Timber Bridges in South America

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Abstract

Timber bridges in South America predate the 19th century. This paper provides an introduction of the many types of timber bridges currently used in South America. The five basic types used, which are, the longitudinal beam, frame, truss, arch and suspension superstructures, are presented. Research on new bridge designs, using tropical and reforestation wood species, has been developed in the Laboratory of Wood and Timber Structures, Sao Paulo University in Brazil, on prestressed timber bridge and decks composed with two diagonal layers of sawn wood connected with wood dowels over composed longitudinal beams. We will construct the first prestressed timber bridge in South America in this year using Eucalyptus Citriodora specie.

Keywords: timber, briges, South America, Brazil

Introduction

This paper provides an introduction to the many types of timber bridges currently used in South America. Although decks are technically part of the superstructure, they are addressed separately because of their varied application on many superstructures types.

Beam Superstructures

Longitudinal beams superstructures are the simplest and most common timber bridge type and consist of a deck system supported by a series of timber beams between two or more supports. Bridge beams are constructed from logs and sawn lumber, single or composite elements.

Log Beams

The simplest type of timber bridge in South America is the log beam. It is constructed by placing round logs alternately tip and butt sections. The span of log beam is limited to sizes and truck loads. The clear span of 5 to 12 meters are most common (Figure 1).

In order to support high truck loads, LaMEM developed a longitudinal beam with composite configuration of two logs alternately tip and butt sections and connected with split rings and bolts (Figure 2). This configuration give a stiffness property of 80% of the theoretical value, and was used in several bridges construction (Figures 3 and 4).

Figure 1. Single log beam bridge over Corumbatai river. This bridge is 22 meters long, 11 meters span, consists of eight longitudinal single log beams of eucaliptus specie and was built in 1985.

