent, P.N.: JP 81031286, I.D.: 810720. [Japanese].

Summary: The report describes production of practically carbon-free white ash from rice husks for use in fireproof building materials. Volatile matter is expelled and fixed carbon is converted into a volatile compound at a temperature below the crystallization temperature of SiO_2.

960. Barfield, L.T.; Kellie, J.L.F. 1970. Refractory compositions for producing thermal-insulating articles for use in casting metals. Patent, P.N.: SA 70 01065, I.D.: 700909.

Summary: The compositions contain 10 to 30 percent by weight lightweight anisotropic material of vegetable origin containing 40 to 90 percent SiO_2 rice husks (preferably burnt) and have lower specific gravity than most hot top compositions that contain all their refractory material as isotropic particles. Compositions have adequate strength and flexibility.

961. Bartha, P.; Tutsek, A. 1977. Method of producing low-carbon white-husk ash for refractory building materials from rice husks; specific heating temperatures. Assignee: Refratechnik GmbH De. Utility, P.N.: US 4049464, I.D. 770920.

Summary: Low-carbon, white-husk ash suitable for use in manufacturing building materials, more particularly refractory building materials, are prepared by first removing volatile constituents by heating the husks first to a relatively low temperature below the ignition point of the husks. (Rice husks are generally used, but wheat, oat, or barley husks can also be used.) Fixed carbon is then oxidized in the presence of a reagent by heating the husks to a second temperature above the separation temperature but below the crystallization temperature of the SiO_2 in the husks, followed by heat treatment at a third temperature above the crystallization temperature of the SiO_2, to produce a uniform SiO_2 crystal structure.

962. Belladen, L.; Galliano, G. 1941. The ash of rice chaff as raw material for refractory insulators. Metallurgia Italiana. 33: 349-352.

Summary: The ash from rice chaff contains 93.46 percent SiO_2, 1.4 percent Al_2O_3 and Fe_2O_3, 1.6 percent CaO, 0.74 percent MgO, and 2.75 percent alkali. Bricks formed of this material provide good heat insulation. They can be used up to a temperature of 787.8°C, or higher under certain conditions.

963. Chvatal, T. 1971. Binders containing powdered aluminum phosphate for making refractory bricks and mortar. Patent, P.N. DE 2126521, I.D.: 711216. [German].

Summary: Aluminum and possibly chromium phosphate containing a powder-form binder for preparation of refractory building material is characterized as follows: the phosphate solution is deposited on finely divided porous carrier material from the ash of organic material with a fiber structure and a high silicic acid content, such as ash from burning reeds, rice straw, and rice husks.

964. Cutler, I.B. 1976. Solid solution of aluminum oxide in silicone nitride. Patent, P.N.: US 3960581, I.D.: 760601.

Summary: A refractory with a low thermal expansion coefficient is made from a solid solution containing 15 to 70 percent by weight Al_2O_3 and 30 to 85 percent by weight Si_3N_4. The $A1_2O_3$ and Si_3N_4 reactants are obtained by selecting clay containing Al_2O_3 and Si_3N_4, a coked mixture of rice hulls, and an aluminum source. The aluminum is obtained from clays formed by the decomposition of aluminum compounds, oxides, and salts of aluminum, aluminum metal, and a precipitate containing Al_2O_3 and Si_3N_4. The reactants are placed in an enclosure and heated to 93.3°C to 871.1°C with carbon and nitrogen until a solid solution results.

965. Das, S.; Dan, T.K.; Prasad, S.V.; Rohatg, P.K. 1986. Aluminum alloy-rice husk ash particle composites. Journal of Materials Science Letters. 5(5): 562-564.

Summary: The use of rice husk ash particles in molten aluminum-silicon alloys and the effects of second-phase particles on the solidification behavior of aluminum-silicon alloys are studied. Because rice husk ash particles are conducting materials, they do not allow heat to be dissipated immediately. Consequently, molten metal remains at higher temperatures for a longer time in the vicinity of the ash particles in the composites than in the base alloys.

966. Devidts, P. 1964. Insulating and refractory materials utilized in the iron and steel making industries. Centre Documents Siderurg. Circ. Inform. Tech. 3: 717-754.

Summary: The report describes the use of rice sinter powder in the insulating and refractory industries.

967. Falk, R.A. 1987. Insulative composition and method of making articles from such material. Patent, P.N.: US 4659679, I.D.: 870421.

Summary: Insulating compositions prepared from a mix of refractory fibers and burned rice hull ash are useful for the manufacture of temperature-resistant parts for the metal industry. A tundish liner board was manufactured by casting a composition consisting of high-temperature refractory fibers, Secor high-Al_2O_3, high-temperature cement, SiO_2-C powder (containing the rice hull ash), and SiO_2-C 3.175-mm particles. The product has good temperature and abrasion resistance, high density, and average breaking-strength, and is brittle but not hard.

968. Goodwin, J.D.; Mulkey, F.W. 1988. Expanded lightweight silicate aggregate from rice hull ash. Patent, P.N.: AU 578241, I.D.: 881020.

Summary: A lightweight silicate aggregate consists of (percent by weight) 45 to 75 percent dry rice hull ash (with a carbon content of less than 4 percent by weight), 10 to 25 percent alkali metal hydroxide, 2 to 4 percent H_3BO_3, and 10 to 25 percent water. The mixture is heated to 71.1°C and cured at <37.8°C until a friable mass is formed. The mass is pulverized, and expanded silicate aggregate is formed by rapid heating. The product can be used as a sorbent, filler, or energy insulator, or in filters.

969. Guha, S.; Dhindaw, B.K. 1986. Wear properties of aluminum-10 silicon composites with white ash and silicon carbide. Wear. 110(1): 87-89.

Summary: Cast A1-10 Si-6 mg composites containing 8 SiC or 1.5 percent by weight white ash were prepared by stirring in the particulate additions at approximately 426.7°C. White ash was prepared from rice husk and consisted of 95 percent SiO_2; the balance was phosphate. The sliding-wear resistance of the aluminum alloy was increased by a factor of approximately 20 by silicon carbide addition and to a lesser extent by the white ash.

970. Hooper, J.F. 1969. Lining ingot molds to prevent rapid cooling of metals. Patent, P.N.: FR 1573344, I.D.: unknown. [French].

Summary: Rice ash is used in the composition that is used as a refractory heat-insulating material in the production of iron and steel.

971. Jones, J.D. 1948. New refractory from vegetable source. Canadian Metals. 16(1): 22-24.

Summary: A satisfactory refractory material was developed from rice hull ash.

972. Jones, J.D. 1958. Porous media. Patent, P.N.: US 2826505, I.D.: unknown.

Summary: The patent describes the use of rice hull ash to produce porous media for refractory material.

973. Krasil'nikova, T.P. 1991. Preparation of silicon carbide whiskers from rice hulls. Kompleksn. Ispol'z. Miner. Syr'ya. 1: 80-83. [Russian].

Summary: The report describes the use of rice hulls as a material for preparing silicon carbide whiskers as a reinforcing material for high-strength composite materials. The report includes 12 references.

974. Mehrotra, B.B.; Fink, F.; Lippe, K.F. 1970. Refractory insulation from rice husk ashes. Assignee: Edelstein- und Mineralien-Handelsgesellschaft MINEG mbH. Patent, P.N.: DE 1812827, I.D.: 700618. [German].

Summary: Refractory insulation is made from rice husk ashes consisting of crystalline and amorphous material in proportions of 40 to 60 percent each. The product is obtained by heating the rice husks at 1,200°C to 1,400°C.

975. Ol'khovskii, I.A.; Toropov, S.A. 1969. Vibration packing of high-grog-containing and lightweight refractory masses. Tr., Vses. Gos. Inst. Nauch.-Issled. Proekt. Rab. Ogneupor. Prom. 41: 294-309. [Russian].

Summary: Vibration compaction of mixtures consisting of high Al_2O_3 content (≈45 percent) and grog containing 8 to 13 percent moisture content and mixtures filled with lightweight rice husk or rice husk ash improved the mechanical properties of fired grog and rice husk refractories in comparison with properties of refractories pressed at 9.8 to 49.0 MPa.

976. Ono, T. 1975. Heat-insulating materials for molten metals. Patent, P.N.: JP 75123525, I.D.: 750929. [Japanese].

Summary: A granulated mixture containing perlite, carbonaceous materials with a large amount of ash (such as wood barks, pulp sludge, and rice husks), clays, Fuller's earth, white clay, and sodium silicate is an excellent heat insulator for molten metals in the ladle or in other melting and casting devices.

977. Phillips, W.L. 1978. Elevated temperature properties of silicon carbide whisker reinforced aluminum. ICCM/2: Proceedings of the international conference of composite materials: 2: 567-576.

Summary: Silicon carbide whiskers were prepared from rice hulls and added to an aluminum alloy by pressure casting. Initial random whiskers were aligned by warm extrusion. The strength and stiffness of silicon carbide fiber/AA 2024 composites at 100°C to 400°C were 20 to 30 percent higher than those for the AA 2024 control, but the ductility was lower by a factor of approximately 10.

978. Pompei, L.; Licini, C. 1955. Chromite-periclase or magnesite refractories. Patent, P.N.: IT 518463, I.D.: unknown. [Italian].

Summary: Rice bran ash is used in the production of refractory materials.

979. Rowland, M. 1966. Heat-resistant refractory coatings. Patent, P.N.: FR 1447610, I.D.: 660729. [French].

Summary: Furnace walls can be made more resistant to convected or radiated heat if rice hull ash is mixed with aluminum cement of less than 7 percent by weight iron content as binder and enough water to form a paste capable of being hardened.

980. Rowland, M. 1966. Low-density refractories. Patent, P.N.: FR 1447611, I.D.: 660729. [French].

Summary: The addition of rice hull ash to aluminum cement and crushed waste of refractory brick made the brick light, temperature resistant, and heat reflecting. The ash of carefully calcined rice hulls will retain a porous silica structure with a very irregular surface. Consequently, no compacting or curing is required when the ash is added to the cement binder and refractory filler in the manufacture of bricks.

981. Rowland, M. 1967, Cast self-hardening refractory bodies containing rice hull ash and aluminous cement. Patent, P.N.: GB 1085977, I.D.: unknown.
(no abstract available)

982. Roy, N.C. 1958. Refractory and heat-insulating bricks, blocks, and tiles, Patent, P.N.: IN 60735, I.D.: unknown.

Summary: Rice hull ash is used in the manufacture of refractory materials in the form of bricks, blocks, and tiles.

983. Roy N.C. 1964. Heat-insulating bricks. Patent, P.N.: IN 77891, I.D.: unknown.

Summary: Rice husk ash is used in the production of bricks that are heat-insulating and can be used as refractory materials.

984. Shioda, M.; Kato, T.; Numata, S. 1975. Refractory mix for production of high-strength, shrinkage-resistant refractory material. Assignee: Asahi Glass Co. Ltd. Patent, P.N.: JP 75 33081, I.D.: 751027. [Japanese].

Summary: Siliceous sinter was mixed with 42 percent K_2CO_3 and heated at 537.8°C to obtain a siliceous material containing more than 70 percent tridymite; rice hulls were heated with a small amount of K_2CO_3 at 537.8°C to obtain ash containing more than 80 percent tridymite. Then, 46 parts siliceous material, 26 parts rice hull ash, and 10 parts clay were mixed with a suitable amount of water, compacted at 11.8 MPa, and fired to obtain a refractory material having a density of 1.22 g/cm^3, strength of 18.1 MPa, and refractoriness >31 (as Seger cone). No shrinkage was observed even when the material was heated at 648.9°C for 8 h.

985. Takashima, M. 1974. Hot top for steel ingots to render them free from fume and dust formation in use. Assignee: Aikoh Co. Ltd. Patent, P.N.: JP 74 16170, I.D.: 740420. [Japanese].

Summary: The patent describes a fume- and dust-free hot-top heating agent for casting steel ingots in a mold. The agent contains 15 to 25 percent rice hull ash, 58 to 81 percent aluminum ash residue, 2 to 10 percent metal oxide powders, 0 to 5 percent chloride, and 0 to 7 percent carbonates. The agent prolongs the exothermic reaction, resulting in a flat ingot surface.

986. Takashima, M. 1975. Heat-insulating board for covering the top surface of a feeder head. Assignee: Aikoh Co. Ltd. Patent, P.N.: US 3923526, I.D.: 751202.

