Railway track and structures

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Les ponts des petites lignes peuvent-ils supporter des wagons de 286 000 livres ?

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Can shortline bridges handle 286k cars?

A recent study sponsored by the ASLRRA and funded by FRA helps shortlines evaluate the capability of timber trestles to handle 286,000-pound freight cars.

Tens of thousands of timber trestles, large and small, carry shortline track. But how do you determine whether or not those trestles will be able to handle the 286,000-pound cars now entering service? A new tool can help railroads do just that.

At the 2003 AREMA Technical Conference in Chicago, John Horney, P.E., Carter & Burgess, Inc., delivered a joint presentation for the Federal Railroad Administration and Carter & Burgess that provided the results of a study to evaluate the capability of shortline railroad timber trestles to handle 286,000-pound freight cars. This study was funded by the FRA, sponsored by the American Short Line and Regional Railroad Association, completed by Carter & Burgess, and is available through the ASLRRA.

ASLRRA initiated a committee with representatives from five shortline railroads to oversee, review and provide comments throughout the development of the program. Carter & Burgess was selected to develop the program. Horney worked closely with Don Plotkin of FRA, Steve Sullivan of ASLRRA, and the ASLRRA Committee: Chris Dodge, OmniTRAX; John Porter, RailAmerica; Bill McKillp, Dakota, Minnesota and Eastern; P. Sheldon, Iowa Interstate, and R. Buchan, Paducah & Louisville.

"The objective of this project is to develop a program for the shortline railroad industry that will provide a consistent methodology for evaluating their timber bridge inventory," Horney said. "This method of evaluation is in the form of a questionnaire and computer program that will provide the user with instructions and diagrams to help explain the detailed information that is needed and how to enter the data necessary for the program to properly analyze the timber structures. The program has a computer matrix analysis that will characterize a timber bridge and determine its capability to safely support the 286,000-pound cars. To accomplish this, the program must consider the method of bridge construction, environment, train speeds and both mechanical and organic decay. With this program, the FRA, ASLRRA and railroad industry will have a system that will form the basis for a bridge management program."

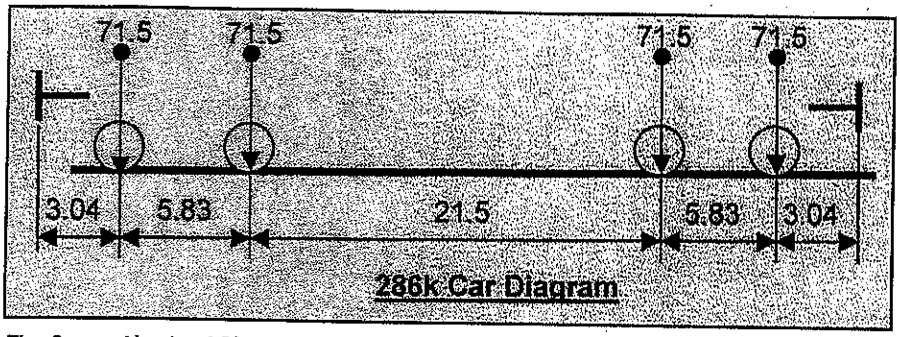
Can Class 1 and 2 railroad bridges, such as this one on Montana Rail Link, handle 286,000-pound cars? A new tool helps provide the answers. (Photo by Mark Simonson)

The focus of the program questionnaire is on the individual timber trestle component sizes, quantities and method of construction requiring detailed information for each span of each timber bridge. Specific questions are asked that will determine the physical condition of key components of the trestle by use of a rating system.

"The results of this project will provide the shortlines with a consistent method for the engineering industry to evaluate the capacity of these timber trestle structures," Horney pointed out. "Shortline railroads could use the results of this report as a tool for developing their planning programs and budgets."