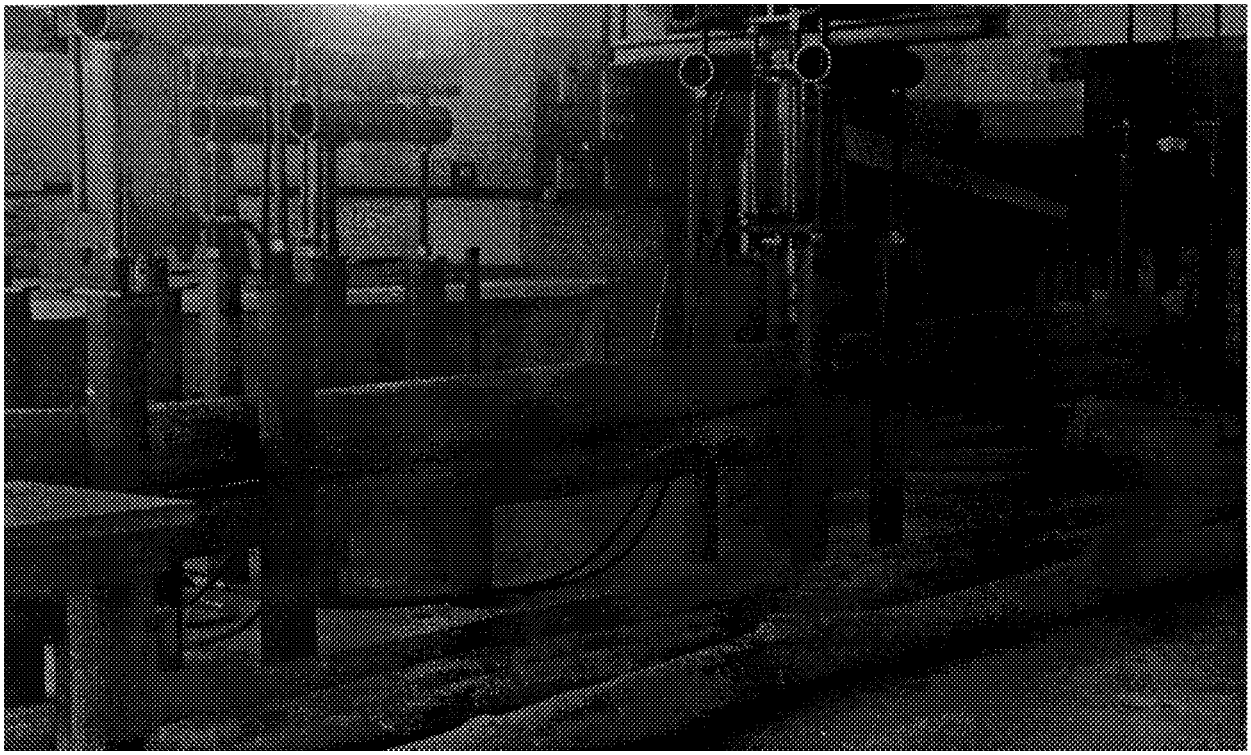

Figure 2. Composite log beams.

Figure 3. Composite log beam bridge over Ribeirao dos Porcos river. This strut frame bridge is 21 meters long, 15 meters span, consists of four longitudinal composite log beams of eucalyptus specie and was built in 1974.

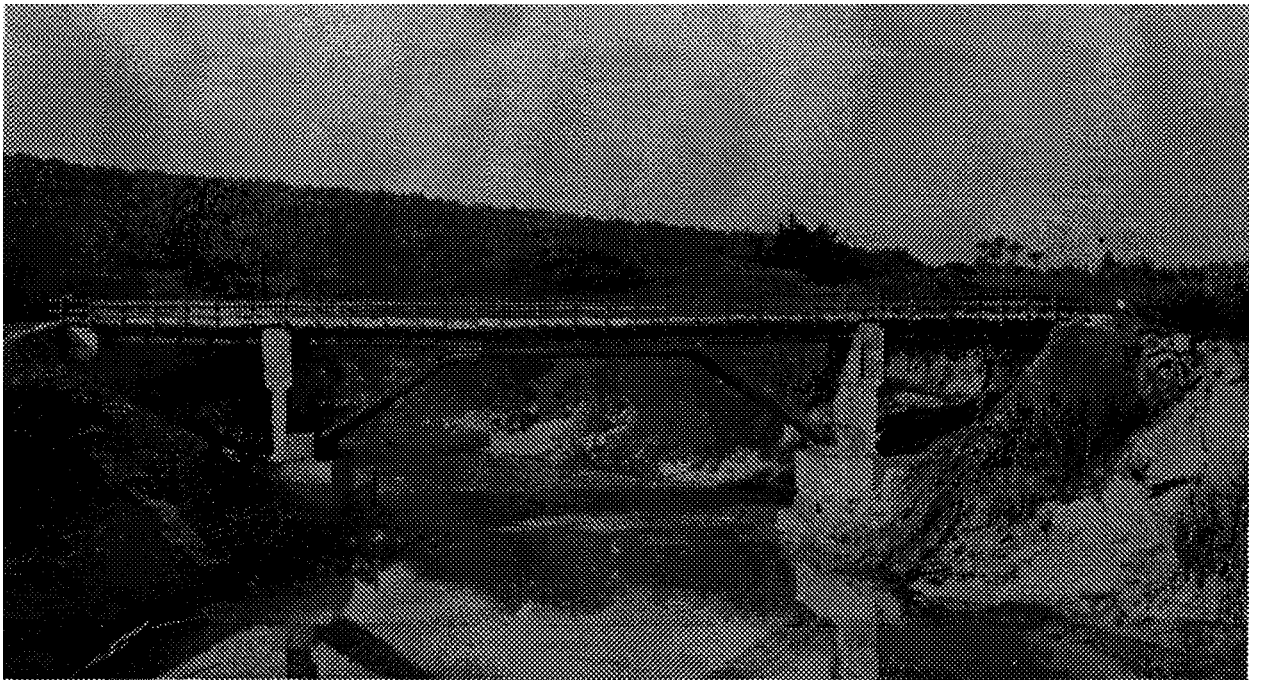

Figure 4. Composite log beam bridge over Vespasiano river. This strut frame bridge is 32 meters long, 20 meters span, consists of four longitudinal composite log beams of eucaliptus specie and was built in 1983.