Summary: Improved coverings are described for hot tops to retard cooling of the upper parts of ingots or risers of castings of molten steel or other alloys. Hot tops retard heat loss more effectively if they are flat plates composed chiefly of thermally insulating refractory or exothermic material and have rims of expandable material to close tightly the clearance between the plate and ingot mold, or riser openings of sand molds. Carbonized rice husks are used in the manufactured mixture.

987. Wecht, P. 1982. Silicon carbide-bonded silicon carbide moldings. Patent, P.N.: DE 3031526, I.D.: 820325. [German].

Summary: Molded silicon carbide (SiC) articles bonded with SiC are prepared at lower energy expenditures than by the usual process. Rice husks containing Si and C in approximately the same ratio as in SiC are suspended to obtain an intimate mixture with SiC grains and fired at >1,290°C to form crystalline SiC, which grows on the primary crystalline SiC grains and forms bridges between the grains.

988. Wright, J.C. 1968. Thermally insulating bodies for delaying the cooling of the tops of freshly poured metallic castings. Assignee: Columbiana Inc. Patent, P.N.: US 3372042, I.D.: 680305.

Summary: Hot-top compositions are improved by using rice hulls instead of wood dust or chips for combustible insulation, and Haydite or crushed shale calcined at 1,204.4°C for the bloated lightweight aggregate instead of dolomite. Hot tops have good strength and porosity, which is attributable to the 18 to 25 percent of rice hulls used in the composition.

(Also see reference 879.)

Resins/Binders

989. Anonymous. 1974. Thermosetting phenol-formaldehyde resin. Assignee: Cor Tech Research Ltd. Patent, P.N.: BE 818697, I.D.: 741202.

Summary: A thermosetting phenol-formaldehyde resin containing mainly benzyl ether groups modified with 0.25 to 1.5 percent toluenesulfonic acid, which caused scission of lateral hemiformal groups, gave a product used as a binder for rice hulls and molding sand. Typically, acid-modified resin immediately hardened at 177°C to give a brittle infusible mass.

990. Liu, C.T. 1978. Studies on the adhesive filler from rice hull. K'o Hsueh Fa Chan Yueh K'an (National Science Council Monthly, ROC). 6(12): 1184-1196. [Chinese; English summary].

Summary: Ground rice-hull flour was used as a substitute for wheat flour filler in adhesives. Variation in pH and viscosity of rice-hull flour mixed with urea-formaldehyde resin was the same as that of wheat flour. Plywood made from urea- or phenol-formaldehyde resins mixed with 20 percent rice-hull flour as filler showed satisfactory results in bonding strength and passed the Chinese Standard. Using urea or resorcinol formaldehyde or polyvinyl acetate mixed with 15 percent rice-hull flour to laminate wood resulted in bonding strength similar to that of wheat flour as filler or of the same resins used without any fillers.

991. Mehta, P.K.; Pitt, N. 1976. Energy and industrial materials from crop residues. Resource Recovery and Conservation. 2(1): 23-38.

Summary: Crop residues such as rice hulls and rice straw can be a valuable resource for the recovery of energy and useful industrial products. By a special process, combustion of rice hulls produces a reactive silica ash, which is used for making acid-resistant hydraulic cement and reinforcing filler for rubber. Properties of the hydraulic cements and the rubber filler made from rice hull ash are described.

992. Narayanamurti, D.; Kohli, R.C. 1959. A new extender for adhesives from rice husks. Kunststoffe. 49(6): 269-270. [German; English summary].

Summary: Rice-husk meal and the gel obtained from the alkaline extract of rice husks by acidification were found to make excellent extenders for phenolic wood-laminating resins. The residue from the alkaline extraction can be used, after addition of 12 to 15 percent phenolic resin, as a binder in the manufacture of hardboard from rice husks and related agricultural wastes.

993. Williamson, R.V.; Clark, T.F. 1950. Lignocellulose, phenol-formaldehyde, and inorganic-filler molding composition. Assignee: USA, as represented by the Secretary of Agriculture. Patent, P.N.: US 2502498, I.D.: 500404.

Summary: Molded articles with good physical properties may be formed at 176.7°C and 20.7 MPa from compositions containing 50 percent lignocellulose flour (rice hulls, peanut shell, wheat straw), 25 percent phenolic resin, 22.5 percent precipitated chalk, 2 percent dye (if desired), and 0.5 percent zinc stearate. The usual procedure of mixing the material in a dough mixer, rolling the mixture on heated rolls, and grinding the rolled sheets to powder is followed.

(Also see references 438, 485, and 486.)

Rubbers

994. Anonymous. 1977. Opal black: from rice hulls to rubber filler. Rubber World. 176(5): 28-29.

Summary: The report describes the processing of rice hulls to give fillers for rubbers.

995. Anonymous. 1980. Rubber composition containing ground graminaceous rice product especially for manufacturing molded panels. Assignee: Signoretto Teresio (IT). Utility Patent, P.N.: US 4202803, I.D.: 800513.

Summary: In addition to elastomers, a composition for the manufacture of a vulcanized rubber includes vulcanizing agents, anti-aging agents, and other known additives, and a filler consisting of finely divided, dry waste products from the extraction of grain from cereal crops, such as stalks, husks, and chaff (particularly rice chaff).

(Also see reference 1099.)

Miscellaneous

Economics

(See references 231, 815, and 823.)

Loose Insulation

996. Algalite, S. 1953. Lightweight insulation. Patent, P.N.: IT 484118, I.D.: unknown. [Italian].

Summary: Rice bran is used in the production of lightweight insulation.

997. Hotz, G.; Bartha, P. 1968. Granular porous heat insulation. Assignee: Refratechnik Albert GmbH. Patent, P.N.: DE 1271670, I.D.: 680704. [German].

Summary: The ash of rice shell is used to produce highly-porous, low-weight granules of good mechanical strength, suitable for thermal insulation without the need for an additional firing step.

Material Preparation/Pulping/Storage Methods

(See reference 231.)

General Information/Reviews

998. Anonymous. 1984. A lightweight inorganic hardened product, used as building material consists of inorganic binder (at least one binder of silicon), fly-ash or shirasu, and carbonized rice bran. Assignee: (MATW) Matsushita Elec Works. Patent, P.N.: JP 59088354, I.D.: 840522. [Japanese].

Summary: The patent describes a product with excellent size stability and little efflorescence effect, for use as building material. The product consists of an inorganic binder-at least one member of the group of silicon dust, fly ash, and shirasu (a kind of white volcanic ash)-and carbonized rice bran.

999. Anonymous. [nd.] Houses built from rice waste. Science Journal (London). 3(11): 22.

Summary: Rice hulls were used as a component in the construction of houses.

1000. Govindarao, V.M.H. 1980. Utilization of rice husk-a preliminary analysis. Journal of Scientific and Industrial Research. 39(9): 495-515.

Summary: This report is a review on the uses of rice husk in animal feeds, agriculture, fuel, food, organic and inorganic chemicals, carbon production, abrasives, refractory and insulating materials, building materials, plastics, pollution, pressing, and filtering acid. The processing of rice husk is also described.

1001. Hough, J.H.; Barr, H.T. 1956. Possible uses for waste rice hulls in building materials and other products. Bull. No. 507. Baton Rouge, LA: Louisiana State University Agricultural Experiment Station. 36 p.
(no abstract available)

1002. Mizukami, F.; Maeda, K.; Niwa, S.; Toba, M.; Murakami, T. 1991. Carbon-metals composites with high adsorbability and their preparation from rice hulls. Assignee: Agency of Industrial Sciences and Technology, Fuji Kagaku Kogyo Co. Ltd. Patent, P.N.: JP 03106442, I.D.: 910507. [Japanese].

Summary: Carbon-metal composite materials are made from reduced rice hulls carrying iron, copper, silver, titanium, zinc, calcium, magnesium, and/or their oxides, The materials are prepared by heat reduction of rice hulls impregnated with these salt solutions. Metals, or oxidized metals, are homogeneously and finely dispersed on the surfaces of carbonized cellulose, an activated carbon-like material, and silica, which are useful as adsorbents,

1003. Secondi, A.; Secondi, A. 1955. Nonflammable materials of construction. Patent, P.N.: IT 509408, I.D.: unknown. [Italian].

Summary: A mash of rice, oats, and barley is used to produce a nonflammable material for the construction industry.

1004. Singh, R. 1969. Fibrous building materials produced from agricultural wastes. United Nations Industrial Development Organization document (UNIDO) 1 D/WG/44/18; 1969 October 20-24; Vienna, Austria.
(no abstract available)

1005. Tutsek, A.; Bartha, P. 1975. Carbon-poor, white rice hull ashes for building purposes. Assignee: Refratechnik Albert GmbH. Patent, P.N.: DE 2416291, I.D.: 751023. [German].

Summary: The patent describes a method of producing white ash with uniform low carbon concentration and well-defined SiO, crystal form with a homogeneous degree of crystallization for construction purposes. The ash is produced from white rice hulls and hulls treated with furfural recovery .

Material Used in Natural State

(See reference 925.)

Rye [Straw]

Panel Board
Particleboard

(See reference 660.)

Fiberboard/Hardboard

1006. Abele, W. 1937. Steamed straw for paper, board and building board. Papier-Zeitung. 62(34): 589-590. [German].

Summary: Moistened straw is steamed without the addition of chemicals giving a yield of about 60 percent in the case of rye straw and 57 percent in the case of wheat straw. The resulting pulp can be used for the manufacture of building boards.

Cement/Clay/Gypsum/Plaster Materials

(See reference 1156.)

Molded Masses
Resins/Binders

1007. Zahradka, A. 1982. Adhesive mixture for veneering construction elements. Patent, P.N.: CS 200297, I.D.: 821201. [Slovakian].

Summary: Veneering of particleboards designated for a subsequent application of a high-gloss surface finish is carried out without a preliminary application of a veneer or nonwoven textile underlayer in a multistage press utilizing an adhesive consisting of urea-formaldehyde resin, rye flour, ground gypsum, and 25 percent NH_4Cl hardener. The adhesive has an extended pot life and does not blunt tools as much as a similar adhesive without gypsum.

Scrub Palmetto

Panel Board
Insulation Board

1008. Anonymous. 1944. Scrub palmetto. Modern Industry. 7(1): 38-39.

Summary: Scrub palmetto has a log-like root that yields a pith and a fiber. The fiber can be used for brush bristles, upholstery stuffing, and twine. The pith can be used in manufacturing insulation boards.

Seaweed

Panel Board
Particleboard

1009. Chanda, S.; Bhaduri, S.K.; Sardar, D. 1991. Chemical characterization of pressed fibrous residues of four aquatic weeds. Aquatic Botany. 42(1): 81-85.

Summary: Pressed fibrous residues from four aquatic weeds (*Pistia stratiotes,* L. var. *cuneata* Engl.; *Nymphoides cristatum*, Kuntze; *Lemna perpusilla,* Torr.; and *Allmania nodiflora* R.Br. ex Hook. f.), generated as a byproduct during the large-scale manufacture of leaf protein, were analyzed for their chemical and mineral composition. All the values obtained were compared with those of other similar aquatic weeds and agricultural residues, such as rice and wheat straw, grass, and bagasse, which are usually used in the preparation of silage, compost, biogas, and several other products.

Insulation Board

(See reference 149)

Sisal [Stalk]

Panel Board
Particleboard

1010. Government of Kenya. 1970. Investigations into the manufacture of particle board from sisal waste. Presented at Food and Agriculture Organization of the United Nations (FAO) Advisory Working Party on Research of the Consultative Subcommittee on Hard Fibre; 1970; Rome. Rome, Italy: Food and Agriculture Organization of the United Nations (FAG).
(no abstract available)

(Also see references 53, 83, and 1023.)

Fiberboard/Hardboard

1011. Narayanamurti, D.; Singh, J. 1962. Hardboard from sisal fibre. Board Manufacture. 5: 133.
(no abstract available)

Cement/Gypsum/Plaster Board

1012. Anonymous. 1978. Composite sisal mat-glass mesh reinforcement for cast plaster panels-for high key and strength properties. Assignee: (FILA-) Soc Expl Filatures. Patent, P.N.: FR 2359945, I.D.: 780331. [French].

