TIMBER BRIDGE DECKS

Comparison of Types, and Evolution of Design

Kenneth A. Johnson, P.E.

INTRODUCTION

Currently there are about 45,000 Treated Timber Bridges in the National Bridge Inventory (NBI). The largest proportion of these are longitudinal timber slab span structures. There are numerous reasons why this is the case. That population of longitudinal treated timber slab span structures contains four distinct deck designs.

The purpose of this paper is to discuss several aspects of these designs. These bridges can categorized as follows:

- Nail-Laminated
- Dowel-Laminated
- Glued-Laminated
- Stress-Laminated.

This type of bridge construction can be described as a structural system where the elements or components span from substructure support to substructure support and form both the deck and the main longitudinal support system for the vehicle loads. These decks do not have longitudinal stringers supporting them. See Figure No. 1 for the nomenclature of the major components of Longitudinal Slab Span Bridges.

There is some confusion and misrepresentation concerning the characteristics, performance, and relative merit of these different deck systems. Wheeler Consolidated, Inc. has been in the Treated Timber Bridge Business since 1892 and is the only timber bridge company that has actually designed and produced all four different styles of longitudinal slab span deck systems. From the vantage point of over 110 years of experience in the timber bridge industry, and of having produced thousands of treated timber structures, we feel it is important, in fact our obligation, to address all the confusion surrounding slab span timber structures.

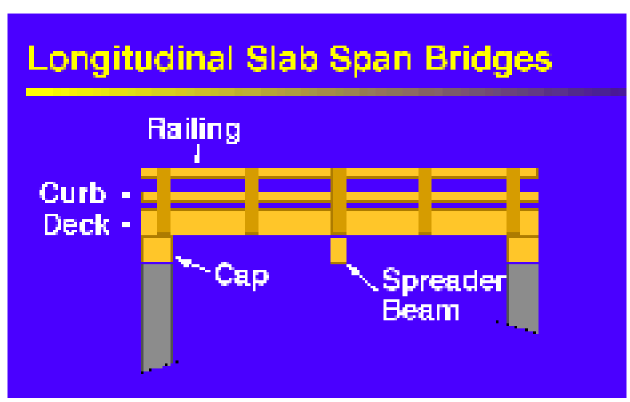


Figure No. 1 - Illustration of the major components of a Longitudinal Slab-Span bridge identified.

Kenneth A. Johnson, P.E.
April 10, 2002

TIMBER BRIDGE DECKS

EVOLUTION OF SLAB SPAN DECKS

The first timber bridges had longitudinal stringers with transverse timber decking. The purpose of the deck was to provide a surface to support the loads and distribute those loads to adjacent stringers. The very early bridges used round logs for stringers and round poles for decking with some earthen cover for the wearing surface. See Photograph No. 1 for view of a typical early bridge constructed with round members. As solid sawn lumber material became available, it was used to replace the round poles for the decking. Gradually the round log stringers were replaced with solid sawn timbers.

Photograph No. 1 - A typical bridge build in the early 1900's constructed with native untreated round members for both stringers and deck.

As horses and wagons gave way to cars and trucks the demands placed on the bridge components grew. Likewise, as the early trucks were replaced with larger and larger trucks the deck systems changed. Most of the material used in the early bridges was native untreated poles and logs. As the vehicle loads increased both in number and size, there was a shift from native timbers to species with higher strength properties and also to the use of preservative treatment. The dominate specie used was Coastal Region Douglas Fir, the use of which was influenced by the availability of low cost, large, solid sawn timbers. Typical stringer sizes were 8 inches by 22 inches in lengths up to 48 feet.

The first timber decks employing solid sawn material involved transverse deck planks. The typical thickness was 3 inches. The design of these plank decks was based on the assumption that each wheel load was supported by a single plank. As larger stringers became more readily available, the stringer spacing was increased so as to utilize deck planks of 4 inches or more in thickness. The design of the plank deck was subsequently modified using the Timber Strip Deck to increase efficiency of the larger stringer and wider stringer spacing. See Photographs No. 2 & 3 for details of typical bridges with large solid sawn stringers and a Nailed-Laminated Transverse Deck.