Sawn Lumber Beams

Sawn lumber beam bridges that are commonly 20 cm wide and 30 cm deep. Solid timber blocking is placed between beams for alignment and lateral beam support. Sawn lumber beams bridges are limited in span by the availability of lumber beams in the required sizes. The clear span of 5 to 12 meters are most common (Figure 5). Longer crossings are achieved by using a series of simple spans with intermediate supports (Figure 6).

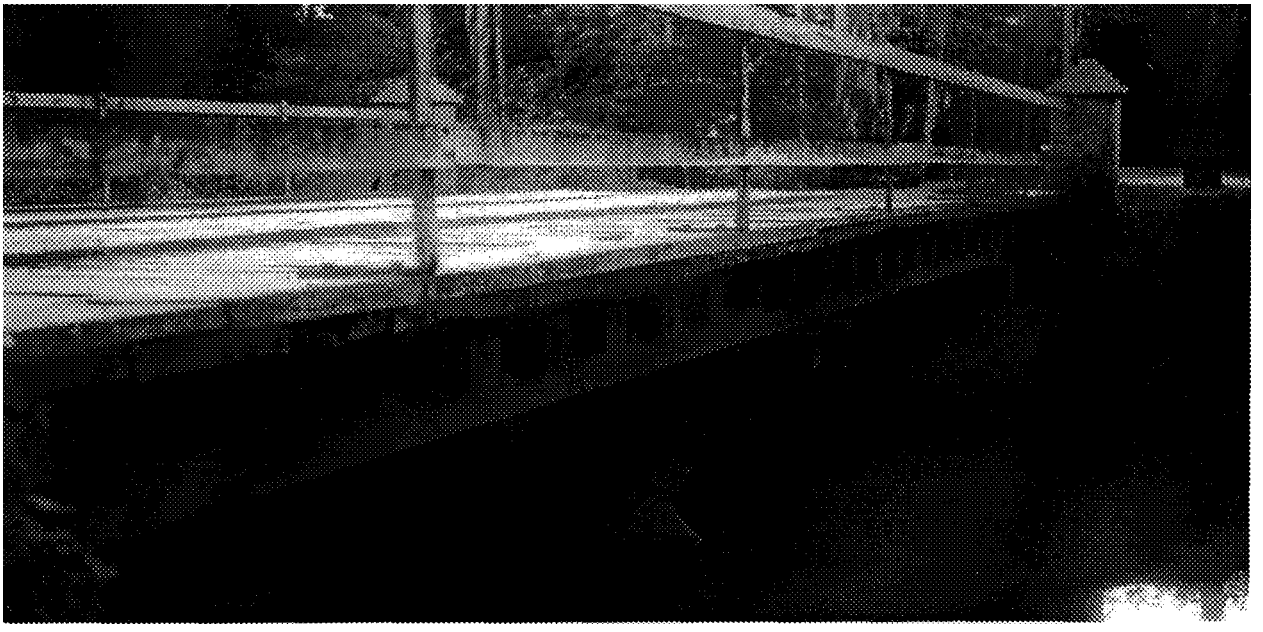

Figure 5. Single sawn lumber beam bridge over Passacinco river. This bridge is 22 meters long, consists of eight longitudinal single sawn lumber beams of eucaliptus specie.

