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Factors Influencing Timber Bridge Performance

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Abstract

This paper examines National Bridge Inventory data to determine timber bridge performance as affected by maintenance responsibility and design load. Results indicate that design load has the greatest effect on bridge performance. Bridges have higher performance ratings in areas where maintenance is the combined responsibility of state and county or town agencies.

Introduction

In 1967, the Federal Highway Administration (FHWA) established the National Bridge Inventory (NBI) to catalog bridge inspection data and condition evaluations for over 575,000 bridges in the United States. As a result of information provided by the states, bridges may be rated as structurally deficient (SD), or functionally obsolete (FO) as defined by the FHWA. Bridges not defined as SD or FO are categorized as satisfactory. Due to the large number of bridges in the inventory, the NBI serves as a valuable tool in assessing the condition of the infrastructure. For example, a previous study analyzing the 1992 NBI reported that almost half of the bridges cataloged were deemed SD or FO (Stanfill-McMillan and Hatfield, 1994).

The number of bridges considered SD or FO is a concern since all of these bridges will eventually need to be rehabilitated or replaced. For timber bridges. two areas can be identified that potentially affect performance: maintenance responsibility and design load (FHWA, 1988). Through the use of statistical data obtained from the 1992 NBI, this paper examines the importance these factors on the performance of timber bridges.

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Maintenance Responsibility Related to Bridge Performance

The first factor that may influence timber bridge performance is maintenance responsibility. Based upon NBI data, primary maintenance responsibility is grouped into state, county, and combined categories. The combined category reflects joint maintenance completed by state and county or town agencies. The NBI shows eight states with maintenance responsibilities primarily at the state level, 21 states with maintenance responsibilities at the county level, and 21 states with a combined maintenance program. The individual states are listed in Table 1 according to maintenance responsibility.

Table 1. Maintenance responsibility by state

Primary Maintenance Responsibility	States
State	AK, DE, NH, NM, NC, RI, VA, WV
County	AL, AZ, CA, FL, ID, IN, IA, KS, KY, MD, MI, MS, MO, NE, ND, OH, OK, SD, TN, TX, WY
Combined	AR, CO, CT, GA, HI, IL, LA, ME, MA, MN, MT, NV, NJ, NY, OR, PA, SC, UT, VT, WA, WI

The timber bridge maintenance responsibility data presented in the NBI was sorted according to the SD, FO, and satisfactory criteria. FHWA does not use the SD and FO ratings on structures that have been constructed in the last ten years. However, in this study, these ratings were used for bridges constructed in the last ten years to obtain a more realistic population. The results from this sort are presented in Table 2.

Table 2. Performance of timber bridges by maintenance responsibility.

Maintenance responsibility	Total	SD	FO	Satis-factory	SD (%)	FO (%)	Satis-factory (%)
State	1576	571	455	550	36	29	35
County	23213	14415	3265	5533	62	14	24
Combined	12241	5074	1709	5458	41	14	45
Total	37030	20060	5429	11541	54	15	31

The results suggest an advantage to states that follow a combined maintenance program. This advantage may be the result of a reallocation of maintenance responsibilities—the state agencies concentrate on specific bridge types while the county or town agencies focus on the remaining bridge types. It is probable that the county or town agencies are responsible for the smaller and simpler bridges because of the lower costs associated with this type of maintenance. State agencies are most likely responsible for the more complex bridges since such agencies are more likely to be supplied with equipment, personnel, and budget for these types of bridges.

Design and Performance

Each state has varying standards for bridge design. For this paper, bridges are classified as either American Association of State Highway Transportation Officials (AASHTO) design load or non-AASHTO design load. The AASHTO design load category includes all bridges that were designed with an design load of AASHTO H-10 or HS-15 and greater. The H-XX and HS-XX designations signify the design load in tons. The non-AASHTO design load category includes all bridges that do not fit into this category. These categories were used to determine the importance of design load on the performance of bridges. Results presented in Tables 3 and 4 indicate the performance of AASHTO and non-AASHTO design load timber bridges by maintenance responsibility.

Table 3. Performance of AASHTO design load timber bridges by maintenance responsibility.

Maintenance responsibility	Total	SD	FO	Satis-factory	SD (%)	FO (%)	Satis-factory (%)
State	331	73	88	170	22	27	51
County	7162	4664	742	1756	65	10	25
Combined	8107	3158	1253	3696	39	15	46
Total	15600	7895	2083	5622	51	13	36

Table 4. Performance of non-AASHTO design load timber bridges by maintenance responsibility.

Maintenance responsibility	Total	SD	FO	Satis-factory	SD (%)	FO (%)	Satis-factory (%)
State	1245	498	367	380	40	30	30
County	16051	9751	2523	3777	61	16	24
Combined	4134	1916	456	1762	46	11	43
Total	21430	12165	3346	5919	57	16	27

The results indicate that the best-performing AASHTO design load bridges are state-maintained, and states that use a combined maintenance program have the best non-AASHTO design load bridges. Tables 3 and 4 also illustrate that when a bridge is designed for an AASHTO design loading, the percentage of satisfactory timber bridges increases. The difference in percentage of satisfactory ratings of AASHTO and non-AASHTO design load bridges is much greater when the values for H-10, H-15 and HS-15 design loads are removed from the sample, as shown in Table 5. The higher AASHTO design load bridges reflect more modern loading requirements than lower AASHTO design loadings. The bridges with higher design loads are also newer and may not have experienced maintenance problems, so maintenance responsibility would not have as great of an effect on bridge performance.

Table 5. Performance of H-20, HS-20 and HS-25 rated timber bridges by maintenance responsibility.

Maintenance responsibility	Total	SD	FO	Satis-factory	SD (%)	FO (%)	Satis-factory (%)
State	141	13	39	89	9	28	63
County	1010	157	163	690	16	16	68
Combined	2014	211	246	1557	10	12	77
Total	3165	381	448	2336	12	14	74

Conclusions

Timber bridge performance appears to be affected by two factors: maintenance responsibility and design load. The most important is use of adequate AASHTO loads in bridge design since a lower design load causes a large number of timber bridges to be classified as structurally deficient. The second factor is utilizing the combined method of maintenance responsibility between state and county or town agencies. The combined maintenance responsibility appears to distribute resources to allow better performance of timber bridges in the state.

References

Federal Highway Administration. 1988. Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges. Report No. FHWA-ED-89-044. Washington DC: United States Department of Transportation.

Stanfill-McMillan, Kim and C.A. Hatfield. 1994. "Performance of Steel, Concrete, Prestressed Concrete and Timber Bridges." Pp. 341-354 in 4th International Conference on Short and Medium Span Bridges, Halifax, Nova Scotia, 1994 August 8-11. Montreal, Canada: Canadian Society of Civil Engineering.