Photograph No. 2 - This bridge is typical of many of the bridges constructed near the middle of the 1900's, and were built with large solid sawn timber stringers with a Transverse Nail-laminated Deck.

This deck consisted of 3 inch thick members, 4 to 6 inches in width, placed on edge transversely cross the width of the bridge. Sometimes 2 inch dimension lumber was used for this design. The strips were then nailed to each other with 20 penny (d) spikes. This deck was attached to the solid sawn stringers with "toe-nails" placed at a given pattern. The design of this type of timber deck was called a "Nail-Laminated

Photograph No. 3 - The primary design variables for stringers bridges are the stringer size and spacing. As the availability of large solid sawn stringers declined the stringer spacing became less and less and eventually the Longitudinal Nail-Laminated deck was born.

Deck." As the width of our roads and bridges increased, a system of staggered butt-joints were used with each butt-joint over a stringer.

This deck was considered a "Continuous Nail-Laminated Deck" as there were no transverse joints between large components. The timber deck was idealized to be a continuous beam over the stringers with a width, in the direction of traffic, of 15 inches plus the thickness of the deck itself. The width of the wheel was defined by AASTHO 3.25.1. The wheel load for the design of this type of deck, for AASHTO HS-20, is 12,000 pounds, which has a width of 17.32 inches.

The timber deck in this design does not provide any additional longitudinal strength to the longitudinal stringers since it only distributes the wheel loads and adds dead load. This deck system enjoyed it greatest use in the late 1940's through the 1960's. However, as the loads continued to increase in both size and number, there was a corresponding decrease in the commercial availability of large solid sawn stringers. The smaller stringer sizes available required a reduction in the average stringer spacing. It didn't take long for engineers to realize that by letting the spacing between the stringers go to zero, they could eliminate the transverse deck. Thus was born the **"Nail-Laminated Longitudinal Slab Span Deck."**

NAIL-LAMINATED DECK

This transformation in deck design represented a major development in the modern timber bridge. This design consisted of 2 to 3 inch thick treated planks with widths from 8 inches to 14 inches. Planks were placed on edge and nailed to each other with nails that penetrate, in most cases, only one and one-half laminates. See Figure No. 2 for a partial cross section of a Nail-Laminated Deck. See Photograph No. 4 for a view of early Nail-Laminated Deck Bridge. The nailing pattern called for nails spaced at 6 to 9 inches, depending on the depth of the deck, and were placed alternately near the top and bottom of the laminate. All of the nailing was done in the field. You can imagine standing on the bridge deck, driving nails laterally into the deck, below where you are standing. It was extremely hard, back-breaking work.

Quality control in the construction of these bridges was a major problem, due to the tendency of construction crews to not place all of the nails required for good load transfer. However, those bridges which were constructed as designed performed very well. Thousands of these structures were built in the 1950's and 60's, many of which are still performing today.

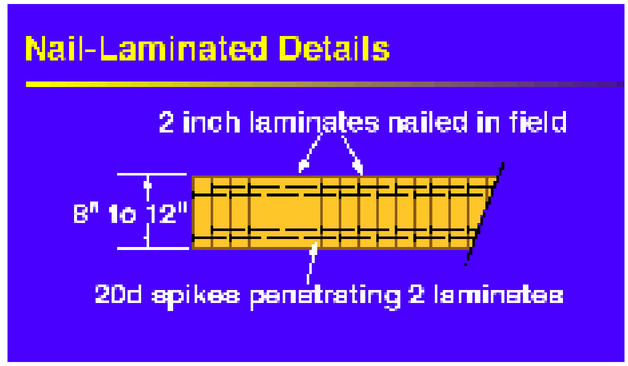


Figure No. 2 - Nail-Laminated Longitudinal Decks were nailed n the field using dimension lumber generally 2 inches in thickness and from 8 inches to 12 inches in width. There was no predrilling of holes prior to treatment of the material.