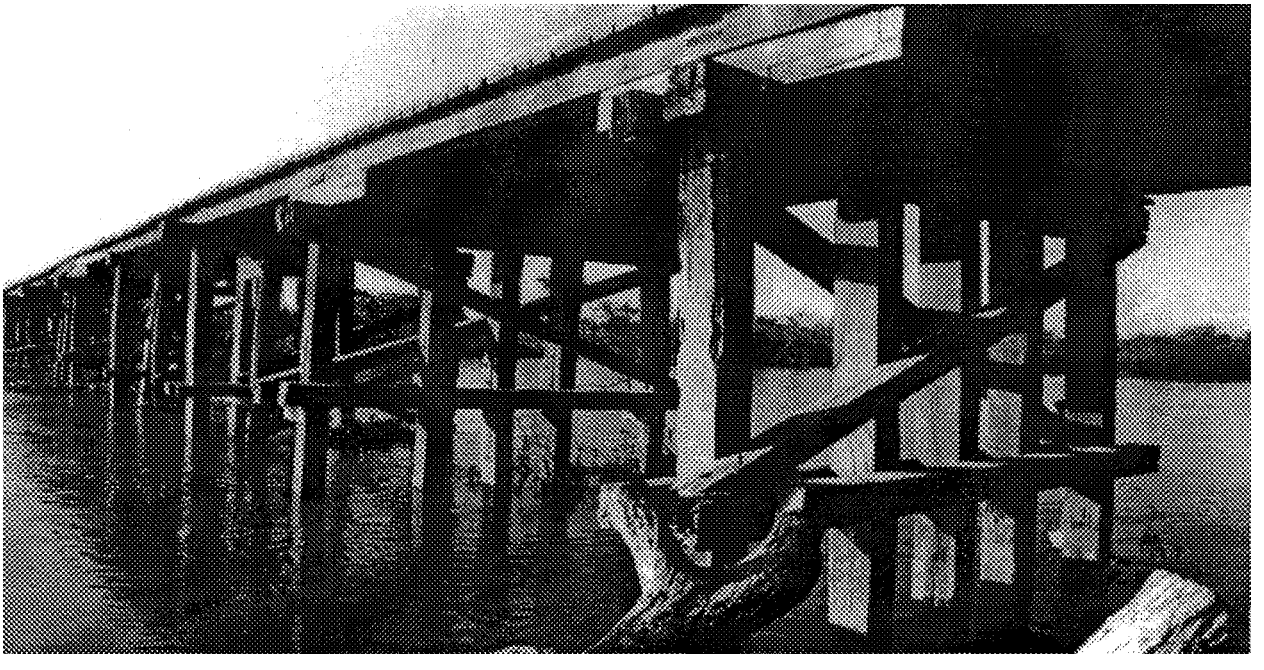

Figure 6. Single sawn lumber beam bridge over Jauru river. This bridge is 60 meters long, 5 meters span, consists of five longitudinal single sawn lumber beams of aroeira specie.

Other type of sawn lumber beam is the longitudinal multi-lattice boarded nailed I beam with diagonally crossed web boards with 2.5 cm thick, nailed together and straightened with stiffening ribs. The chord of the longitudinal beam consists of boards of 2.5 cm thick arranged in two layers with boards on each side of the web in each layer(Figure 7).

Figure 7. Multi-lattice boarded nailed system over Sorocaba river. This bridge is 28 meters long, consists of two longitudinal nailed I beams with diagonally crossed web of Macaranduba specie and was built in 1990.

Truss Beams

Truss beams consists of straight members connected to form a series of triangles. A typical truss superstructure consists of two main trusses. Timber truss beams are constructed in many geometric configurations but the three of the most popular are the bowstring truss, parallel-chord truss and strut frame truss (Figures 8, 9 and 10). The top and bottom chords are constructed of a series of straight sawn lumber members.