Summary: Composite reinforcement for plaster panels consists of a layer of entangled fibers of sisal or similar vegetable fiber supported by a flexible mesh, specifically of resin-coated glass cords. The fibers are fixed to the mesh by entanglement by pricking. The composite is used for strengthening cast panels for decorating the walls and ceilings of buildings. The mesh support increases panel strength and fracture resistance.

1013. Baradyana, J.S. 1987. Sisal fibre concrete roofing sheets. In: Building materials for low-income housing: Proceedings of a symposium held at the United Nations; 1987 January 20-26; Bangkok, Thailand. London, England: E. and F.N. Spon Ltd.: 57-63.

Summary: Sisal fiber corrugated into 750- by 750-mm roofing sheets is now being produced commercially in Tanzania. The process of production and the properties of the resulting boards are described in detail. The economic and physical advantages of sisal fiber concrete roofing sheets are outlined.

1014. Berhane, Z. 1987. Durability of mortar roofing sheets reinforced with natural fibres: a review of the present state-of-the-art. In: Building materials for low-income housing: Proceedings of a symposium held at the United Nations; 1987 January 20-26; Bangkok, Thailand. London, England: E. and F.N. Spon Ltd.: 321-327.

Summary: Results from research activities on the use of corrugated mortar roofing sheets made from sisal, jute, and coir have not shown a significant increase in the flexural and other mechanical properties of the board; a pronounced improvement in the ductility and impact resistance of the material has been reported. This paper reviews the use of corrugated mortar roofing sheets and discusses the loss of sheet durability over time.

1015. Cappelen, P. 1985. Roofing sheets made of sisal reinforced concrete. Working Rep. 14. Tanzania: Building Research Unit.
(no abstract available)

1016. Gram, H.E.; Nimityongskul, P. 1987. Durability of natural fibres in cement-based roofing sheets. In: Building materials for low-income housing: Proceedings of a symposium held at the United Nations; 1987 January 20-26; Bangkok, Thailand. London, England: E. and F.N. Spon Ltd.: 328-334.

Summary: Natural fibers such as sisal, jute, ramie, and coir have been used as reinforcement in cement-based roofing sheets. This paper reports on a study of the decomposition of the natural fibers and the resulting brittleness it produces in cement-fiber composites. The study shows that embrittlement can be prevented by replacing a part of the ordinary Portland cement by a highly active pozzolanic material, such as silica fume or rice husk ash.

1017. Mattone, R. 1987. Operational possibilities of sisal fibre reinforced gypsum in the production of low-cost housing building components. In: Building materials for low-income housing: Proceedings of a symposium held at the United Nations; 1987 January 20-26; Bangkok, Thailand. London, England: E. and F.N. Spon Ltd.: 47-56.

Summary: The paper presents the results of an experiment on sisal fiber reinforced gypsum. Following a series of tests aimed at the optimization of the composite specifications (reinforcement percentages and types, water-gypsum ratio), modular elements were produced with structural and nonstructural functions. The construction procedures and tests were conducted on an anticlastic ruled surface and on a base module, which may be used as walling, roofing, or flooring elements.

1018. Persson, H.; Skarendahl, Å. 1978. Sisal fibre concrete for roofing sheets and other purposes. In: Forum on appropriate industrial technology; United Nations Industrial Development Organization (UNIDO); New Delhi, India. Stockholm, Sweden: Swedish International Development Authority. 57 p.
(no abstract available)

1019. Persson, H.; Skarendahl, Å. 1979. Implementation of a building material–Sisal fibre concrete roofing sheets. Report 20. Stockholm, Sweden: Royal Institute of Technology, Department of Building Engineering. 26 p.
(no abstract available)

1020. Persson, H.; Skarendahl, Å. 1983. Feasibility study on a pilot plant for the production of sisal fibre concrete roofing sheets in Tanga, Tanzania. Stockholm, Sweden: Natural Fibre Concrete AB.
(no abstract available)

1021. Sakula, J.H. 1982. Sisal-cement roofing in east and southern Africa. Evaluation of sisal-cement roofing sheet technologies in Malawi, Zimbabwe, Zambia, Tanzania and Kenya. Rugby, England: Intermediate Technology Industrial Services, Development Group Ltd. 186 p.
(no abstract available)

1022. Simatupang, M.H.; Habighorst, C. 1993. Manufacturing and properties of rapid hardening cement-bonded specimens and particleboards fabricated by injection with carbon dioxide-state-of-the-art. Holz als Roh- und Werkstoff. 51(1): 31-35.

Summary: Literature on the use of rapidly hardening inorganic binders in the manufacture of cement bonded composites is briefly reviewed. The influence of carbon dioxide on hydrating cement, cement stone, setting of cement in the presence of set-inhibiting wood extractive, and durability of cement-bonded fiberboards reinforced with sisal or glass fiber is reviewed in detail. Processes known to shorten the solidification time of cement mortar or lime containing mortar under the influence of carbon dioxide are presented in detail.

1023. Van den Beuken, H.T.; Bettendorf, J.F. 1981. Structural material and a component produced from the material. Patent, P.N.: BE 887951, I.D.: 810716. [Dutch].

Summary: Building materials that are inexpensive and lightweight and have good thermal insulating and mechanical properties contain a binder such as cement, ground mollusk shells, and 18 to 28 percent by volume elastic particles. A typical composition could include sisal.

Plastic/Plastic-Bonded Board

1024. Chand, N.; Verma, S.; Rohatgi, P.K. 1987. Tensile, impact, and moisture studies of sisal-polyester composites. Tropical Science. 27(4): 215-221.
(no abstract available)

1025. Pavithran, C.; Mukherjee, P.S.; Brahmakumar, M.; Damodaran, A.D. 1987. Impact properties of natural fibre composites. Journal of Materials Science Letters. 6(8): 882-884.

Summary: The purpose of the study was to correlate the impact behavior of natural fiber composites with the fiber properties. Unidirectionally aligned fiber/polyester composites containing roughly 0.5 volume fraction of sisal, pineapple, banana, and coir fibers were prepared from unsaturated polyester preparations. The variation in impact properties among the various natural fiber composites is explained by the microfibrillar angle of the fibers.

1026. Satyanarayana, K.G.; Kulkarni, A.G.; Sukumaran, K; Pillai, S.K.G.; Cherian, K.A.; Rohatgi, P.K. 1981. On the possibility of using natural fiber composites. In: Marshall, I.H., ed. Proceedings of the 1st international conference on composite structures. London, England: Elsevier Applied Science Publications: 618-632.

Summary: Palmyra, coir, banana, sisal, and pineapple leaf fibers for use in polymer-based composites were examined. Tensile strength, percentage of elongation, modulus, electric resistivity, dielectric strength, and mechanical and physical properties of natural fiber-polyester composites were measured. The properties of the untreated fiber-polyester composites were lower than that of either the polyester or the fiber, pointing to the need for surface modification to improve bonding. The beneficial effects of surface treatments, such as copper coating on coir fiber, on coir fiber properties and on the properties of the coir-polyester composites are described.

Roofing Board

(See references 1013-1021. and 1048.)

Unknown Board

1027. Belmares, H.; Barrera, A.; Castillo, E.; Verheugen, E.; Monjaras, M.; Atfoort, G.A.; Bucquoye, M.E.N. 1981. New composite materials from natural hard fibers (sisal, heneguen, palm fibers). Industrial and Engineering Chemistry, Product Research and Development. 20(3): 555-561. (no abstract available)

1028. Bisanda, E.T.N. 1992. Sisal fibre-reinforced composites. Bath, England: University of Bath. 337 p. Ph.D. thesis.

Summary: The tensile properties and the structure of sisal fiber were found to be dependent on the position along the fiber length. The fibers were then modified by chemical treatment, and the effects of the treatment on the mechanical and physical properties of the sisal–epoxy composites were investigated. The treatment of sisal fiber by mercerization improved the interfacial properties, as indicated by improvements in the mechanical and physical properties. A flexural strength of 262 MPa and flexural modulus of 17 GPa were obtained for a unidirectional mercerized sisal-epoxy composite with a fiber volume fraction of 40 percent.

1029. Bisanda, E.T.N.; Ansell, M.P. 1992. Properties of sisal-CNSL composites. Journal of Materials Science. 27(6): 1690-1700.

Summary: Cashew nut shell liquid (CNSL), a natural monomer blend, was condensation-polymerized with formaldehyde in the presence of an alkaline catalyst to produce a thermosetting resin. Plain woven mats of mercerized sisal fiber were impregnated with CNSL-formaldehyde resin to produce plain and corrugated laminated composites that have a mean tensile strength of 24.5 MPa and Young's modulus of 8.8 GPa. Bending tests demonstrated that the corrugated composites have adequate strength for roofing applications. Dynamic mechanical thermal analysis was used to assess the effect of simulated sunlight on composites as a function of time. After long irradiation times, the authors deduced that the resin component of the composite undergoes further cross-linking, while reinforcing cellulosic sisal fibers suffer some degradation.

1030. Klingel, W. 1972. Weatherproof building material from vermiculite and wastes. Assignee: Klingel, Hans. Patent, P.N.: DE 2125453, I.D.: 721221. [German].

Summary: Materials of increased strength and rigidity were prepared at low costs from vermiculite, polyester resin binders, wastes from natural fibers (sisal, coconut, jute), synthetic fibers (polyamide, spandex, polyester), acrylic resins or polystyrene resins, paper or paperboard, or wood fibers.

1031. Pavithran, C.; Mukherjee, P.S.; Brahmakumar, M.; Damodaran, A.D. 1991. Impact properties of sisal-glass hybrid laminates. Journal of Materials Science. 26(2): 455-459.

Summary: Work of fracture of unidirectionally aligned sisal-glass hybrid laminates, especially glass core-sisal shell laminates, were studied using flat charpy test. Keeping the volume fraction of sisal at about 0.4, the work of failure of the sisal-glass laminates linearly increased from 80.2 to 228. kJ/m^2 by varying the volume fraction of glass at the core from 0 to 0.2.

1032. Vidaurre, S.F. 1983. Some variables affecting the principal mechanical and physical properties of sisal-fiber reinforced, sulfur-based composite boards. Forest Products Abstracts. 6(11): 333. (no abstract available)

(Also see references 3, 197, and 665.)

Cement/Clay/Gypsum/Plaster Materials

1033. Anonymous. 1977. Patent for a construction material premixture containing gypsum, expanded material, cement and polypropylene, fibreglass or sisal fibres. Assignee:

(COPE/) Copeland W L, (COPE-) Copeland Concrete. Patent, P.N.: US 4047962, I.D.: 770913.

Summary: The patent describes a composition that forms a construction material when mixed with water and then set. The material consists of gypsum, an expanded material, cement, polypropylene, and glass or sisal fiber.

1034. Bessell, T.J.; Mutuli, S.M. 1982. The interfacial bond strength of sisal-cement composites using tensile test. Journal of Materials Science Letters. 1(6): 244-246.
(no abstract available)

1035. Bortolotto, E. 1985. Analysis and experiments on composite building materials for developing countries: sisal fibre as concrete reinforcement. Turin, Italy: Architecture Faculty of Turin Polytechnic. Ph.D. thesis.
(no abstract available)

1036. Canovas, M.E.; Selva, N.H.; Kawiche, GM. 1992. New economical solutions for improvement of durability of Portland cement mortars reinforced with sisal fibers. Materials and Structures. 25(151): 417-422.

Summary: Research was carried out with the aim of solving the problem of vegetable fiber mineralization in Portland cement mortars. The first part of the report deals with pore sealing, mechanical strength, and alkaline reduction. The second part deals with fiber impregnation, including a short description of the compounds used and the aging of mortars, with and without admixtures, which are reinforced with impregnated or unimpregnated sisal fibers under different conditions. Products used in this solution are mainly compounds derived from timber, insoluble in water, and unextractable by water and water vapor. Results are promising.

1037. Filho, A.C. 1990. Mortar reinforced with sisal-mechanical behavior in flexure. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 130-138.

Summary: The use of sisal as a reinforcement in mortar was investigated. Three fiber length ratios, 1.80 cm, 3.70 cm, and 5.60 cm, were tested in different composites. Samples with different mix proportion were compared to brittle matrix in which no sisal fibers were used; flexural strengths were compared at 7, 28, and 63 days. In addition, the impact strengths were evaluated. Flexural strength decreased in the composite compared to the brittle matrix, but only in absolute value. The composite showed an elasto-plastic behavior after multiple cracking. Significant impact strength was noted in all cases of sisal fiber reinforced mortars.