Photograph No. 4 - Typical three-span Longitudinal Nail-Laminated timber bridge with timber substructures. This one has spans of 20 feet with a 24 foot roadway and the deck thickness is 12 inches.

The AASHTO approved design of this type of deck was based on idealizing the deck to be a beam the depth of the deck, the width assumed to be the width of the tire plus the thickness of the deck itself. These bridges generally had a transverse spreader beam at mid-span. The spreader beam was commonly 6 inches by 12 inches made of the same specie and stress grade of the deck material. The spreader beams had a minimum EI of 1,555,200 kip-in^2. Those bridges of this style normally had every tenth plank continuous over the support. This was occasionally incorrectly interpreted as an effort to create some amount of continuous action over the support. This practice was intended only to help hold the two adjacent deck spans together.

One of the unfortunate characteristics of this type of bridge was that all of the laminates did not bear uniformly on the spreader beam, this was due to the nature of field construction. Due to the very nature of solid sawn timbers, very few were perfectly straight. See Photograph No. 5 for a close-up view of the underside of a Nail-Laminated Deck and transverse spreader beam. The laminates were placed individually, with the instruction to place all members with any curvature up. This resulted in a condition where all of the laminates were supported uniformly on the substructure caps, but did not provide a smooth uniform surface at mid-span on the bottom side of the deck, where the spreader was located. Those planks not bearing on the spreader beam assumed a disproportionate share of the imposed load. This in turn cause excessive stress on the nails transferring the loads to the adjacent laminates and resulted in the crushing of wood fibers reducing the load transferring ability.

Photograph No. 5 - Shown is one of the major design flaws of the field constructed Nail-Laminated bridges. All of the individual laminates do not bear on the Spreader Beam. Under load those laminates deflect down to the spreader beam causing crushing of wood fibers around the nails resulting in loss of load sharing.

The engineers at Wheeler looked for ways to make the bridge easier to erect in the field and to help make the spreader beam more effective. The design that evolved addressed both concerns. The solution was to prefabricate the deck sections in the shop making the bottom surface of the panels smooth and even at mid-span. The resulting product evolved into the **"Wheeler Dowel-Laminated Panel-lam Deck System."**

DOWEL-LAMINATED DECKS

The development of the Wheeler Dowel-Laminated Panel-lam Deck System started in the early 1970's. It is properly called a Dowel-Laminated Deck System, but sometimes is referred to as a "Spike-Laminated Deck." The concept was to produce a system of deck panels that could be easily placed in the field and one that would be superior to the Nail-Laminated System in load capacity. See Photograph No. 6 for close-up of a Wheeler Dowel-Laminated Deck Panel.

Photograph No. 6 - Shown is a newly manufactured Dowel-Laminated Deck Panel which is smooth on the bottom surface as all of the variation in plank depth is in the top surface, also shown is the top half of the Ship-Lap Joint which connects the panels to each other.

Wheeler designed and constructed the manufacturing facilities necessary to produce a truly "Manufactured Product." Cutting and drilling of the timbers would be done prior to preservative treatment. See Photograph No. 7 for view of drilling machine. The thickness of the individual laminates was increased to 4 inches to minimize the number of pieces to be handled in the manufacturing process. The individual laminates are passed through a timber sizer so as to produce laminates of a uniform thickness, normally 3.875 inches. This is necessary to produce panels of uniform width over their entire length.

The connecting hardware was also changed to provide better load distribution among the laminates. Special "Ring-Shank Dowels" 3/8 inch in diameter and 15 1/2 inches in length were manufactured for this purpose. The word "Dowel" means a cylindrical fastener that penetrates multiple laminates. The Dowels in the Wheeler Panel-lam System penetrate four laminates. See Figure No. 3 for a partial cross section of a Dowel-Laminated Deck. The pattern of the Dowels - function of the span length, design load, and deck thickness - involves two lines of Dowels, one near the top of the laminate and the other near the bottom, spaced at one foot. Longer spans may utilize three rows of dowels placed at one foot centers.

