Section Ten
Timber

10.1 Introduction

Timber is an abundant and renewable resource. It can be used by itself or in conjunction with other construction materials such as concrete and steel for the construction of bridges.

By using different types of construction techniques, timber can be used for a wide range of bridge spans. From a small stream crossing to an intricate long trestle, timber is a viable construction material. When and where timber should be considered for use as a possible bridge construction material requires an engineering evaluation of each site. First costs may be of great importance, but constructability, durability and compatibility with given site conditions is required when considering timber as a possible bridge construction material.

Prior to starting design, the U.S. Forest Service Publication entitled *Timber Bridges - Design, Construction, Inspection and Maintenance* should be reviewed.

10.2 Characteristics and Properties of Wood as a Construction Material

Timber is relatively strong, light in weight, resilient and capable of supporting short-term overloads without sustaining permanent structural damage. Construction of timber structures is not affected by inclement weather conditions such as rain and cold and usually can be accomplished without the use of heavy equipment and highly skilled labor.

The material properties of wood make it unsusceptible to damage resulting from freeze/thaw cycles and de-icing chemicals. Large wood members also offer a surprising resilience to damage by fire. Today's treated lumber provides a material that is highly resistant to decay, rot and attack by insects. Properly treated and maintained timber structures can be expected to provide a design life of 50 years or more. Treated timber does not have to be painted. Minor periodic maintenance such as the washing and removal of moisture laden debris from the timber elements will greatly increase their life expectancy.

10.3 Types of Construction

Timber bridges can be made entirely from wood or be a composite design utilizing other materials such as reinforced concrete and steel. Both superstructures and substructures can be made of wood in all or in part. The size and type of a structure will determine whether it is made of individual commercial sized pieces of lumber or of laminated units utilizing many pieces.
Glue-laminated (GLULAM) timber units first appeared in the late 1940s or early 1950s. Glulam members can be made into almost any size and shape unit. In recent years, improvements in the lamination process and adhesives have increased the potential for use in highway bridge design. In the late 1970s, stress-laminated procedures were developed in Ontario, Canada, as a new method of bridge construction. During the late 80s and early 90s, several installations and additional research have been conducted in the United States, using stress-laminated construction.

### 10.4 Selection Criteria

The criteria used to determine if the use of a timber bridge is appropriate are the same used for all bridge types. However, due to some preconceived notions on durability, the first selection criterion is the acceptance of a timber bridge by the owner. Concerns for fire resistance, rot, decay, insect attacks and long-term durability must be satisfied. All of these concerns can be adequately addressed, but the final decision belongs to the owner of the bridge.

With the acceptance of timber, the following site conditions are considered:

- The length of the bridge and the span arrangement
- Available depth for the superstructure
- Debris and ice problems
- Aesthetics
- Type of roadway
- Traffic volumes and operating speeds
- Alignment and grade of the roadway
- Construction procedures

Generally, the depth of a timber unit for any span would be deeper than a composite steel or prestressed concrete bridge. Span length limitations would also require the use of multiple spans for long bridges. When the profile requires camber corrections, timber can be cambered to some extent. Wood structures blend nicely with the site and a variety of shapes and forms can be provided. Like its steel and concrete counterparts, the fabrication of a timber arch, truss or other special type structure will involve additional costs. Due to the smaller size and weight of normal timber units, the construction of a timber bridge may be accomplished with the equipment and personnel that many town and county highway departments have available.

The various criteria and procedures previously outlined in Section 2 and Section 3 should be used to evaluate any site. If timber can meet the site criteria and is acceptable to the owner, it should be considered as an option.

If the final decision is based on first costs, a superstructure cost savings of approximately 25% over a concrete or steel structure can be expected. The use of a concrete substructure is recommended. Only minor substructure cost savings should be expected between alternates involving steel, concrete, or timber multibeam, single-span installations.
10.5 Superstructure Components

10.5.1 General

Timber can be used by itself or as a component of a bridge system. It can play a major or minor role. The use of timber in the superstructure can range from a timber railing system to a laminated arch with a timber deck design. Depending on span lengths and the allowable depths for the superstructure, a variety of timber and timber composite systems can be employed.

10.5.2 Railing

Timber bridge railing is a viable option when a rustic aesthetic look is desired. It is particularly recommended for use on all highways, except interstates, in the Adirondack and Catskill Parks.

10.5.3 Decking and Deck Bridges

Timber decking can employ four types of laminated construction:

- Nail-laminated plank decks
- Nail-laminated deck panels with interconnecting transverse stiffener beams
- Glue-laminated deck panels (doweled and undoweled)
- Stress-laminated decks

Except for stress laminated decks, the lamination can be placed either transversely or longitudinally depending upon the span and/or support configuration. Longitudinal deck panel bridge spans are limited by the depth available for the section. Stress-laminated longitudinal decks are efficient up to about a span of 12 m.