1038. Foti, M.; Gilbert, A. 1990. Vegetable fibres in craftwork techniques for building care. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 21-28.

Summary: The report examines the use of high technology fibers used as reinforcement in mortar and concrete. Attempts to identify possible similar applications or natural woven fibers, such as sisal, were pursued in this study.

1039. Gram, H.E. 1988. Durability of natural fibres in concrete. In: Swamy, R.N., ed. Natural fibre reinforced cement and concrete. Glasgow, Scotland: Blackie and Son Ltd.: 143-172. Chapter 4:

Summary: The durability of natural fibers, especially sisal, used to reinforce concrete is discussed in detail. Included are countermeasures to reduce age-induced brittleness of the fiber-concrete composite. The embrittlement of sisal fiber concrete can be almost completely avoided by reducing the alkalinity of the concrete pore water. This reduction in alkalinity is achieved by replacing part of the ordinary Portland cement with fine-grained pozzolanas, such as silica fume, rice husk ash, or diatomite. Tests on specimens stored outdoors in different climates confirmed the results obtained in the laboratory.

1040. Hernandezolivares, F.; Oteiza, L.; Devillanueva, L. 1992. Experimental analysis of toughness and modulus of rupture increase of sisal short fiber reinforced hemihydrated gypsum. Composite Structures. 22(3): 123-137.

Summary: This paper presents an experimental analysis of the mechanical properties of gypsum reinforced with small volume fractions of sisal short fiber which were randomly mixed with the matrix. The modulus of rupture and toughness on both fiber length and fiber volume fraction are discussed jointly with the critical fiber length parameter. The micromechanisms of fiber debonding and fiber pull-out are related to composite toughness increase.

1041. Mawenya, A.S. 1983. Development in sisal fibre reinforced concrete. In: Proceedings of symposium on appropriate building materials for low-cost housing, African Region. France: International Council for Building Research Studies and Documentation-The International Union of Testing and Research Laboratories for Materials and Structure: 90-99.
(no abstract available)

1042. Morrissey, F.E.; Coutts, R.S.P.; Grossman, P.U.A. 1985. Bond between cellulose fibers and cement. International Journal of Cement Composites and Lightweight Concrete. 7(2): 73-80.

Summary: A model system of sisal slivers embedded in a cement matrix and protruding from the matrix at one end was studied in relation to conflicting reports on the predominance of fracture or pull-out of wood pulp fibers from a cement

matrix. About 200 model systems were tested under tension in the fiber direction, and their load extension behavior and modes of failure were recorded. The tensile strength of the slivers averaged 420 MPa. The onset of debonding was independent of embedment length. Slivers with shorter embedment length tended to pull out whereas those with a long embedment tended to fail in tension (embedment lengths ranged from 10 to 60 mm). The changeover of mode occurred approximately at 30 mm of embedment length at an aspect ratio of approximately 110.

1043. Nilsson, L. 1975. Reinforcement of concrete with sisal and other vegetable fibres. Swedish Council for Building Research, Doc. D14. Stockholm, Sweden: Svensk Byggtjänst. 68 p.
(no abstract available)

1044. Persson, H.; Skarendahl, Å. 1978. Sisal reinforced concrete-study no. 1 on materials. Report 7822. Stockholm, Sweden: Swedish Cement and Concrete Research Institute, Consultant Section. 15 p.
(no abstract available)

1045. Schafer, H.G.; Brunssen, G.W. 1990. Sisal-fibre reinforced lost formwork for floor slabs. In: Vegetable plants and their fibres as building materials: Proceedings of the 2d international symposium sponsored by the International Union of Testing and Research Laboratories for Materials and Structures (RILEM); 1990 September 17-21; Salvador, Bahia, Brazil: 173-181.

Summary: A formwork system and its load-carrying behavior are described by which structural timber can be substituted through cementitious "lost" formwork elements reinforced with sisal fibers.

1046. Swift, D.G. 1981. The use of natural organic fibers in cement: some structural considerations. In: Marshall, I.H., ed. Proceedings of the 1st international conference on composite structures. London, England: Applied Science Publications: 602-617.

Summary: The use for natural organic fibers in reinforcing cement-based materials is complicated by their low elastic modulus, water-absorbing properties, susceptibility to fungal and insect attack, and variability of properties among fibers of the same type. These points were examined theoretically and in the light of experiments carried out on sisal-cement composites. Relevance of the variables to the design of structures using organic fiber-cement composites was discussed. Such composites are appropriate for many low-cost structures in developing countries.

1047. Swift, D.G. 1985. Sisal–cement composites and their potential for rural Africa. Composite structure 3 conference; 1985 September 9-11; Paisley, Scotland. New York: Elsevier Applied Science Publications: 774-787

Summary: The composite material formed by reinforcing cement mortar with sisal fibers has properties that make it suitable for several structures in rural Africa. The report presents data and information on a long-term study on sisal-cement composites in Africa and considers the general implications for materials research in the Third World.

1048. Swift, D.G.; Smith, R.B.L. 1979. Sisal-cement composites as low-cost construction materials. Appropriate Technology. 6(3): 6-8.

Summary: The properties of sisal fiber-reinforced cement are discussed. Applications include flat roofing tiles, corrugated roofing sheets, cladding for mud brick walls, and construction of grain and water storage containers.

1049. Swift, D.G.; Smith, R.B.L. 1979. The flexural strength of cement-based composites using low modulus (sisal) fibres. Composites. 10(4): 145-148.
(no abstract available)

1050. UNCHS-HABITAT. 1981. Construction with sisal cement. Technical Note 1. Nairobi, Kenya: UNCHS-HABITAT. 4 p.
(no abstract available)

(Also see references 199, 212, 338, and 455.)

Molded Masses
Plastics

1051. Chand, N.; Rohatgi, P.K. 1986. Adhesion of sisal fiber-polyester system. Polymer Communications. 27(5): 157-160.

Summary: The effect of alkali treatment on the surface adhesion of sisal fibers to polyester resin was determined from pull-out tests; a significant improvement in adhesion was shown. Improvement in tensile strength was also observed for alkali treatment and was at maximum for the 90-h alkali treatment. Increase in adhesion for alkali treatment was caused by leaching and creation of a mechanical locking arrangement and hence improved bonding between the fiber and polymer. Observation of the alkali-treated surfaces by scanning electron microscopy revealed the mechanical locking sites.

1052. Chawla, K.K.; Avillez, R.R.; Rodrigues, R.R.; Sa, A.C.M.; Serra, R.G.; Cavadas, L.G.P.L. 1978. Mechanical behavior of polyester resin-carbon, Kevlar 29, sisal, and glass fiber composites. Revista Brasileira de Tecnologia.
9(1/2): 79-99. [Portuguese].

Summary: Microstructural characteristics, tensile strength, and modulus of elasticity of carbon, Kevlar 29, sisal, and glass fibers were determined. Based on a comparison of properties and approximate prices of these fibers, sisal fiber is indicated as the most promising fiber for the reinforcement of resins. Composites consisting of polyester resin and sisal fibers in different volume fractions were fabricated and subjected to fracture testing. The results revealed that the interface sisal/matrix was the weakest. To improve the properties of the sisal composites, the fibers should receive some surface treatment.

1053. Joseph, K.; Thomas, S.; Pavithran, C. 1992. Viscoelastic properties of short-sisal-fiber-filled low-density polyethylene composites-effect of fiber length and orientation. Materials Letters. 15(3): 224-28.

Summary: The viscoelastic properties of low-density polyethylene filled with short sisal fibers were studied. The influence of fiber orientation on the viscoelastic properties of the composites was investigated. The longitudinally oriented fiber composites showed the maximum values of storage and loss moduli, whereas transversely oriented fiber composites showed the minimum values. The viscoelastic properties were also strongly influenced by fiber length.

1054. Pavithran, C.; Mukherjee, P.S.; Brahmakumar, M.; Damodaran, A.D. 1988. Impact performance of sisal-polyester composites. Journal of Materials Science Letters. 7(8): 825-826.

Summary: The work of fracture of sisal composite was identical to that of an ultra-high modulus polyethylene composite, and toughness was only 25 percent less than that of glass fiber composite when the density of the latter was taken into account. Although the impact performance of the sisal composite is attractive, other mechanical properties are inferior to those of synthetic fiber composites.

1055. Riquelme, P.F.; Ramirez, A.P.; Leon, A.G. 1981. Polyethylene sisal composites. Conferencia Inter-Americana en tecnologia de materiales, Trabajos presentados en la 7th conferencia; 1981 October 19-23; Mexico City, Mexico: 145-148. [Spanish].
(no abstract available)

Resins/Binders

1056. Bisanda, E.T.N.; Ansell, M.P. 1991. The effect of silane treatment on the mechanical and physical properties of sisal-epoxy composites. Composites Science and Technology. 41(2): 165-178.

Summary: The surface of sisal fibers was modified by mercerization and silane treatment to improve adhesion characteristics and moisture resistance. Silane treatment was most effective in reducing moisture uptake of the fibers in humid environments. Sisal fibers with and without surface pretreatments were combined with epoxy resin to form composite materials. The compressive strengths of these composites were improved by pretreatment, but the flexural strength and stiffness were not affected. In moist environments, all mechanical properties were improved by silane treatment.

(Also see references 1028 and 1029.)

Miscellaneous
General Information/Reviews

1057. Patel, M.; Padhi, B.K. 1992. Al-metal composite using sisal fibre based alumina fibre. Powder Metallurgy International. 24(1): 39-41.

Summary: Aluminum-metal composites using sisal fiber based on alumina fiber were made by the powder metallurgy method. The tensile strength of the composites showed a 50 percent increase and a decrease in elongation of approximately 85 percent with 4 percent of the fiber. The density of composites at various temperature is given. Micrographs of alumina fiber distribution in the metal are also provided. The elongation behavior of the fiber during fracture is explained with regard to its structure.

(Also see reference 1014.)

Sorghum [Flour, Stalk]

Panel Board
Fiberboard/Hardboard

1058. Escourrou, R. 1965. Sorghum as a raw material for the manufacture of papermaking and other pulps. Papeterie. 87(11): 1479-1482. [French].

Summary: The report provides the full text of a patent dealing on the pulping of sorghum. Sorghum stems are cooked in a rotary digestor, first with 0.2 to 0.8 percent NaOH for 0.5 to 1 h, then with 1.2 to 2 percent NaOH at 120°C for 2 to 3 h. The resulting pulp, either bleached or unbleached, is preferably blended with wood pulp to give fiberboards and various paper grades. According to recent data, the quality of insulating boards is improved by the replacement of spruce fibers by sorghum fibers.

1059. Guha, S.R.D.; Sharma, Y.K.; Kumar, K. 1969. Lime pulps from arhar sticks (*Cajanus* sp.) and jawar stalks (*Sorghum* sp.). Indian Forester. 95(10): 689-691.

Summary: Laboratory experiments on the production of lime pulps from arhar sticks and jawar stalks (sorghum) for the production of strawboard are described. Pulping of arhar with 14 percent lime for 4 h at a 1:6 material:liquor ratio and 142°C resulted in the best pulp. In the case of sorghum, cooking with 12 percent lime at a material:liquor ratio of 1:8 for the same length of time and at the same temperature yielded the best results. Arhar gave higher pulp yields than did jawar, but the jawar pulps had higher strength properties. Board sheets of satisfactory strength were produced from both pulps.

1060. Nemrhal, J.; Kuniak, L. 1961. Sweet sorghum as a raw material for the manufacture of fiberboards. Drevo. 16(1): 16-17. [Slovakian].

Summary: The utilization of sorghum (*Sorghum saccharatum*) waste for the manufacture of hardboards was

investigated in laboratory experiments. The material was treated with 1 percent NaOH at a room temperature for 4 h, fiberized in a Bauer refiner to 10°SR, mixed with a sizing and waterproofing agent, and pressed into boards. An additional heat treatment at 140°C for 4 h followed. The mechanical and physical properties of the sorghum hardboards were equal or even superior to those of standard hardboards made from spruce wood. The best results were obtained with boards containing a thermosetting resin.

(Also see references 70 and 1063.)