Photograph No. 7 - This is a view of the assemble line at the Wheeler Consolidated's bridge manufacturing facility showing the Gang-Drill which drills all of the holes for the Dowel Connectors. All drilling is done prior to treatment.

The laminates are assembled, after preservative treatment, into panels approximately 7 feet in width. The actual width of the panels is a function of the width of the structure, but in no case does the width of the panel exceed the width that can be easily shipped via trucks without special permits.

The panel are created in a large hydraulic press where the individual laminates are installed in pairs. See Photograph No. 8 for view of panel press. All of the steel dowels for two laminates are inserted simultaneously. The press has provisions for creating approximately 1 inch of camber in the panel. This camber is not intended to off-set dead load deflection, rather it is the result of a system that produces a panel that not only bears uniformly on the ends, but also is smooth and even at mid-span so that all laminates bear uniformly on the spreader beam. The manufacturing process developed by Wheeler can produce panels of any width, any angle of skew and any length up to about 70 feet.

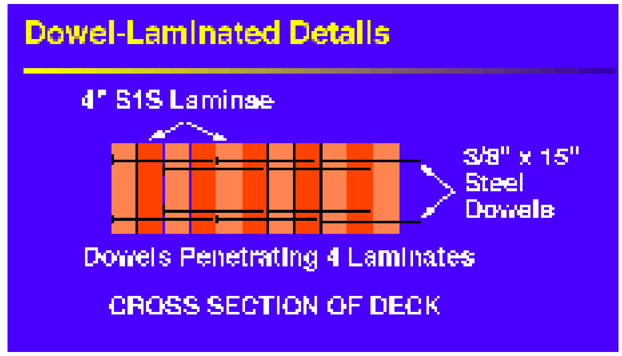
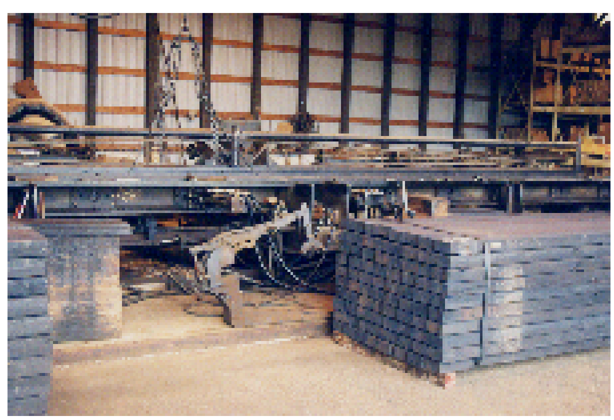


Figure No. 3 - The Dowel-Laminated Deck System consists of Laminates that are 4 inches in thickness and range from 8 inches to 18 inches in depth. They are connected with steel Dowels that are installed in a hydraulic press.

The panels are connected to each other in the field by means of a Longitudinal Ship-Lap Joint. This joint consists of a half-laminate attached to the bottom half of the side of one panel. The other half-laminate is attached to the top half of the side of the adjacent panel. These half-laminates are attached to the panels in the shop. See Figure No. 4 for a detail of the Ship-Lap Joint used with the Dowel-Laminated Deck System. See Photograph No. 9 showing a Dowel-Laminated Deck Panel being place. Dome-head drive spikes are then driven down vertically to connect the two half-laminates to complete the joint. A spreader beam for each span is installed at mid-span. Longer spans, over 32 feet, may have multiple spreader beams. The minimum size of the spreader beam is 6 inches by 12 inches, with the 12 inch dimension vertical. Just like the spreader beams for the nail-laminated decks, these spreader beams have a



Photograph No. 8 - This is view of the hydraulic press used at Wheeler's plant to manufacture Dowel-Laminated Deck Panels that have a smooth surface on the under side.

minimum EI of 1,555,200 kip-in^2. The spreader beams are attached with 3/4 inch diameter dome-head bolts through the deck. The bolts attaching the spreader beam are placed in the pre-drilled holes which previously held eye-bolts used to lift the panels.