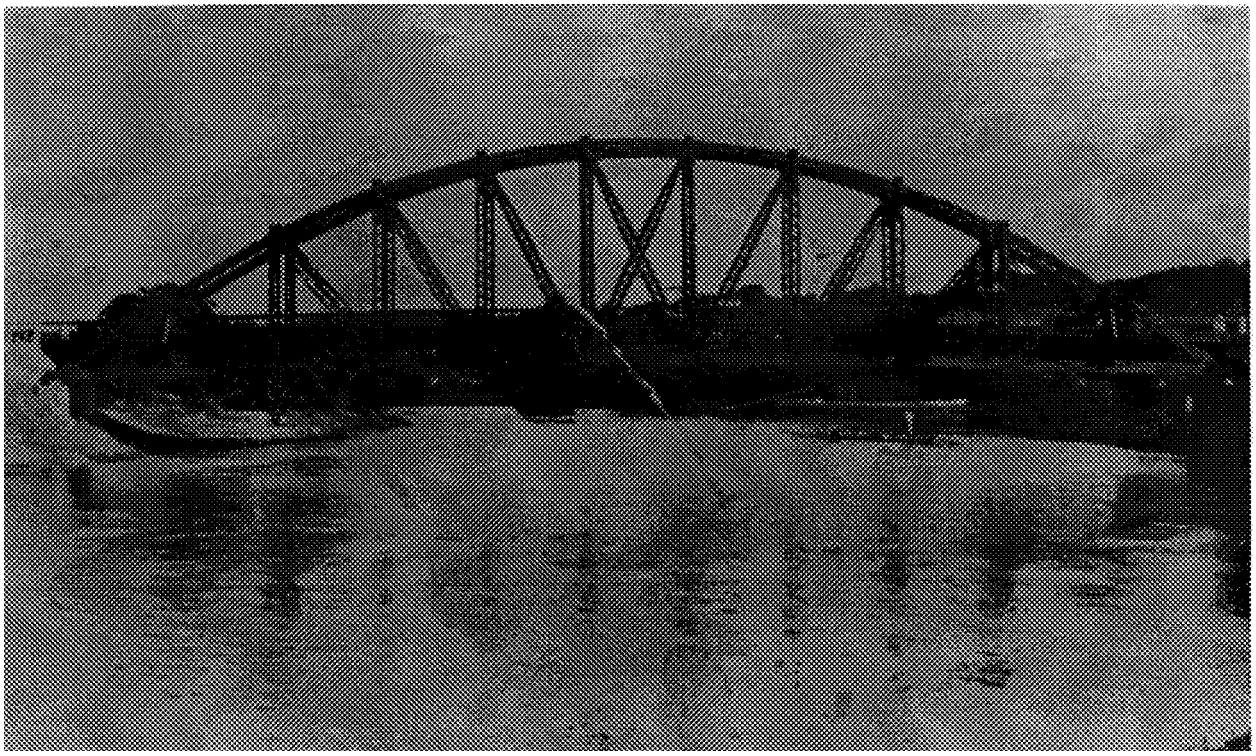

Figure 8. Bowstring truss bridge over Tiete river. This bridge was 52 meters long, consisted of two longitudinal bowstring truss beams of Peroba Rosa specie and was built in 1930.

Figure 9. Parallel chord truss bridge over Chinchina river, Colombia. This bridge was 30 meters long, consists of two longitudinal parallel truss beams of Culifierro specie and was built in 1987.