Insulation Board

1061. Gabir, K.; Khristova, P.; Yossifov, N. 1988. Composite boards from guar and sorghum (dura) stalks. Biological Wastes. 31(4): 311-314.

Summary: Laboratory trials were carried out to determine the suitability of guar (sugarcane) and sorghum stalks from Sudan as basic materials for composite insulation boards manufacture using cement binder. Lignocellulosic material-to-cement ratios of 1:1.5 and 1:2 were used. The results show that these raw materials could successfully be used for insulation boards, with a density of 0.53 to 0.70 g/cm^3, satisfactory strength, and very good heat-insulation properties.

1062. Girarcl, C.F.; Rose, A. 1965. Internal strengthening of insulating board with cereal flour. Patent, P.N.: US 3197360, I.D.: unknown.

Summary: Low-grade cuts and bran from sorghum flour are used to increase the internal bonding strength of insulating boards.

1063. Inoue, T.; Ohara, O.; Smimizu, S.; Tanaka, T. 1990. Laminated materials made of lignocellulosic stalks; insulation, building materials. Assignee: Koyo Sangyo Co. Ltd. Utility, P.N.: US 4968549, I.D.: 901106.

Summary: A laminated material in board form is made by cutting open a lignocellulosic stalk (sorghum) in the fiber direction, flattening the stalk by means of a roller press to form a compressed stalk with epidermis on one side, arranging a plurality of the compressed stalks parallel to one another to form a sheet, coating the sheet with a resin adhesive, stacking the sheets, and bonding with heat and pressure in a hot press. The laminated material has equal to or higher flexural strength than conventional plywood and has excellent sound-absorbing and heat-insulating properties in comparison with that of conventional particleboard and fiberboard.

1064. Shimizu, O.; Tamaka, A.; Osamu, O.; Lue, D. 1987. Cellulose laminates and their manufacture. Assignee: Koyo Sangyo Co. Ltd. Patent, P.N.: CN 87104121, I.D.: 871230. [Chinese].

Summary: Cellulose laminates, useful for building materials and sound and thermal insulators, are prepared by (1) pressing sliced stems (from sorghum, corn, sugarcane; degreased or dewaxed) at 49.0 to 980.6 kPa, (2) binding the compressed stems in the parallel orientation with adhesives to form thin panels, (3) laminating the panels, in which the stems in adjacent panels are arranged perpendicular to each other (like plywood), and (4) pressing the panels at 180°C and 490.3 kPa to 2.9 MPa.

(Also see reference 159 and 1058.)

Cement/Gypsum/Plaster Board

1065. Slotter, R.L. 1952. Dextrinization of sorghum flour. Patent, P.N.: US 2601335, I.D.: unknown.

Summary: The patent describes the use of sorghum flour in the production of gypsum board plaster.

(Also see reference 1061.)

Unknown Board

(See reference 3.)

Molded Masses
Resins/Binders

1066. Hart, W.H. 1952. Modified starch product. Patent, P.N.: US 2585651, I.D.: unknown.

Summary: Low-grade sorghum flours are used in the production of wall board.

Miscellaneous
General Information/Reviews

1067. Hahn, R.R. 1970. Dry milling and products of grain sorghum. In: Wall, J.S.; Ross, W.W., eds. Sorghum production and utilization. Westport, CT: Avi Publishing Company.

Summary: The report discusses alcohol, fermentation, building industry, foundry binders, mineral refining, charcoal binders, drilling starch, papermaking, corrugating adhesives, and materials made from sorghum.

Soybean [Stalk]

Panel Board
Particleboard

1068. Shi, W.; Ma, Y.; Sun, D. 1988. Soybean stalks for synthetic woods and their products. Assignee: Baicheng District Agricultural Science Institute. Patent, P.N.: CN 87103249, I.D.: 881116. [Chinese].

Summary: Soybean stalk boards, useful for building materials, furniture, decoratives, and packaging materials, are prepared by hot pressing ground soybean stalks and urea-formaldehyde copolymer, and, optionally, waterproofing agents, preservatives, insecticides, and fragrances.

Molded Masses
Resins/Binders

(See reference 530.)

Straw [Unspecified Sources]

Panel Board
Particleboard

1069. Anonymous. 1948. Straw and paper building board. Paper Making and Paper Selling. 67(3): 36.

Summary: In the Stramit process, straw is compressed at 150°C into a continuous slab without previous pulping. The slab is faced with paper on the front, back, and two long edges and cut to desired lengths. The resulting board is very rigid and has high fire resistance, low thermal conductivity, and good acoustical properties.

1070. Chawla, J.S. 1982. Utilization of ligno-cellulosic waste of essential oil industry (for straw boards, fibre boards and paper pulp). In: Atal, C.K.; Kapur, B.M., eds. Cultivation of aromatic plants. Jammu-Tawi, India: Regional Research Laboratory, Council of Scientific and Industrial Research: 754-758.
(no abstract available)

1071. Espenhain, F. 1975. Valuation of some ways of using straw. 1. Alkali treated straw, cellulose and particle boards of straw. Ugeskrift for Agronomer og Hortonomer. 4(26): 510-513. [Danish].
(no abstract available)

1072. Groner, R.R.; Barbour, J.F. 1971. Straw particleboard: an engineering and economic analysis. Presented at the Forest Products Research Society annual meeting; 1971 June 29; Pittsburgh, PA. Corvallis, OR: Oregon State University, Department of Agricultural Chemistry. 24 p.

Summary: Particleboard was produced with straw as the raw material. The authors conclude that variations in press pressure have a greater effect on board density than do variations in press time. The physical properties appeared to be directly related to the board density. Low internal bond strength values were the result of unexplained surface failures. For design purposes, it was assumed that an acceptable product 0.635 cm thick with a density of 0.70 g/cm^3 could be prepared with 5 percent polyisocyanate resin. The pressing conditions would be approximately 1 min at 2.8 MPa and 176.7°C.

1073. Groner, R.R.; Barbour, J.F. 1973. The polyisocyanate straw particleboard process. Corvallis, OR: Department of Agricultural Chemistry at Oregon State University. 46 p.

Summary: The use of polyisocyanate resins in making straw particleboard resulted in board strong enough to be used for underlayment, paneling, and furniture manufacturing. Recent data indicate that a particleboard with strength properties similar to those of plywood could be developed. Three different polyisocyanate resins were used in board manufacture, with little difference between the resins in resulting board properties. Properties of boards produced with straw chips were better than those of boards containing tubules. Extensive data and processing procedures are given along with illustrations.

1074. Harmer, B. 1988. Agricultural waste-containing polymer compositions for furniture. Patent, P.N.: ZA 8707672, I.D.: 880629.

Summary: Molded compositions are prepared from 50 to 94 percent chopped straw or bagasse, 6 to 30 percent synthetic resins, and 0 to 44 percent nonvegetable fillers and additives.

1075. Heller, W. 1980. The manufacture of particleboard from nonconventional raw materials. Holz als Roh- und Werkstoff. 38(10): 393-396. [German; English summary].

Summary: The report describes the utilization of nonconventional materials for the production of particleboard. Materials include straw, bagasse, cotton stalk, and bamboo.

1076. Hesch, R. 1978. Straw is viable raw material for particleboard industry. Plywood and Panel. 19(7): 26-27.

Summary: Wall thicknesses and densities required to achieve a given insulation value were compared for low-density straw board and other construction materials, including wood, particleboard, gypsum board, foamed concrete, foamed glass, and vermiculite. Generally, at the same density and resin content, better board properties could be achieved with straw than with wood particleboard.

1077. Otlivanchik, A.N.; Mironov, V.P.; Demakina, G.D. 1968. New type of panels from organic raw material. Derevoobrabatyrayushchaya Promyshlennost., 17(8): 5-6. [Russian].

Summary: Binderless particleboards were produced on a pilot-plant scale from agricultural residues (such as straw and cotton stalks) and wood waste. The most important part of the manufacturing technology was the control of particle size of the milled material. Boards are generally used as heat-insulating materials.

1078. Rexen, F. 1977. Straw as an industrial raw material. Joint conference on solar energy in agriculture; 1976. London, England: International Solar Energy Society: 38-43.

Summary: The report discusses the utilization of straw in the production of pulp, particleboard, and proteins.

1079. Schnellert, G.L. 1984. Research into the bonding of prairie dryland grain straw to form residential construction panels. Bemidji, MN: Bemidji State University, College of Education. 66 p. Unpublished thesis.

Summary: The thesis investigates the bonding of straw particleboards with an urea-formaldehyde resin. Data include resin manufacture process, press temperature, press time, vent time, and prepressing conditions of the straw. Boards were made from 24 combinations of press and resin conditions, with only one replicate per combination. Internal bond was the only property evaluated according to standard methods.

1080. Sheperd, E.S. 1932. Building board. Patent, P.N.: US 1891732, I.D.: 321220.

Summary: Building board is made from cereal straws without any binders or gum substances. Boards comply with all commercial requirements.

1081. Wolski, E. 1983. Fire-retardant pressed board. Patent, P.N.: DE 3209603, I.D.: 830929. [German].

Summary: A mixture containing 25 percent chopped straw and 75 percent asbestos, or a mixture of 17 percent chopped straw, 17 percent wood meal, and 66 percent cement, is pressed at 115°C to 140°C to result in pressed board. For compositions containing 15 to 20 percent straw, phenol-formaldehyde copolymer was used as a binder.

(Also see references 53 and 80.)

Fiberboard/Hardboard

1082. Escodero Molina, J.E. 1980. Variety of alternatives for the use of cereal straw. In: 3d Proceedings of the Congress National Quim; 1980. 1: 453-466. [Spanish].

Summary: Straw from cereal production can be used in the manufacture of cellulose pulp, fiberboard, and other building materials, as an animal bedding, and as a source of fuel. The burning and/or plowing under of straw into fields does not improve soils or crop growth.

1083. Khomenko, Z.S.; Otlivanchik, A.N.; Korchagina, LA.; Makarova, M.M. 1961. Hardboards from straw. Stroitel'nye Materialy. 7: 14-15. [Russian].

Summary: Straw is cooked at 100°C with a 0.2 to 1 percent NaOH solution (liquor to straw ratio of 8 to 10:1), chopped, and beaten to 13°SR to 16°SR in a hammermill. The processed straw is added in amounts of 30 to 50 percent to hardboard fibrous stock or in amounts of 10 to 30 percent to insulation board stock. The boards are formed in the usual manufacturing manner.

1084. Nair, N.P.B. 1976. Boards such as partition boards and hard boards. Assignee: Narayanan K, P K. Patent, P.N.: IN 140692, I.D.: 761211.

Summary: Hardboard is produced by pressing a mixture (80:20 ratio) of *Salvania auriculata* soda pulp and straw pulp, air drying, and calendering.

1085. Ngatijo, B.; Priyadi, T.; Sujono, R. 1988. Straw and waste paperboard pulp as fibrous materials for ceiling board. Berita Selulosa. 24(1): 13–18. [Indonesian].

Summary: Pulps from straw cooked by the cold soda process and from waste paperboard were used to prepare ceiling fiberboard by using a dough composition containing 60 percent cement, 32 percent lime, and 8 percent pulp. Straw pulp strength and the addition of waste paperboard pulp improved the bending strength of the fiberboard. However, bending strength was still lower than that of ceiling boards made from 10 percent waste paperboard pulp or 100 percent waste staples.

1086. Oman, E. 1955. Manufacture of fiberboard. Patent, P.N.: DE 934388, I.D.: 550929. [German].

Summary: Fiberboards are formed from a mixture of wood fibers and straw fibers that have been decomposed in a CaOH solution. The spent liquor from the cooking of the straw is added to the fiber mixture, improving the hardness and strength properties of the board.

1087. Ruyter, K.K. 1969. Curable compositions. Assignee: Shell Internationale Research Maatschappij NV. Patent, P.N.: GB 1149610, I.D.: 690423.

Summary: A ß-propiolactone/polyisocyanate composition is polymerized and cured in the presence of an anionic initiator to form a composition for use in the manufacture of hardboard or strawboard or like products.

1088. Wang, M. 1991. The patent describes the manufacture of hardboard for furniture and other products using binder containing wood or straw-fibre cinder in China wood oil, rosin, salt, and plastics. Assignee: (WANG/) Wang W. Patent, P.N.: CN 1054629, I.D.: 910918. [Chinese].
(no abstract available)

(Also see references 80, 103, 862, 1070, and 1080.)