The purpose of the spreader beam, for Panel-Lams, is to increase the lateral distribution of wheel loads to a wider portion of the deck. It does this by increasing the transverse stiffness of the deck system, requiring much larger size of the spreader beam, than the stiffener beams used in glulam deck system. The purpose of "stiffener beams" used in glulam deck systems is to resist inter-panel shear, hence the much smaller size with a minimum EI of 80,000 kip-in^2. The stiffness of the spreader beams used for Wheeler's Panel-Lam Decks are about 19 times stiffer than the stiffener beams in the Glulam System.

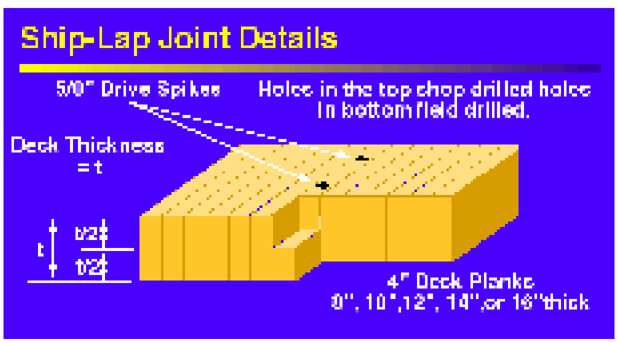


Figure No. 4 - Shown are the details of the Ship-Lap Joint that is used to connect adjacent deck panels. The spacing of the vertical Drive Spikes is designed to create composite action of the two half-planks used in the Ship-Lap Joint. Single-Member bending resistance is achieved.

The design algorithm approved by AASHTO for this type of bridge has undergone some changes over the years. Initially, when Wheeler first introduced its Dowel-Laminated Panel-Lam Deck System, the deck was idealized as a beam the depth of which was equal to the deck thickness and the width of the beam was assumed to be the width of the tire plus one thickness of the deck. This was the same distribution width used for Nail-Laminated decks. However, after the construction of a few of these new bridges it was very apparent that this deck system offered greater load distribution over the old Nail-Laminated design.

Wheeler conducted full-scale tests of this system to validate the load sharing properties of

Photograph No. 9 - Construction of a Dowel-Laminated Longitudinal Slab-Span Bridge is shown. The bottom half of the Ship-Lap Joint Plank can be seen. The Spreader Beam is connected to the completed deck using the holes for the lifting eye-bolts.

the deck and to test the Ship-Lap Joint. This testing was conducted in the spring of 1978 at its Cass Lake Bridge Fabrication Plant. The testing was supervised and observed by Twin City Testing, Inc., a independent material testing and engineering firm. Numerous load tests were performed on various aspects of a full-scale bridge. The analytical results of the tests were presented at the 1980 meeting of the AASHTO Timber Bridge Committee. That Committee accepted the results and presented it to the full AASHTO Bridge Committee which approved a change in their Standard Bridge Specifications to increase the distribution width for timber decks as manufactured by Wheeler. The change allowed the width of the idealized beam to the width of the tire and twice the thickness of the deck. See Figure No. 5 for illustration of the Distribution Width used for

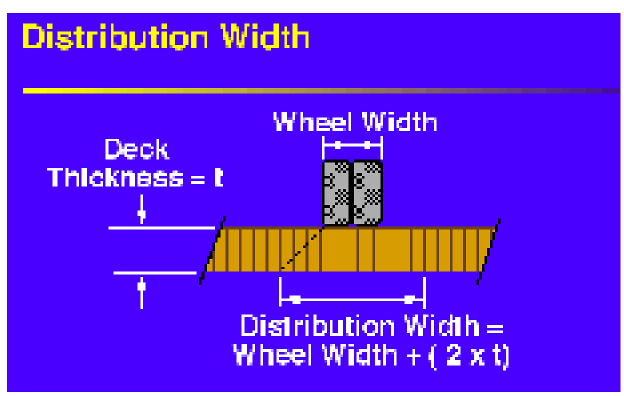


Figure No. 5 - The structural analysis of the Dowel-Laminated Deck System is based on the idealization of a longitudinal beam the width of which is defined by the Distribution Width.

the design of Dowel-Laminated Decks. This change was predicated on the conditions of the full-scale tests conducted by Wheeler. Those conditions included a 6 inch by 12 inch spreader beam at mid span and a Ship-Lap Joint between panels.