Matrix evaluation

This program requires the user to respond to a series of questions that ultimately identify the physical properties of the timber bridge. The questions address the size and number of each of the bridge components that identify the physical shape and size of the bridge. The user will be asked about the status of the bridge's mechanical and organic decay. Additional questions address the environment, such as the bridge height,



The Cooper Live Load Diagram is a common "yardstick" that railroad bridge engineers use to measure the magnitude of trainloads on a railroad bridge. One of the objectives of this project is to determine an equivalent Cooper Rating for 286,000-pound freight cars as they relate to timber railroad bridges. The illustration represents the wheel loads and spacing for a 286k freight car as used for this project. Although there are 286k freight cars that may be longer, this diagram, using a shorter wheelbase, provides conservative values for the purposes of this project.

scour and the authorized train speed.

This program will evaluate only timber bridges, but, for inventory purposes, the user will be asked to enter the bridge description that includes any steel or concrete spans. The program recognizes the following types of bridge segments:

Timber Trestle – Open Deck
Timber Trestle – Ballast Deck
Concrete Spans
Steel Spans

In order to perform a structural analysis, the program will need to know specific details of each component of the structure. It will be the responsibility of the user to physically determine all the timber component dimensions needed to perform this analysis. Based on information that the user provides, the program will perform detailed calculations that will identify the stresses generated by 286,000-pound cars. There will be numerous questions asked that will need to have a response. To help keep this exercise as user-friendly as possible, every effort is made to provide instant duplication of responses by the computer for common timber sizes rather than require the user to make multiple duplicate responses.

The program will develop a weight-per-foot-of-bridge for the rail, ties, inside guardrail, tie spacers, hardware, footwalk and handrails. If the bridge is a ballast-deck structure, it will calculate the weight of the rail, ties, hardware, ballast, ballast stops, ballast deck and handrails. For ballast-deck bridges, the weight of the ties is included in the volume of ballast, since the unit weights are nearly the same. Each open-deck bridge can have different size rail and ties, or the ties may have different spacing that will all affect the value of the dead load. The answers provided by the user will identify all of this information and generate a dead load that is unique to that structure.

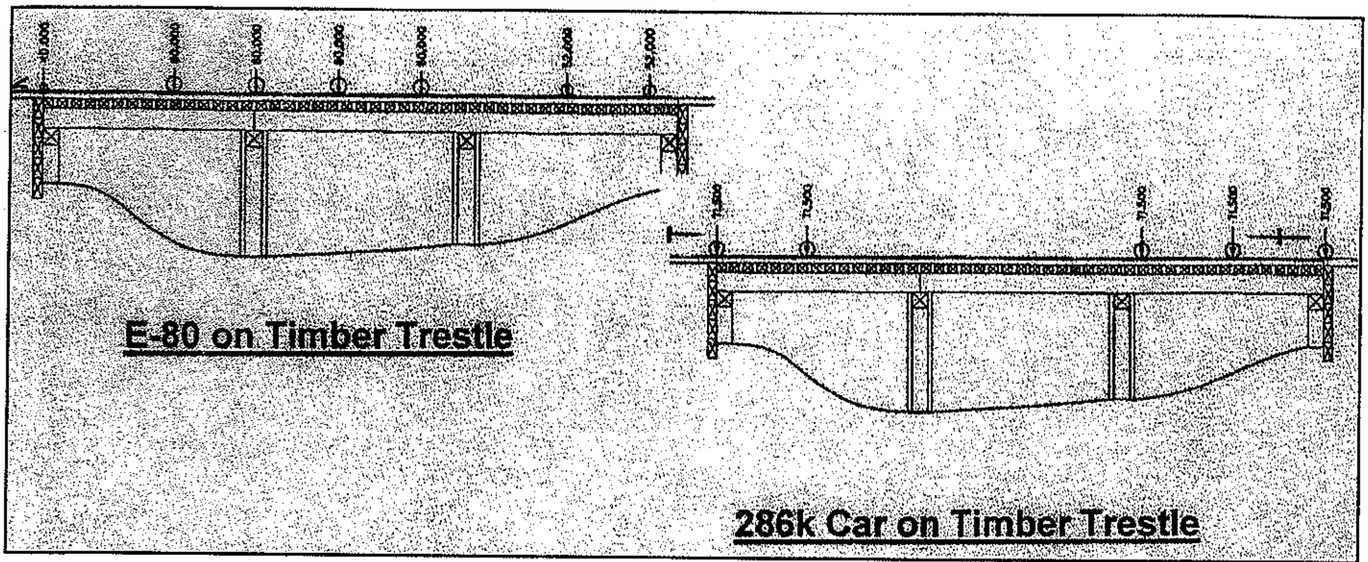
The user will provide the number and size of each stringer in each span of the bridge. The program will evaluate each span and each bent separately, based on the information unique to that span and bent. That evaluation will incorporate variations of span lengths and the number or size of stringers in each span. The program will determine the stringer dead load per-foot-of-track and add it to the dead load above the stringers to obtain a total uniform dead load for each span across the bridge that will be used to obtain the dead load bending moments and reactions.