Nail- and glue-laminated deck panels can be placed on top of glue-laminated girders and steel wide flange beams. These panels can also be placed on a stringer/floorbeam support system for the deck of a wood, iron or steel truss.

10.5.4 Laminated Beam Sections

Glue-laminated rectangular shaped beams ranging in depths from 0.5 m to 1.8 m are capable of spans approaching 25 m. Stress laminated parallel chord trusses, “Ts” and box sections can span the same range with the advantage of shallower section depths (see Figure 10.1 thru Figure 10.4 for typical stress-laminated sections).
Figure 10.1
Longitudinal Stress Laminated Deck

Figure 10.2
Parallel Chord Truss
Figure 10.3
'T' Section Bridge

Figure 10.4
Box Section Bridge
10.5.5 Special Types: Arches, Frames and Trusses

Large glue laminated units can be fabricated into numerous shapes. Through and deck arches, rigid frames and deck trusses or covered bridge thru trusses are the most familiar types of large timber designs. The fabrication of trusses or trestles can also be accomplished using small commercial-sized lumber and steel bolt and plate connections.

10.5.6 Timber Decks with Steel Beams

When using any type of steel beam, especially weathering steel beams, it is important to protect these members from extended periods of contact with moisture. Without adequate protection, timber decking can act as a source of moisture.

To provide protection for bridges using timber decking with steel girders, the top flange of all steel girders supporting a timber deck should be isolated from the timber decking. This can be done by placing a strip of waterproof membrane material on the top and over the sides of the top flange. Tar paper is less durable, but an acceptable alternative. It is also recommended that the entire top flange of all girders be painted or galvanized.

In addition to isolating the top flange from the decking, it is also recommended that some type of waterproof membrane be placed between any asphalt wearing surface and the timber deck. This membrane should extend over the fascia sides for a short distance (~25 mm) below the bottom of the deck. This membrane should also extend beyond the ends of the bridge into the approach fills.

Details concerning the most appropriate type of membrane for these uses should be obtained from the Materials Bureau.

10.6 Substructures

For the majority of cases, the use of a concrete substructure is encouraged. Since the vast majority of timber structures will cross water, the soil interface zone will be subjected to continuous cycles of wetting and drying and should be considered a hostile area for wood.

Timber sheeting and timber piles with lagging walls, either tied or untied, are the typical types of timber substructure construction. Constructability, first cost and life-cycle costs are factors that must be considered prior to selecting a type of substructure.

Timber piling can also be used, but the use of these piles in a zone of wetting and drying cycles is undesirable. Areas likely to contain marine borers and other types of wood destroying fungi should also be avoided. Wood pile bents can be protected to some degree by using protective sleeves in the trouble area. Timber piling installed in an area where it has been constantly wet is often found to be in good condition after many years of service. Prior to reusing existing timber piles, a test pit should be dug to gain access to evaluate their condition.
10.7 Wearing Surfaces

Timber bridge deck installations that are to be used as a permanent deck system must be protected from the abrasive wearing action of the traffic it carries. Traffic must also be provided with a skid resistant roadway surface, and a transverse cross sloped surface for drainage. The use of a wearing surface serves these important functions.

The type of wearing surface used will often depend on the class of roadway and the traffic volume. The range varies from full-width asphalt pavements to single lane timber plank longitudinal strips. The use of a full width asphalt wearing surface with a geotextile membrane adjacent to the deck is recommended for the majority of cases. A minimum thickness of 50 mm is recommended for the asphalt wearing course. A low-volume, single-lane bridge would be considered as a possible candidate for the strip plank treatment.

10.8 Maintenance and Repairs

Maintenance of a timber bridge will require procedures that are unique to wood. With timber structures, maintenance starts with the proper treatment of the wood. If possible, all fabrication and installation details requiring drilling should be done prior to treating the wood with preservatives. An in-place application of preservatives to problem areas should also be continued throughout the life of the structure. Checks, splits and damaged areas should be treated as soon as possible. Field drilled holes should be treated with preservatives before installing bolts and other hardware.

Moisture is the chief enemy of wood. Design details that trap moisture on the bridge should be avoided. Periodic washing will eliminate dirt and debris that hold moisture. A protective wearing surface and the maintenance of this surface are important.

Deterioration caught early can be treated, controlled or eliminated. Splicing of members, in-field drilling and treatment with preservatives, the installation of protective jackets or component replacement are ways of dealing with problems. Delayed maintenance will only lead to further deterioration and the need for early repairs or replacement.

10.9 Conclusions

Timber is a versatile, economical and adaptable material that provides an alternative solution for a bridge repair and replacement program. It is an effective and economical answer for bridges with spans of 25 m and less where vertical clearance is not a problem. Variations in timber bridge designs can address, to some extent, vertical clearance limitations. Timber bridges can be aesthetically pleasing and simple to construct. When properly maintained they can be expected to last for 50 years or more.