Thousands of bridges utilizing this design have been built across thenation. See Photograph No. 10 for a typical Dowel-Laminated Longitudinal Slab Span Bridge. These structures have a number of very positive attributes that may be overlooked as they perform their function decade after decade.

Photograph No. 10 - This is a typical three-span Dowel-Laminated Longitudinal Slab-Span Bridge. This bridge has a Crash-Tested Railing.

Some of these advantages are subtle and may be only appreciated by bridge engineers. The entire system is very redundant as there are numerous longitudinal members with massive load sharing, to the point where the weakest member no longer defines the system's strength. Coupled with the use of many ductile fasteners creates a system with thousands of load paths, the weakest member does not determine the strength of the system. Additional, the fact that each of the individual laminates are treated after all of the cutting and drilling is done and prior to assembly into panels is a major advantage. The panels are somewhat analogous to ships with many water-tight bulkheads, a breach in one of them does not imperil the entire panel. The completed panels have a much higher percentage of the entire volume impregnated by the preservative than most other types of timber deck panels.

The manner in which the panels are assembled creates an upper surface that is ideally suited to receive a bituminous wearing surface. By manufacturing a panel with the bottom surface smooth, all of the variance in size in the depth of the individual laminates occurs in the top surface, thus creating many gripping surfaces for the bituminous mixture.

Another feature is the fact that the panels are produced in widths almost twice as wide as other types of panels, producing decks with less total linear feet of joints where possible reflection cracking of the asphalt may occur.

An example would be a typical 100 foot long, 4 span bridge with a 24 foot roadway. The Dowel-Laminated bridge would be constructed with 4 panel wide with three joints for a total longitudinal joint length of 300 feet. While the same example bridge, constructed with Glulam Panels, would be 6 panels wide with 5 joints for a total longitudinal joint length of 500 feet.

In an attempt to minimize joints, some of the more recent Glulam Designs, have specified panel lengths that span two spans. In the example bridge above, a Glulam design would have one transverse joint of 24 feet, while the Dowel-Laminated would still have three transverse joints for a total of 72 feet. Therefore, the combined joint lengths for the Dowel-Laminated bridge would be 372 feet, while the Glulam bridge would be 524 feet, this results in approximately 40% more the length of joints than the Dowel-Laminated System.

Perhaps more importantly, is the fact that the Dowel-Laminated Panels have a direct mechanical connection using a ship-lap joint within the panels themselves, whereas the Glulam Panels are only supported at a couple of point along the length of the span.

GLUED-LAMINATED PANELS

Longitudinal timber bridge deck systems utilizing Glued-Laminated Panels were developed in the 1970's by U.S. Forest Service at the Forest Products Laboratory at Madison, Wisconsin. The panels used were generally 4 feet in width and could contain multiple piece laminates on the deeper deck sections. The width of the panels is restricted due to the limiting size of treating cylinders. The major design problem to be overcome was found to be the transfer of shear between adjacent panels.

A number of different schemes for shear transfer were investigated. They included tongueand-groove joints, splines, and steel dowels. Early work seemed to favor the use of steel dowels as the most effective vertical shear transfer mechanism. This is one example of an idea that looked good on paper, but doesn't work as intended in reality. If the panels and the holes for the steel dowels are fabricated with tolerances necessary for the shear transfer to occur without undo differential panel deflection, the dowels cannot be installed. If the holes for the dowels are drilled with sufficient oversize to allow for construction, the shear transfer is not achieved without differential movement. Other investigation were started to find a substitute for the steel dowels.