For ballast-deck timber trestles, the computer will generate a modified uniform dead load that will analyze the main load carrying stringers. The modified uniform load will neglect the outside stringer on each side of the bridge deck, ballast retainers and the outside two feet of timber deck and ballast on each side of the bridge.

Once the number of main stringers and their sizes are identified, the program will develop the structural characteristics for the main stringers in each span, such as area, weight, and section modulus, that will ultimately determine the stringer's stresses. For ballast-deck trestles, the program will use all the stringers to determine dead loads for the piles. However, when evaluating the stringers, it will omit the outside stringers and their respective dead load, as identified above, then use the remaining dead load and all the live loads to be supported on the interior stringers. Also, only the properties for interior stringers will be used to determine the ballast deck stringer stresses.

This report will use 286,000-pound freight cars for its live load analysis. By applying dead and live loads according to the AREMA guidelines, the respective loads and stresses will be determined for each of the timber bridge components. The induced stresses will be compared to the allowable timber stresses as identified by AREMA.

AREMA Section 2.7.1c states that "Where timber is treated by creosoting or other process rendering it decay resistant, the working stresses for continuously dry may be used except in compression perpendicular to the grain and for joists and planks continuously



When the Cooper E-80 Load is placed across a bridge it will generate definable forces throughout the structure. With this approach, the maximum forces will define the value needed to size the various bridge components to resist the applied loads. By moving the load to specific locations across the bridge, the maximum values will be found to design for bending, shear, and compression stresses.

submerged." The exception accounts for stresses in the stringer where it is bearing on the bridge cap. This area is noted for its ability to retain moisture because it is protected from the sun and slow to dry.

According to AREMA, "There are many factors affecting the strength of lumber for which no satisfactory, commercially applicable methods of evaluating the effects have been found. These factors produce a variability among pieces which otherwise seem to be alike. Since the allowable stresses are based on the strength of the weakest pieces that may occur in the grade and assume that each piece just carry its load, it follows that if a load is carried by several members, not independent of each other, the designer could reasonably allow somewhat higher stresses. Conversely, if the failure of a single member would cause unusually great damage, the allowable stress on that member should be reduced. An overload of 50 percent will cause failure in only rare cases, but if the load is doubled, failures will be frequent."

Bridge condition

Regardless of how well and how strong a bridge may have been constructed, its capacity may be significantly reduced if it is in poor physical condition. Two independent types of deterioration define the physical condition of a timber trestle: organic deterioration and physical or mechanical deterioration.

"To require detailed input from a good physical bridge inspection is beyond the intention of this program," Horney said. "General questions will be presented that will require the user to note a general condition of the structure. For organic decay, the user needs to determine if there are any obvious bulges along the face of the cap or piles, or if there are noticeable decay pockets along the top of the stringer between the ties. If the owner has obtained a detailed inspection report that provides known boring data, such as shell thickness and void depths, it would be wise to have that information available while responding to the program questions.

"For mechanical decay, the user will be asked to enter the depth and number of shims between the stringer and cap, or pile and cap, or if there are any gaps and their size," he noted.