Insulation Board

1089. Aero Research. 1952. The gluing of “Strami” boards. Aero Research Tech. Notes Bull. 113. 4 p.

Summary: The Stramit process for the manufacture of insulation boards from cereal straw is described. Unprocessed straw is compressed under heat and pressure into an endless slab and covered with strong paper liners.

1090. Anonymous. 1962. The story of British Stramit. Board Practice. 5: 8-11.
(no abstract available)

1091. Anonymous. 1982. Chipboard core material manufacture from straw chips, polyvinyl acetate, and vinyl acetate emulsion, used for sound and heat insulation. Assignee: (YAMA-) Yamaichiyamagishi S. Patent, P.N.: JP 57089945, I.D.: 820604. [Japanese].

Summary: Straw chips are mixed with an aqueous solution of polyvinyl acetate and an aqueous vinyl acetate emulsion by spraying method, and the straw chips mixture is then spread over a hot-press base and hot pressed at 150°C to 160°C and under a pressure of approximately 40 t to obtain an approximately 20-cm-thick straw chipboard. Board has excellent heat- and sound-insulating properties and is very light.

1092. Anonymous. 1984. Built-up partition wall consists of panels containing plaster joined by strips of compressed straw fibres. Assignee: (STRA-) Stramit BV. Patent, P.N.: NL 8203970, I.D.: 840501. [Dutch].

Summary: A partition wall is constructed from panels containing plaster and joined to each other by bonding material to form a complete unit. The material consists of compressed straw fibers laid in strips spaced apart between the panels. Hollow spaces can be formed between the strips, which can be filled with insulating material. The strips can be enclosed in strong paper and the wall can have a straight bottom wooden strip, for alignment and fitting to plinths. Panels can be glued to one another.

1093. Aronovsky, S.I.; Lathrop, E.C. 1952. Paper Mill News. 75(38): 92, 94, 96, 126.

Summary: The work of the Pulp and Paper Section of the Agricultural Residues Division is described, including investigations on straw collection and procurement, preservation of straw and storage, and production of pulp and insulating boards.

1094. Bourgoin, L.; Belleville, L. 1934. Investigations on pressed straw. Revue Trimestrielle Canadienne. 20: 131-147.

Summary: Building boards 0.635 cm thick were made from untreated, water-soaked straw. Before pressing, an agglomerate consisting of casein, CaOH, starch or gluten, and lead arsenate was added and thoroughly mixed with the straw. The product showed remarkably high fire resistance, good heat-insulating properties, and better tensile strength properties as compared to Celotex.

1095. Dahl, E. 1954. Machines for manufacturing boards from straw or like material. Patent, P.N.: CA 499188, I.D.: 540112.

Summary: The patent describes a machine for making a continuous strip of insulation board with unprocessed straw or other long-fibered vegetable material as the filler and face sheets of paper, cardboard, or fabric. The straw is fed from a hopper and compressed between the forming platens by a reciprocating plunger.

1096. Ecolasse, G. 1970. Process for manufacture of panels for partitions. Patent, P.N.: FR 1589376, I.D.: 700331. [French].

Summary: An insulation board for use as partitions consists essentially of a strawboard core sandwiched between plastic sheet layers.

1097. Englert, G. 1980. Building materials made of straw. Landtechnik. 35(8/9): 380-381. [German; English summary]

Summary: The report discusses the use of straw for insulation and as a construction material. Roof panels made of a layer of compressed straw between two sheets of fire-resistant kraft paper are considered.

1098. Fujimoto, M.; Taguchi, N.; Hatsutori, S. 1988. Manufacture of cushioning and sound-insulating composite boards. Assignee: Oshiko Shinko KK. JP 63221008, I.D.: 880914. [Japanese].

Summary: Boards consisting of surface layers of cork particles, and cores from wood chips, chaff, or chopped straw, useful for floors and walls, are manufactured using synthetic rubber latexes obtained from the emulsion polymerization of conjugated monomers or their mixtures, with natural rubbers as binders.

1099. Gibson, A.G. 1930. Insulating board from straw. Industrial and Engineering Chemistry. 22(3): 223-226.

Summary: The report describes the production of straw insulating board at the Stewart Inso Company. Straw is used as a raw material for the manufacture of insulating boards similar to those made from wood waste and bagasse.

1100. Hesch, R. 1979. Straw as raw material for boards. 2. Insulating boards of straw as wall elements in the prefabricated house building. Holz-Zentralblatt. 105(13): 195-196. [German].
(no abstract available)

1101. Ikemann, G. 1987. Lightweight thermal insulation panels are prepared from straw, which is sprayed with aqueous adhesive solution. Assignee: (IKEM/) Ikemann G. Patent, P.N.: DE 3602381, I.D.: 870730. [German].

Summary: A panel used for constructing a wall is made from straw. First the straw is arranged in a loose heap. The straw is then sprayed with an aqueous adhesive solution, compressed to the required shape, and dried. The stalks of straw are irregularly oriented, and the air spaces between the straws have a total volume equal to at least 50 percent of the total volume of the panel. The aqueous adhesive solution contains a fire-inhibiting additive.

1102. Kakuk, S. 1992. Construction kit with lightweight panels made of pretreated straw and binder. Assignee: (KAKU/) Kakuk S. Patent, P.N.: DE 3776293, I.D.: 920305. [German].

Summary: A lightweight construction element for building walls, pillars, ceilings, and roofs consists of a panel made from pretreated straw impregnated with a binder. The thermal insulation properties of the panel are increased by cavities that extend over the length of the panel.

1103. Kalnin, I. 1958. A new method of manufacturing thermal insulation materials. Kholodil'naya Tekhnika. 6: 57-58. [Russian].

Summary: A process for the manufacture of thermal insulation panels and molded articles from porous materials, such as wood bark, chopped straw, and reed, is briefly described. Urea-formaldehyde resin is used as the binder.

1104. Khaleyan, V.P.; Bagdasaryan, A.B.; Khaleyan, G.V. 1981. Composition for moulding structural panels containing phenol-formaldehyde resin, foamer, urotropin, expanded perlite, ground straw, and reed stems. Assignee: (ERSH=) Erev Shinanyut Wks, (ACSM=) Armn Cons Mater Ind. Patent, P.N.: SU 885206, I.D.: 811130. [Russian].

Summary: Lightweight structural panels are cast from a composition containing (by weight) 40 to 43 percent phenol formaldehyde, 0.7 to 1.0 percent foaming agent, 5 to 5.2 percent urotropin, 10 to 13.4 percent expanded perlite, 8 to 10 percent ground straw, and 28 to 32 percent reed stems. Use of high amounts of reed stems increases the strength of the material and reduces its density. Panels are thermally hardened by heating to 80°C for 1 h, heating to 120°C for 0.5 h, and then holding at 120°C for 2.5 h before cooling and removing from the oven. Final product density is 0.188 to 0.214 g/cm^3 with a compressive strength of 13.7 to 14.5 MPa and a bending strength of 10.8 to 11.0 MPa.

1105. Maciver, W.J. 1952. Insulating board from waste straw. Pulp and Paper Magazine of Canada. 53(7): 101-105.

Summary: The Canadian Bodite process for manufacturing insulating board from soaked, shredded, and chemically treated straw is described. The process is continuous, except for the pressing stage. Bodite board is only one-third as heavy as wood pulp board and shows good fire resistance. Nail- and screw-holding values are satisfactory, whereas tensile strength is lower than that of boards made from wood.

1106. Nielson, K.W. 1954. Manufacture of insulating board from straw. Patent, P.N.: DE 902219, I.D.: 540121. [German].

Summary: Straw is chopped, pressed, cooked in alkaline solution, centrifuged, washed, refined, and, if molded boards are to be formed, recooked for a few minutes in a weak alkali solution prior to pressing and drying.

1107. **Schulze, B.** 1940. Comparative investigations of fiber building boards and other insulating materials with regard to their resistance to rots, mold, and insects, 1. Insulating wall boards. Holz als Roh- und Werkstoff. 3(11): 357-364. [German].

Summary: Methods for evaluating the resistance of fiber building boards and other insulating materials to the attack of rots, molds, and insects are described in detail. More than 35 products were tested, sometimes under rather drastic conditions. Mineral-bonded wood-wood boards were found to exhibit an excellent resistance to micro-organisms whereas strawboard was completely destroyed by fungi after a short time.

1108. Schulze, B. 1940. Comparative investigations of fiber building boards and other insulating materials with regard to their resistance to rots, mold, and insects. 2. Insulating panels and boards, flexible blankets. Holz als Roh- und Werkstoff. 3(12): 409-422. [German].

Summary: The resistance of fiber building boards and other insulation type materials was evaluated for their resistance to rot, mold, and insect attack. Boards composed of wood fibers and insulation boards made from straw, cork, and peat were tested.

1109. Sinclair, G.D.; Sallans, H.R. 1958. New Saskatoon plant produces insulating board from straw and hardboard from wood. Paper Mill News. 81(50): 10, 12, 24-25; Paper Trade Journal. 142(50): 48-50.

Summary: The first mill in Canada to produce insulating board from straw pulp is described. Because of the possibility of a straw shortage during drought years, wood can be used as an alternative raw material.

(Also see references 103, 147, 159, 512, 1077, and 1115.)

Cement/Gypsum/Plaster Board

1110. Hoebner, J.E. 1986. Preparation of molded articles from gypsum, especially panels. Assignee: Bison-Werke Baehre und Greten GmbH und Co KG. Patent, P.N.: DE 3431953, I.D.: 860306. [German].

Summary: Gypsum is mixed with water and poured into molds, and reinforcement particles are added before applying pressure to give a finished product. Appropriate reinforcement particles are wood chips, wood fibers, straw, flax, cotton stalks, vermiculite, perlite, and glass fiber mesh.

1111. Suwa, M. 1991. Manufacture of nonflammable boards with high bending strength. Assignee: Mitsubishi Heavy Industries Ltd. Patent, P.N.: JP 03037149, I.D.: 910218. [Japanese].

Summary: Alkali-treated straw is mixed with water, gypsum, and coal ash, press molded to remove excess water, cured, and dried to give boards. Boards will not stain upon touching.

(Also see references 149 and 885.)

Plastic/Plastic-Bonded Board

1112. Fujimoto, K. 1975. Plastic-wood boards. Assignee: Otsuka Chemical Drugs Co. Ltd. Patent, P.N.: JP 50041982, I.D.: 750416. [Japanese].

Summary: Monomers were used to impregnate wood chips, twigs, or straw ropes, and the materials were then polymerized. The impregnated materials were heated under pressure; treated with mixtures of vinyl monomers, polymers, and powdered wood or plant fibers to fill the holes on the surface; and molded under pressure and heat to prepare board.

1113. Ohtsuka, M. 1973. Composite with natural high polymers and polymethylmethacrylate. Assignee: Otsuka Chemical Drugs Co. Ltd. Patent, P.N.: JP 48015986, I.D.: 730228. [Japanese].

Summary: A methyl methacrylate solution of poly-methyl methacrylate containing polymerization catalysts was mixed with natural polymers such as straw or wood powders, chips, or particles, and polymerized to give composites. Resulting boards had a density of 0.52 g/cm^3 and a bending strength of 47.6 MPa.

1114. Ohtsuka, M.; Uchihara, S. 1973. Resin-impregnated, fire-resistant straw mats used as construction materials. Assignee: Otsuka Chemical Drugs Co. Ltd. Patent, P.N.: JP 48022178, I.D.: 730320. [Japanese].

Summary: A straw mat impregnated with vinyl monomers was cured and laminated with fire-resistant cloth to give a construction material. A 5- by 90- by 90-cm, 10-kg straw mat was impregnated with 5 kg of a mixture of styrene, methyl methacrylate, and divinylbenzene, wrapped with aluminum foil, heated for 4 h at 65°C and laminated with cotton cloth treated with fire retardant at 110°C and 9.8 MPa for 25 min to give a board with a density of 0.6 g/cm^3 and a flexural strength of 6.9 MPa.

1115. Reverdy, M. 1989. Granular thermoformable composite material prepared from straw or forage particles and polymer powder. Assignee: (REVEL) Reverdy M. Patent, P.N.: FR 2626580, I.D.: 890804. [French].

