Fire Testing of Recycled Materials for Building Applications

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Abstract

To gain wide market acceptance of new building products made from recycled materials, fire testing may be necessary. In this paper, some applicable fire tests are discussed. The paper concludes with a brief review of past USDA Forest Service fire research of such products.

Introduction

Building products need to meet a variety of performance requirements. Although there are few fire performance requirements for building products in one-family dwellings, such requirements are significant for commercial, industrial, and multi-family buildings. Depending on the type of materials and intended application, specific fire performance properties of new building materials should be evaluated as they are being developed.

Fire tests

The three main fire test methods for building products are ASTM E 136 for combustibility (8), ASTM E 84 for flame spread (14), and ASTM E 119 for fire resistance (15). Both untreated and fire-retardant-treated wood are combustible when tested in the ASTM E 136 vertical furnace. Based on their flame spread index, determined in the ASTM E 84 tunnel test, interior finish building products are rated Class I, II, III, or unclassified. Most wood products are rated Class III. Fire-retardant treatments and coatings can be used to obtain a Class I flame spread index. The ASTM E 119 fire resistance test is a test of the assembly or major structural member (beam or column). The assembly is assigned an hourly rating if the assembly endures the specified fire exposure without failing one of the failure criteria of structural failure, excessive temperature increase on the unexposed surface, or flame penetration. For wood floor or wall assemblies, gypsum board is usually used to protect the structural elements and obtain the 1-hour rating for the assembly.

There are also fire tests for specific products. Examples of such tests include the ASTM E 108 tests for roof coverings (5), the ASTM E 970 (or ASTM E 648) critical radiant flux test for exposed attic floor insulation (12) (or floor coverings (10)), and the NFPA 252 fire resistance test for door assemblies (28). In some applications, foam plastic needs to be protected with a thermal barrier. The UBC 26-2 thermal barrier fire test (24) is one option for evaluating potential panel products for that application (38,39). Other fire tests have been used in product specifications. Such tests include the ASTM E 162 test for surface flammability (9) and the ASTM E 662 test for specific optical density of smoke (11,16,31). The ASTM D 2863 oxygen index test is often cited in literature on the fire performance of plastic products (2,37). In addition to ASTM E 84, many other tests are available for surface flammability and related properties (20).

Although not currently used for regulatory purposes, heat release rate is an important tire property. Heat release rate is a critical factor in flame spread and fire growth in a room (19). It is a potential way to measure the degree of combustibility. The ASTM E

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1354 cone calorimeter (6,22) is the most widely used method to obtain heat release rate. An older method is the ASTM E 906 Ohio State University calorimeter (1,32,33). The cone calorimeter uses a 100-mm^2 specimen; therefore, it is a useful test for research and product development. When a larger specimen size is needed for proper evaluation, there is the ASTM E 1623 Intermediate Scale Calorimeter (7). The room/comer test provides for full-scale testing of panel products (19,34).

For some materials, ignitability and smoldering characteristics are important. The heat release rate calorimeters and the LIFT flame spread apparatus (3, 18) can be used to determine the ignition characteristics of materials exposed to a radiant flux. Fiberboard (17) and cellulosic insulation (29) are examples of materials where smoldering frees became a problem. A cigarette smoldering test (4) is used to evaluate the effectiveness of fire-retardant treatments to limit the smoldering characteristics of cellulosic insulation.

Fire-retardant treatments for wood (25) are designed to reduce the flame spread of wood products to Class I. Fire-retardant-treated products generally have a low heat-release rate and self-extinguish if the external heat source is removed. For building applications, fire-retardant-treated wood is required to have a Class I flame spread index of 25 or less and be subject to tests of a 30-minute duration during which the flame spread does not progress more than 10.5 feet (3.2 m) beyond the centerline of the burners, with no evidence of significant progressive combustion (35). The ASTM E 69 fire tube test (13) is used for quality control of fire-retardant treatments and can be used to evaluate potential treatments (21). The USDA Forest Service, Forest Products Laboratory (FPL) currently uses a heat-release rate calorimeter to evaluate fire-retardant treatments (27).

Examples of past research

Products that have been evaluated by the FPL for fire performance include wood flakeboard from forest residues, cellulosic insulation, FPL spaceboard, wood fiber-plastics composites, and wood filber-cementblocks.

In an evaluation of a wood flakeboard made from forest residues (23), we evaluated flame spread, heat release rate, smoke development, and the fire endurance of wall assemblies with the panel product. An FPL study on cellulosic insulation was conducted on different methods (dry powder, aqueous solutions, and vapor deposition) of adding the boron fire-retardant chemicals to the insulation (36), To better understand the smoldering of cellulosic insulation, a mathematical model was developed to predict the weight loss from smoldering (26). For some potential applications of the wood fiber product known as FPL Spaceboard, its flame spread index needed to be determined. We initially evaluated versions of the product with our old ASTM E 906 heat release rate calorimeter and verified its flame spread with an ASTM E 84 tunnel test. With wood fiber-plastics composites, we needed to determine whether the synthetic polymers would increase the flammability to unacceptable levels. We used an ASTM E 906 calorimeter in a preliminary evaluation of different wood fiber-plastics composites (30). Heat-release rate results indicated that the polymers had little effect unless the product was 60 or 80 percent synthetic polymer. In the case of wood-cement blocks, our interests are in their ability to provide fire resistance; their flammability is very low. We used our small, vertical fire endurance furnace to conduct a preliminary evaluation of a proprietary wood-cement block product.

Conclusions

To gain wide market acceptance, building products from recycled materials may need to be tested for fire performance. Numerous fire tests can be conducted. The need for specific fire tests depend on the intended applications. Fire-retardant treatments can be used to reduce the flammability of a product.

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