Early in the 1980's research was conducted by W.W. Sanders at Iowa State University at Ames, Iowa, investigating the use of transverse members under the deck, called "Stiffener Beams", to resist inter panel shear and to replace these dowels. These stiffeners are relatively small members, typically about 4 inches by 6 inches and can be attached to the underside of the deck in a number of ways. Normally there is one Stiffener Beam at mid-span, and others spaced not to exceed 10 feet. These Stiffener Beams normally have an EI of 80,000 kip-in^2, and must not be confused with the much larger spreader beams used with the dowel laminated system.

The design of this type of deck system is based on the determination of a Load Fraction, which is the portion of a wheelline load assumed to be carried by an individual panel. The Load Fraction is a function of the width of the panel, the span length and the number of lanes of traffic.

The Glulam Panels used for this type of deck are normally treated after gluing. The preservative envelope is therefore restricted to only the perimeter of the panel, unlike the Dowel-Laminated Panels where each individual laminate is treated prior to assembly into panels. As such Glulam Panels have a much lower percentage of their total volume of material impregnated with preservative. Long-term durability and serviceability are directly related to the amount of preservative in a component. The Glulam panels have relatively smooth surfaces and do not provide good adhesion for the asphalt mixture.

Unfortunately, Glulam Deck Panels tend to assume an "hour-glass" shape due to greater moisture absorption through the end grain at the ends of the panels. This is in part due to the fact that the moisture content of the lumber material going into the panel is at a much lower moisture content than the equilibrium moisture content of the completed panel prior to installation in the bridge.

Some timber bridges lend themselves to continuous spans. Having deck panels that are continuous over three or more supports may offer some advantages over simple spans. However, the suggestion that Continuous Glulam Panels eliminate a transverse crack in the bituminous wearing surface over the intermediate support is not always true. There may develop tension cracks over the intermediate support. Additionally, the connections of the ends of continuous deck panels must be designed to withstand repetitive up-lift loads resulting from the negative moment over the middle support.

STRESS-LAMINATED DECKS

Stress-Lamination is a construction technique originally developed by the Ontario Ministry of Transportation and Communication for fabricating large structural components using shorter-than-span-length timbers and high-strength rods. The basic concept is to achieve load-transfer between individual members by the friction force induced by normal pressure created by post-tensioning of transverse rods. See Figure No. 6 for a partial cross section of a Stress-Laminated Deck.

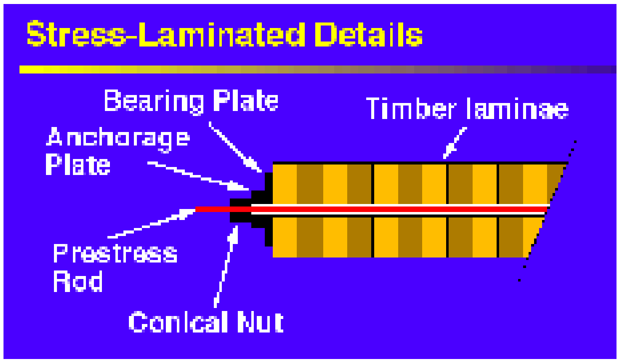


Figure No. 6 - This is the most commonly used anchorage system used for Stress-Laminated Bridges in the U.S.

Wheeler was the very first Company or Public Agency to investigate the application of this system to highway bridges in the United States. Starting in 1985, Wheeler funded research by M. G. Oliva at the University of Wisconsin, at Madison, Wisconsin on the application of this structural system to aspects unique to the United State's bridge market.

Based on the results achieved by Professor Oliva, Wheeler Consolidated designed and furnished the first Stressed-Laminated Timber Bridge in the U.S. The bridge was constructed in February of 1986 in Cook County, Minnesota, on the Gunflint Trail Road.