Summary: A granular thermoformable composite material is prepared by mixing granular of powdery polymer with straw or forage particles, granulating the mixture in a granulating press, and cooling the granular at the outlet of the dies. The composite material can be thermoformed or injection molded at 185°C to 200°C to articles having good mechanical and insulating properties.

1116. White, N.M.; Ansell, M.P. 1983. Straw-reinforced polyester composites. Journal of Materials Science. 18(5): 1549-1556.

Summary: The report describes the preparation and properties of straw-reinforced polyester composites.

Unknown Board

1117. Anonymous. 1988. Manufacture of straw-type chair seat panels. Assignee: (RUTTO Rutte V. Patent, P.N.: IT 1199588, I.D.: 881230. [Italian].
(no abstract available)

1118. Englert, G. 1975. Building materials from straw. Mitt Duetsch Landwirtsch Ges, Ausg A. 90(7): 383-384. [German].
(no abstract available)

1119. Guha, S.R.D.; Madan, R.N. 1979. Straw-boards from Rajasthan raw material (Pearlmillet, *Kochia indica*, *Leptodenia pyrotechnica*). The Indian Forester. 105(8): 571-572.
(no abstract available)

1120. Hesch, R. 1979. Straw as raw material for boards. 1. General significance and hitherto experiences. Holz-Zentralblatt. 105(3): 22. [German].
(no abstract available)

1121. Jeyasingam, T. 1977. An improved processing system for corrugated medium from straw. Paper. 188(1): 668, 671.

Summary: A continuous EW-MCP digestor system is described for producing semichemical as well as high-yield pulp from straw and other annual plants suitable for corrugating medium, linerboard, and yellow strawboard.

1122. Pecha, L. 1981. New trends in the effective utilization of straw (Lignocellulosic boards). Drevo. 36(8): 230-232. [Slovakian; English, German, and Russian summaries].
(no abstract available)

1123. Rexen, F. 1981. Industrial utilization of straw (Cellulose, biomass, cattle feed, paper and boards, chemicals energy). In: Pmoeranz, Y.; Munck, L., eds. Cereals, a renewable resource: Theory and Practice. St. Paul, MN: American Association of Cereal Chemists: 563-570.
(no abstract available)

1124. Sestak, L. 1971. Economic effectiveness in using straw for production of construction boards. Cesk Akad Zemed Ustav Vedeckotech Inform Zemed Ekon. 17(11/12): 819-827. [Slovakian].
(no abstract available)

1125. Staniforth, A.R. 1980. Cereal straw-a wasted world resource (for use as feeding, pulp, building material, soil improvement, fuel). World Crops. 32(5): 116, 118-19, 122-123.
(no abstract available)

(Also see references 3, 182, 197, 523, and 613.)

Cement/Clay/Gypsum/Plaster Materials

1126. Fedynin, N.I.; Al'tergott, A.A. 1988. Mixture for manufacture of building articles. Assignee: Ural Scientific-Research and Design Institute for Building Materials, Novokuznetsk. Patent, P.N.: SU 1447785, I.D.: 881230. [Russian].

Summary: To increase the frost resistance and to decrease the moisture sorption and cost of building articles, a mixture based on loam is made from Portland cement as binder, anionic surfactant, transmission oil, and chopped straw or sawdust.

1127. Kneule, G. 1983. Porous ceramic molding and its use. Patent, P.N.: DE 3207623, I.D.: 830929. [German].

Summary: A porous ceramic building material for insulation or lightweight concrete is produced without hydraulic or other binders from flue dust or fly ash by the addition of a combustible material and a sinterable silicate or SiO_2-containing material and heating from 700°C to 1,300°C. Suitable combustibles are sawdust, chopped straw, or polystyrene beads. The material may be pressed or pelletized. The pellets have a density of 0.90 to 1.50 g/cm^3 and a bulk density $\leq$0.80 g/cm^3.

1128. Kotani, H. 1989. Compositions useful as coating plasters and rough wall materials. Patent, P.N.: JP 01317141, I.D.: 891221. [Japanese].

Summary: Wall materials are prepared by mixing sand-type pumice, polyurethane paste, and straw or glass fibers, and then adding water to the resulting mixture.

1129. Kuwana, S. .1989. Rough-coated wall materials. Assignee: Kuwana Sangyo YK. Patent, P.N.: JP 01018957, I.D.: 890123. [Japanese].

Summary: Wall materials are made from calcareous clays containing CaO and $CaCO_3$, soil, straw, and water.

1130. Seberini, M. 1971. Loose construction material. Patent, P.N.: CS 141245, I.D.: 710515. [Slovakian].

Summary: Sawdust, wood shavings, cut straw, and like material were heated to 150°C to 200°C and immersed in a calcium chloride solution of 4°C to 10° Beaume containing 5 to 25 percent of polyvinyl acetate, urea-formaldehyde resin, or phenol formaldehyde resin aqueous solutions (0.5 to 1 percent pentachlorophenolate). The resultant product was a water-resistant, plastic-coated material with good heat and noise insulating properties which is useful as a mortar or plaster filler.

(Also see references 197, 622, and 912.)

Molded Masses

Plastics

1131. Anonymous. 1980. Compressed straw building materials mixed with Bakelite (RTM) or polyester for construction of houses, warehouses, silos, or stables. Assignee: (KLEE/) Klee O G. Patent, P.N.: DE 2553968, I.D.: 800124. [German].

Summary: Straw or other cellulose materials, mixed with Bakelite (RTM) or polyesters, is compressed under high pressure and heat. The product is manufactured to a density of 0.50 to 6.50 g/cm^3; is moisture repellent, self-extinguishing, and resistant to chemicals and rotting; and has high compressive strength. The straw is dried to a moisture content of 8 to 10 percent, separated from contaminants, and sprayed with an adhesive in a continuous mixer. The mixture is extruded and pressed at 7.8 MPa.

(Also see reference 1074.)

Rubbers

(See reference 1098.)

Miscellaneous

Economics

(See reference 1124.)

Loose Insulation

(See reference 1127.)

Material Preparation/Pulping/Storage Methods

1132. Green, E.W. 1967. Production of boards from fibrous and like materials. Assignee: Stramit Boards Ltd. Patent, P.N.: CA 754050, I.D.: 670307.

Summary: The patent describes an apparatus for the production of board from straw or other fibrous materials, which includes a hopper for supplying the fibrous material to a channel, a reciprocating ram for compacting the material within the channel and forcing it along the channel, and a rake that moves in an orbital path and works the fibrous material to the channel.

1133. Maisch. R. 1965. Suitability of millet straw for the manufacture of paper or board pulp. Allgemeine Papier-Rundschau. 17: 1132. [German].
(no abstract available)

1134. Younger, J.O.; Aronovsky, S.I. 1945. The physical evaluation of straw and other agricultural residue pulps. Paper Mill News. 68(8): 140-142.

Summary: The proposed laboratory methods include disintegrating, washing, and testing of cook straw. It was possible to establish the relationship between the physical properties of hand-made and machine-made straw pulps.

(Also see references 223, 242, 357, and 1093.)

General Information/Reviews

1135. Khaleyan, V.P.; Kazirelov, G.K.; Bagdasaryan, A.B. 1979. Composition for manufacturing articles of construction. Assignee: "Shinayut" Erevan Plant. Patent, P.N.: SU 687035, I.D.: 790925. [Russian].

Summary: The strength of structural materials is increased and its cost is decreased by adding (by weight) 31 to 34 percent polyvinyl acetate emulsion, 12 to 1.5 percent shredded straw, and 7 to 12 percent water to the composition containing 22 to 26 percent phenol formaldehyde polymer, 2 to 5 percent blowing agent, 4 to 8 percent urotropin, and 15 to 18 percent expanded perlite.

1136. Monties, B. 1991. Plant cell walls as fibrous lignocellulosic composites-relations with lignin structure and function. Animal Feed Science and Technology. 32(1-3): 159-175.

Summary: Natural or artificial lignocellulosic compounds such as woods, straw, or reconstituted woods (fiberboards and particleboards) can be described as composite materials. Their most typical physico-chemico-mechanical properties are shrinkage and water swelling behavior, collapse in relation to tannin and extract content, improvement of biological and dimensional stability by chemical modifications, anisotropic properties of oriented strandboards and fiber-reinforced polyester-based composites, and biological properties (digestibility, extensibility).

1137. Sen, U.S.; Bais, VS.; Yatheesh, S. 1991. The phytoplankton of the straw board mill effluent mixing zone in comparison with a reference zone and diluted zones of the river Dhasan, MP India. Acta Hydrochimica et Hydrobiologica. 19(1): 45-55.

Summary: The study reports findings of 12 months of research on the effect of straw board mill effluents on the distribution and diversity of phytoplankton of the river Dhasan in India. The phytoplankton from three stretches of the river were sampled regularly every month and analyzed qualitatively and quantitatively. Study is in-depth in regard to statistical treatment of data and breadth of results.

Sunflower [Hull/Husk, Stalk]

Panel Board

Particleboard

1138. Gertjejansen, R.O. 1977. Properties of particleboard from sunflower stalks and aspen planer shavings. Tech. Bull. 311. St. Paul, MN: Agricultural Experiment Station, University of Minnesota. 8 p.

Summary: Sunflower (*Helianthus annus*) stalks were satisfactorily broken down into particleboard furnishes by hammermilling or disc refining; ring-flaking was unsatisfactory. In laboratory tests on boards made from sunflower stalks and/or aspen (*Populus tremuloides*) planer shavings, modulus of rupture, internal bond strength, thickness dimensional stability, and durability decreased with an increase in sunflower stalk content, while modulus of elasticity and linear dimensional stability increased. Low internal bond strength, which was the most serious deficiency, could be improved sufficiently by increasing the resin content or density of the board, removing the pith from the sunflower stalks, or adding aspen shavings.

1139. Gertjejansen, R.O.; Haygreen, J.G.; French, D.W. 1972. Particleboard from aspen flakes and sunflower hulls. Tech. Bull. 290. St. Paul, MN: Agricultural Experiment Station, University of Minnesota. 5 p.

Summary: Laboratory particleboards of 0.67 g/cm^3 nominal density were manufactured from sunflower hulls and 1.27-cm aspen flakes. Sunflower hull to aspen flake weight proportions were 1:0 (all sunflower hulls and 1:2, 2:1, and 0:l (all aspen flakes). Although the addition of sunflower hulls reduced board strength and stability, Commercial Standard CS 236-66 minimum property requirements for modulus of rupture and modulus of elasticity were met by the 100 percent sunflower hull boards. The addition of approximately 50 percent aspen flakes would be required to meet the same minimum property requirements for internal bond strength and linear dimensional stability. Susceptibility to decay fungi increased with increasing sunflower hull content.

1140. Mikirtychev, V.A.; Chervyakov, I.A. 1960. Building boards from sunflower husks. Nauch.-Tekh. Inform. 1/2: 10-12. [Russian].

Summary: Building boards were produced on a laboratory scale from sunflower husks using phenol- and urea-formaldehyde resins as binders in amounts of 10 to 12 percent of the waste material. The manufacturing process and physical properties of the resulting boards are briefly described.

(Also see references 44, 70, 487, 661, and 678.)

Fiberboard/Hardboard

(See references 498, 678, and 852.)

Unknown Board

(See references 3 and 517.)

Tobacco

Panel Board

Fiberboard/Hardboard

1141. McHargue, J.S.; Woodmansee, C.W.; Rapp, K.E. 1943. New uses for low-grade tobacco. Chemurgic Digest. 2(15): 130-132.

Summary: Tobacco moisture-free leaves and stems contain approximately 15 to 20 percent of inorganic matter. The range of cellulose for 13 samples of burley tobacco was 10 to 13.5 percent and the average 11.8 percent. For dark tobacco, the crude cellulose ranged from 7.2 to 11.5 percent and averaged 9.3 percent in 33 samples. The other basic chemical constituents of low-grade tobacco stem were also determined.

1142. McHargue, J.S.; Woodmansee, C.W.; Rapp, K.E. 1943. New uses for low-grade tobacco. Chemurgic Digest. 2(16): 136-137.

Summary: Low-grade Kentucky tobacco was used for making fiberboard by pressing the crude fiber. The product was hard and withstood nailing, sawing, and drilling as well as a wooden board. It can be sanded to a smooth finish.

(Also see reference 498.)