A theoretical analysis of a timber trestle will typically show that a cause for rejection will be associated with the bending stress of the stringers, the horizontal shear, or bearing stresses perpendicular to the grain. With the built-in factor of safety previously mentioned, any organic decay issues within the stringers or caps that are not obvious will be considered as acceptable. The program will automatically assume a void in the piles with a 3-1/2-inch outer shell during the evaluation of bearing stresses. With a typical unbraced pile length of 25 feet, the allowable compressive stress of the piles will not represent a cause for rejection under these conditions.

"This program does not have the capability to determine if any of the bridge components have serious organic or mechanical decay without the honest input from the user," Horney explained. "The program will ask several questions regarding the organic and mechanical decay of the bridge. If the user indicates certain conditions exist, such as multiple shim stacks, gaps at bearings that are missing shims, bulges in pile caps or piles, etc., the program will identify these problems. The resulting condition analysis will identify each exception, provide a list of the exceptions, and will place the bridge in a category of either marginal or not acceptable. The reality of this type of result is that these types of bridge conditions exist for a reason – there is a problem. The good news is that these types of problems can be repaired.

Unless a bridge has multiple problems that would justify a new structure, the owner will have a good maintenance list that, when the exceptions are corrected, the program would likely move the bridge to an acceptable structure to support 286,000-pound traffic. It is important for the owner/user to understand that, even with a timber bridge that is in good condition, once 286,000-pound traffic starts to operate across these structures, the inspection and maintenance cost will increase in order to maintain the integrity of timber bridges. If organic or mechanical exceptions already exist, without being repaired before 286,000-pound traffic, there could be serious problems or failures.

Compliance criteria

Based on the results of the program's technical analysis of the bridge components and the response of the user's answers regarding the bridge condition, the following results will be generated by the program:

- Acceptable
- Marginal
- Not Capable

Based on computed analytical stresses of the individual bridge components, the program will generate the following results based on the actual stress as compared to the allowable stresses:

- Not Capable: Any component of the bridge with a stress greater than 15 percent of the allowable stress. Each exception will be identified and listed, e.g., Stringer 3 of Span 5 fails in bending (or compression, or horizontal shear).
- Marginal: Any component of the bridge that is equal to, or up 15 percent greater than the allowable stress. Note: If the actual stress is within this identified range, and the train speed is 30 mph or greater, the program will identify the condition as "Not Capable." Each of these conditions will be identified and listed.
- Acceptable: Any component of the bridge that is less than the allowable stress. No need to identify or list these conditions.

Based on the user's responses to "condition" questions, the following will justify "Not Capable" or "Marginal" response and will be identified as follows:

- Non-compliant FRA track across the bridge - Not Capable.
- Rail size of 115# or greater is Acceptable: 90# or less is Not Capable; and rail between 90# and 115# is Marginal.
- Ties are not anchored to tie spacers or stringers - Not Capable.
- Any deck condition noted as a four to be Marginal, or five to be Not Capable
- Stringers with less than three inches of end bearing on a cap - Not Capable.
- If there are two secondary caps (making three caps: primary and two secondary) - Not Capable.
- Shims: More than three inches high and three or more separate shims at the stringers/caps - Not Capable.
- If track shims are greater than 1/2-inch - Not Capable.
- Void (gap) greater than 1/4 inch between the cap and any pile - Not Capable.
- Piles with an outside shell thickness less than 1.5 inches. - Not Capable.
- Any bridge with a three-pile bent - Not Capable.
- Any rating condition entered as a four will be listed as Marginal.
- Any rating condition entered as a five will be listed as Not Capable.
- Erosion or scour condition as "Progressive," will be listed as Marginal.
- Erosion or scour condition as "Serious" will be listed as Not Capable.
- If the stringers are noted as being framed with square notches, a rating of Marginal will be issued. However, if the horizontal shear stress of the stringers is within 15 percent of allowable, this will cause a Not Capable listing.
- Any bent with two adjacent piles that have been posted, or if there are three or more posted piles, it will be rated as Not Capable.

"Any bridge with a bent height (top of tie to ground line) greater than 30 feet requires detailed inspection by an experienced inspector to verify condition and compliance," Horney said.□