The basic design of this type of bridge consists of solid sawn members 2 to 4 inches in thickness and from 8 inches to 16 inches in depth, with lengths generally less than 20 feet. A typical layout of the laminates has a pattern of butt joints that repeats itself every four laminates. Hole are drilled in the laminates at some interval, generally 2 or 4 feet. See Photograph No. 11 for a view of the construction of a Stress-Laminated Bridge. High strength steel rods (150 ksi) are placed in the holes with suitable anchorage plates at each end of the rods. The rods are then tensioned with a hollow core hydraulic jack. Sufficient tension is imparted to each rod so as to create approximately 100 psi pressure between all interfaces of all laminates.

Due to the large amount of creep in the wood under compression, the tension in the rods must be reestablished several times in order to ensure sufficient long-tern friction forces exist within the deck system. The level of long-term stress in the system is a function of a number of factors, some of which are not well understood.

Photograph No. 11 - A construction scene of a Stress-Laminated bridge. High-strength steel rods are placed transverse to the laminates which have been predrilled. The rods are stressed with a hollow core hydraulic jack.

The system does offer some advantages over the other deck systems discussed. For example, it is very efficient in creating the load sharing amongst the laminates. However it does not increase stiffness and consequently the controlling criteria for these decks is generally live load deflection. Also, even with outstanding strength characteristics, these systems have not proved to be very cost effective. This coupled with the concern over the loss of stress over time, are major deterrences to the use of these systems. Wheeler is currently not recommending this type of design to it's clients. Research work on this system continues and perhaps someday this design will be a viable alternative.

CONCLUSIONS

This paper begain with the description of four different timber deck systems. Experience has indicated that of these four designs, only two systems have the minimum attributes to rise to the level necessary for serious consideration for use in todays bridges. Those two systems are:

- Dowel-Laminated
- Glued-Laminated.

These two deck systems, while performing the same basic function within the bridge, are quite different in several important aspects that impact their performance. This discussion will not focus on those aspects of Slab Span Bridges in general that make them attractive for sites with certain requirements, such as low head-room.

A very important difference between these two systems is the amount of wood actually impregnated with a preservative. As previously stated, the Dowel-Laminated Deck Panels have a much higher proportion of their volume actually containing the wood preservative. Again, durability of treated timber components is directly related to the amount of active preservative in the component.

Following in importance, is the amount of both longitudinal and transverse joints between panels. Again, the Dowel-Laminated Panels offer superior performance in that they are are supplied in much wider widths resulting in less total length of joints. This occurs even where there might be an opportunity for glulam panels to be continuous over a pier. Moreover, the Dowel-Laminated Panels are directly connected to each other by the Ship-Lap Joint.

Probably the next most significant characteristic is the adhesion of the bituminous mixture to the deck surface. Dowel-Laminated deck panels offer an excellent surface for the wearing course to adhere. Obviously there are additional areas that could be pointed to as differences favoring one or the other, but these are the differences that dictate long-term performance and serviceability. In addition to physical differences listed above, there is usually a cost savings of the dowel-laminated system over the glulam system.

I am confident that when the facts about Timber Deck Systems now available to bridge designers and owners are reviewed, the Wheeler Dowel-Laminated Panel-Lam Bridge Deck System will be the Deck System of choice. See Photographs No. 12 - 15 for examples of the range of bridges using Wheeler Components. We also want our clients to know that we are continuing to look for ways to improve our bridges. Wheeler is currently supporting research at the University of Minnesota by H. Stolarski, who is currently developing an analytical model of the Dowel-Laminated Deck System. Bridge engineers will be able to use the analytical tools being developed by Professor Stolarski to design for longitudinal stiffness of the deck by changing the size and number of transverse spreader beams. Additionally, we at Wheeler are constantly in touch with both owner and contractors to find better ways of designing and building bridges. We are concerned that the high quality and close tolerances in our manufacturering are reflected in the ease of installation and the final product.

Photograph No. 12 - Here is a typical urban setting for a Dowel-Laminated structure. This bridge has a sidewalk on one side that also contains a utility chase.

Photograph No. 13 -- This is a Three-Pin Arch with a span of 120 feet. The deck system consists of transverse floor beams spaced at 20 feet and Dowel-Laminated Longitudinal Deck Panels spanning between the floor beams. This bridge carries two sidewalks and several utilities.