Unknown Board

(See references 3 and 784.)

Tomato

Panel Board

Unknown Board

(See reference 784.)

Vine

Panel Board

Fiberboard/Hardboard

(See reference 498.)

Unknown Board

(See reference 666.)

Walnut

Molded Masses

Resins/Binders

(See reference 438.)

Water Hyacinth

Panel Board

Unknown Board

1143. Azam, M.A. 1942. Utilization of water hyacinth in the manufacture of paper. Indian Print Paper. 7(3): 41-44.

Summary: Pulp obtained from water hyacinth (*Eichhornia crassipes*) by boiling in water with or without the addition of chemicals consists of very fine particles. The pulp can be used for special types of paper. When converting into pressed board, even better results are obtained. The products resemble Masonite boards and are very tough.

Wheat [Flour, Puffed Wheat, Straw]

Panel Board

Particleboard

1144. Fujimoto, M.; Taguchi, N.; Hatsutori, S. 1988. Manufacture of straw boards. Assignee: Oshinka Shinko KK. Patent, P.N.: JP 221007, I.D.: 880914. [Japanese].

Summary: Boards, with good cushion and water-resistance properties, and useful for floors and walls, are manufactured by hot-pressing wheat straw and/or rice straw as follows: 2 parts of 50 percent sulfur, 100 parts of 53 percent acrylic acid-styrene-butadiene copolymer latex, 1 part of 50 percent vulcanizing accelerator MZ, 0.5 part of 50 percent vulcanizing accelerator EZ, 12 parts of 50 percent zinc white, and 5 parts of powdered PV alcohol were mixed and sprayed onto chopped straw at a straw:binder ratio of 100:50. Laying the latex-containing straws on a flat platform and hot pressing at 140°C at 7 kg/cm^3 for 40 s for each 1 mm of thickness gave a mat usable for flooring.

1145. Russell, B. 1990. Straw particleboard. In: Proceedings of the 24th Washington State University international particleboard/composite materials symposium; 1990 April 3-5; Pullman, WA. Pullman, WA: Washington State University. p. 264.

Summary: The report evaluates the use of cereal grains, such as wheat, barley, and flax, as furnish for industrial particleboard based on Canadian Standards Association (CSA) criteria for Grade R (high-quality furniture core). Test panels were manufactured using isocyanate. Panels had high strength and also met water-soak-swelling requirements for exterior grade waferboard.

1146. Troger, F.; Pinke, G. 1988. Manufacture of boards glued with polymeric diphenylmethane-4,4-diisocyanate containing various proportions of straw. Holz als Roh- und Werkstoff. 46(10): 389-395. [German; English summary].

Summary: Five types of three-layer boards were made in the laboratory: two types contained milled wheat straw particles (produced in two types of laboratory mills) only; two contained straw and industrial softwood particles (25 percent in the surface layers and 50 percent in the middle layer); and one contained wood particles only. Tests were made on internal bond, bending strength, tensile strength, screw-withdrawal resistance, thickness swelling, and surface roughness. Values were generally poorest in straw-only boards and best in wood particleboards.

1147. USDA Northern Regional Research Laboratory. 1954. The feasibility of manufacturing structural boards from puffed wheat and the bearing of this on relief in the wheat surplus. Unpublished Res. Pap. Peoria, IL: USDA, Northern Utilization Research Branch. 35 p.

Summary: Experimental particleboard was produced using puffed wheat as the raw material. The puffed wheat board had superior resistance to internal shearing in relation to any other similar product with the same strength to weight ratio, and a lower cost of production. Insulating board and hardboard were also reported to be in development. This report covers, in depth, the economical aspects of utilizing puffed wheat as a raw material for particleboard to reduce the wheat surplus in the United States.

(Also see references 660, 823, and 850.)

Fiberboard/Hardboard

1148. Lathrop, E.C.; Naffziger,T.R.; Stivers, E.R. 1951. Boxboard from wheat straw to replace wood veneer in wire-bound shipping containers. Tappi Journal. 34(4): 145-152.

Summary: A wheat straw boxboard was developed that showed performance in standard wire-bound shipping containers equal to that of wood veneer in respective thickness. The study covers the production of the boxboards, small- and large-scale testing and economics of the boxes.

1149. Li, R. 1991. Wheat straw fibreboard production: treating straw with water, making pulp, vacuum drying, cutting edges, pressing, and scalding. Assignee: (HAND-) Handan Inst Second Light Ind. Patent, P.N.: CN 1055785, I.D.: 911030. [Chinese]
(no abstract available)

(Also see references 112, 115, 137, 497, 660, and 857.)

Insulation Board

1150. Wisniak, J.; Lauterback, A.; Vergara, P. 1962. The possible use of wheat straw and red mace for the manufacture of acoustical tile. Tappi. 45: 226A-230A.

Summary: The possibility of manufacturing insulating board, especially acoustical tile, from wheat straw and red mace (*Typha angustifolia,* Linn.) by chemomechanical pulping was studied. Runs were made with cooking times of 10 to 60 min and alkali concentrations of 0 to 5 percent CaO and 0 to 3 percent NaOH. Some cooking variables, the degree of refining of the pulp, and the finishing of the surface were investigated with respect to their influence on the acoustical properties of the boards. The results showed that sound-absorbing properties of the boards are better than those of tiles made from bagasse or pine pulp.

1151. Lathrop, E.C.; Naffziger, T.R. 1949. Evaluation of fibrous agricultural residues for structural building products. II. Fundamental studies on wheat straw fibers. Tappi. 32(2): 91-96.

Summary: Methods are described for cooking and refining wheat straw to produce long fibers and hydrated short fibers. The relationship between fiber properties and physical characteristics of resultant insulation boards was thoroughly studied. Selected long straw fibers give boards of higher tensile and impact strengths than those of wood fibers. Results indicate that wheat straw is highly suitable for the production of structural building boards.

1152. Lathrop, E.C.; Naffziger, T.R. 1949. Evaluation of fibrous agricultural residues for structural building products. III. A process for the manufacture of high-grade products from wheat straw. Tappi. 32(7): 319-330.

Summary: A process for the manufacture of high-quality insulating building board from wheat straw is described in detail. The effect of operating variables on physical properties of the boards was studied. The types of pulp required are unhydrated long-fibered pulp and hydrated pulp. The ratio of pulp types used in board manufacture greatly affects the physical characteristics of the finished products. Process equipment and economics of manufacture are discussed.

1153. Lathrop, E.C.; Williamson, R.V.; Naffziger, T.R. 1947. The small rural industry: a study of the possibility of making insulating board from straw. Circular 762. United States Department of Agriculture. 22 p.

Summary: A process for manufacturing 1.9844-cm sheathing board from wheat straw has been fully developed through pilot plant operations. The board can compete in utility, structural strength, and water resistance with present products. The manufacturing method and resulting properties of the board are described in detail and illustrated.

1154. Naffziger, T.R. 1963. Cross-linked wheat flour xanthate wood pulp blends for insulating boards. Tappi. 46: 428-431.
(no abstract available)

1155. Srivastava, A.C.; Gupta, R. 1990. Feasibility of using trash and straw as a thermal insulator. Biological Wastes. 33(1): 63-65.

Summary: Sugarcane trash, rice straw, and wheat rice were chopped to l-cm lengths, mixed with an arrowroot starch liquid binder, and compressed for 30 s at 350 kN. Five-cm-thick wafers were dried to 7 percent db and their insulation properties measured. All three materials proved to be good thermal insulators; the sugarcane trash was the most effective.

(Also see reference 660.)

Cement/Gypsum/Plaster Board

(See reference 175.)

Unknown Board

1156. Nishizawa, H.; Ohta, K. 1960. Artificial timber. Patent, P.N.: JP 14784, I.D.: unknown. [Japanese].

Summary: The patent describes the use of wheat flour in the production of a composite wood product.

Cement/Clay/Gypsum/Plaster Materials

1157. Blair, R.C. 1963. Gypsum-based plasters. Patent, P.N.: CA 656542, I.D.: unknown.

Summary: Wheat and/or rye gluten are used in the production of a gypsum-based plaster.

1158. Ludwig, N.C. 1950. Cement for lightweight concrete. Patent, P.N.: US 2521073, I.D.: unknown.

Summary: The use of wheat flour in the production of cement for lightweight concrete is discussed.

1159. Polis, C. 1970. Binding composition from gypsum plaster, lightweight granular aggregate, and wheat paste. Patent, P.N.: US 3519450, I.D.: 700707.

Summary: A binding composition used as mortar for securing artificial fiberboard bricks to interior surfaces for decorating purposes is obtained by adding wheat paste to a mixture of gypsum plaster and a lightweight granular aggregate in an amount calculated to reduce drying time to render the composition more workable with improved adhesion. The amount of wheat paste is specified as 6 percent.

(Also see references 392 and 909.)

Molded Masses

Plastics

1160. Cheng, Z.; Li, Z. 1988. Development of thermoplastic composites with mixed fillers. Suliao. 17(5): 37-40. [Chinese].

Summary: Organic fillers, such as wood flour, sawdust, wheat stalk, cornstalk, and straw hull, can be combined with inorganic fillers, such as $CaCO_3$, gypsum powder, and hard stone flour, in the preparation of PVC and polyethylene composites.

Refractory Materials

1161. Hughes, M.J. 1968. Thermally insulating slabs for lining the upper parts of ingot molds. Patent, P.N.: GB 1115435, I.D.: unknown.

Summary: Wheat flour is used in the production of heat-insulating slabs that are used in the steel and iron industry.

(Also see reference 961.)

Resins/Binders

1162. Anonymous. 1977. Starch paste for corrugated boards containing alpha-wheat flour, wheat flour, sodium carbonate, borate, calcium hydroxide. Assignee: (HOHN-) Hohnen Oil KK. Patent, P.N.: JP 77039619, I.D.: 771006. [Japanese].

Summary: Starch paste, useful for the manufacture of corrugated boards, is prepared by dissolving a-starch, starch, one or more hydroxides or oxides of two to three valent metals, and one or more sodium or potassium salts in water.

1163. Nakai, T.; Takatsuji, I.; Tokuda, M.; Kikuchi, K. 1976. Adhesives for corrugated boards. Assignee: Hohnen Oil Co. Ltd. Patent, P.N.: JP 51124132, I.D.: 761029. [Japanese].

Summary: Whole wheat was treated with water to a water content of 17 percent, steamed at 980.6 kPa gage for 30 min, cooled, dry-milled, and separated from bran. Flour (16.5 g) was dispersed in 200 mL of water at 40°C, pasted with 6.6 g NaOH at 60°C for 15 min, diluted with 125 mL of water, and stirred for 10 min. The flour was also dispersed in 500 mL of 33°C water containing 5.5 g borax, 16.5 tannin, and 14 g urea-formaldehyde copolymer and mixed with the above-described paste to yield a high-speed corrugator adhesive with better hot-water resistance than a control prepared without steaming (for denaturation of protein) or without urea formaldehyde and tannin.

1164. Roman, C. 1948. Composite wood products. Patent, P.N.: US 2446304, I.D.: unknown.

Summary: The use of rye and wheat flour in the production of wood composite boards is discussed.

(Also see references 72, 529, 530, 990, 993, and 1154.)

Miscellaneous

Economics

(See references 1147 and 1152.)

General Information/Reviews

1165. Goehre, H.O. 1987. Straw semichemical pulp process for the production of fiber raw material for corrugated board, packaging papers and plain paper board. Papier (Darmstadt). 41(10): 541-546. [German].

Summary: The paper discusses a new process for the use of straw in the production of fiber-based materials in Germany.

Patent Appendix

In this bibliography, patent citations are formatted as follows: P.N. denotes patent number; capitalized letters between P.N. and the number represent the country code; I.D. denotes issue date; and, finally, the date is cited by year, month, and day. For example, in reference 18, the patent number (P.N.) is 1127700, which is preceded by the country code (GB). The issue date (I.D.) is September 18, 1968 (680918).

18. Anonymous. 1986. Bagasse panels bonded with urea-formaldehyde resin. Assignee: Societe Anon. Verkor. Patent, P.N.: GB 1127700, I.D.: 680918.

Notation for patent country codes:

AU	Australlia
BE	Belgium
BR	Brazil
CA	Canada
CN	China
CS	Czechoslovakia
DE	West Germany
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EU	East Germany
FR	France
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