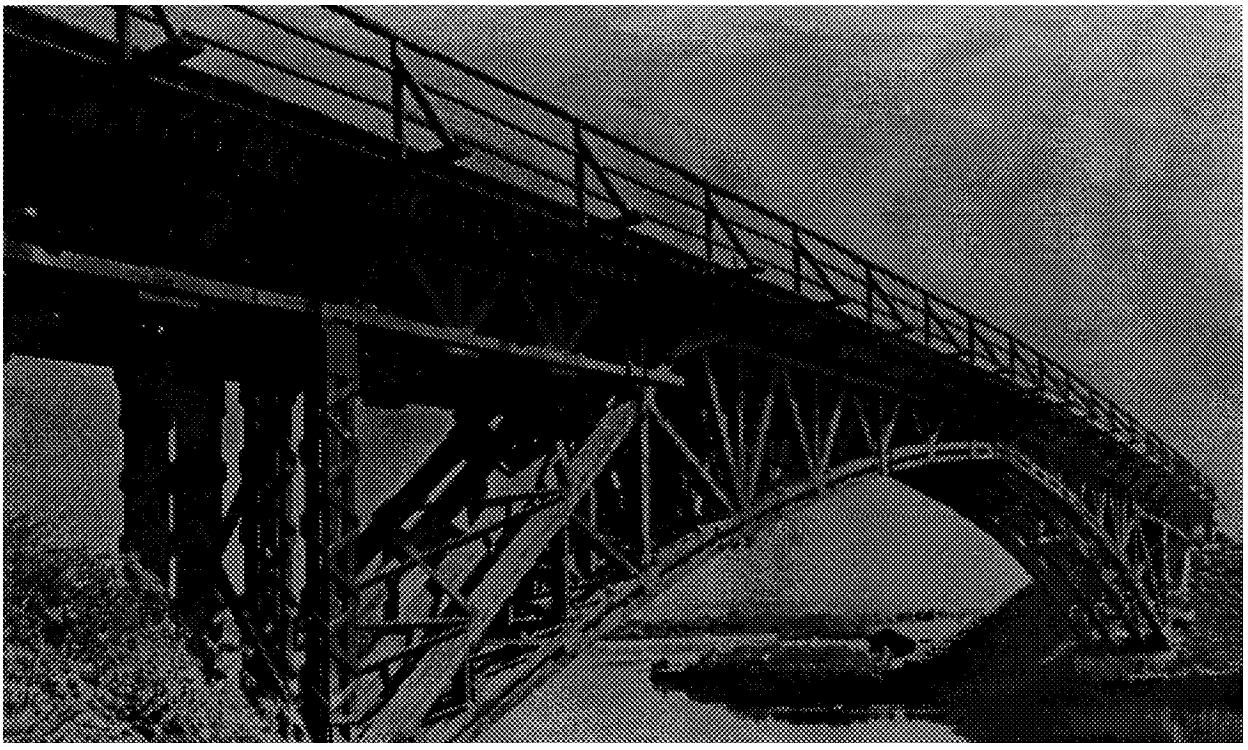

Figure 10. Strut frame truss bridge over Tiete river. This bridge was 60 meters long, consists of four longitudinal strut frame truss beams of Peroba Rosa specie and was built in 1930.

Deck Superstructures

The deck is the portion of the bridge superstructure that forms the roadway and distributes vehicle loads to supporting elements of the structure. The type, thickness, and material of the deck are based on the weight and volume of traffic it must support. Timber decks are typically constructed with sawn lumber planks and composite logs-concrete snabs.

Sawn Lumber Plank Decks

Sawn lumber plank decks are the oldest and simplest type of lumber deck. They are constructed of lumber planks of 3 to 16 cm thick and 25 to 30 cm wide, that are placed flatwise and connected to supporting beams with spikes or wood dowels. The planks are laid in the transverse, longitudinal or diagonal direction and are attached directly to closely spaced beams with spikes or wood dowels (Figure 11 and 12). The planks in laids in diagonal direction are generally composite in two layers of 45 degrees with longitudinal axis of the bridge and 90 degrees among them and attached in the beams with wood dowels (Figure 13).

Figure 11. Transverse sawn lumber plank deck attached to longitudinal beams with spikes.

Figure 12. Longitudinal sawn lumber plank deck attached to longitudinal and transversal beams with spikes.

Figure 13. Diagonal crossed sawn lumber board deck attached to longitudinal beams with wood dowels.

Composite Logs-Concrete Decks

Composite logs-concrete decks are constructed with logs of 20 cm medium diameter fixed in the londitudinal beams using screws and a steel strip of 25 mm wide and 4 mm thickness making a zig-zag between the logs. A concrete and asphalt cover were put over the deck in order to give a uniform surface on the bridge (Figure 14).

Figure 14. Composite logs-concrete deck attached to longitudinal beams with steel strip and lag screws.

Suspension Bridges

Timber suspension bridges consist of a timber deck structure suspended from flexible steel cables that are supported by steel, concrete or timber towers (Figures 15,16, 17). They are capable of long clear spans (over 100 meters) and are normally used only when other bridge types are impractical because of span requirements or when the use of intermediate bents use not possible.

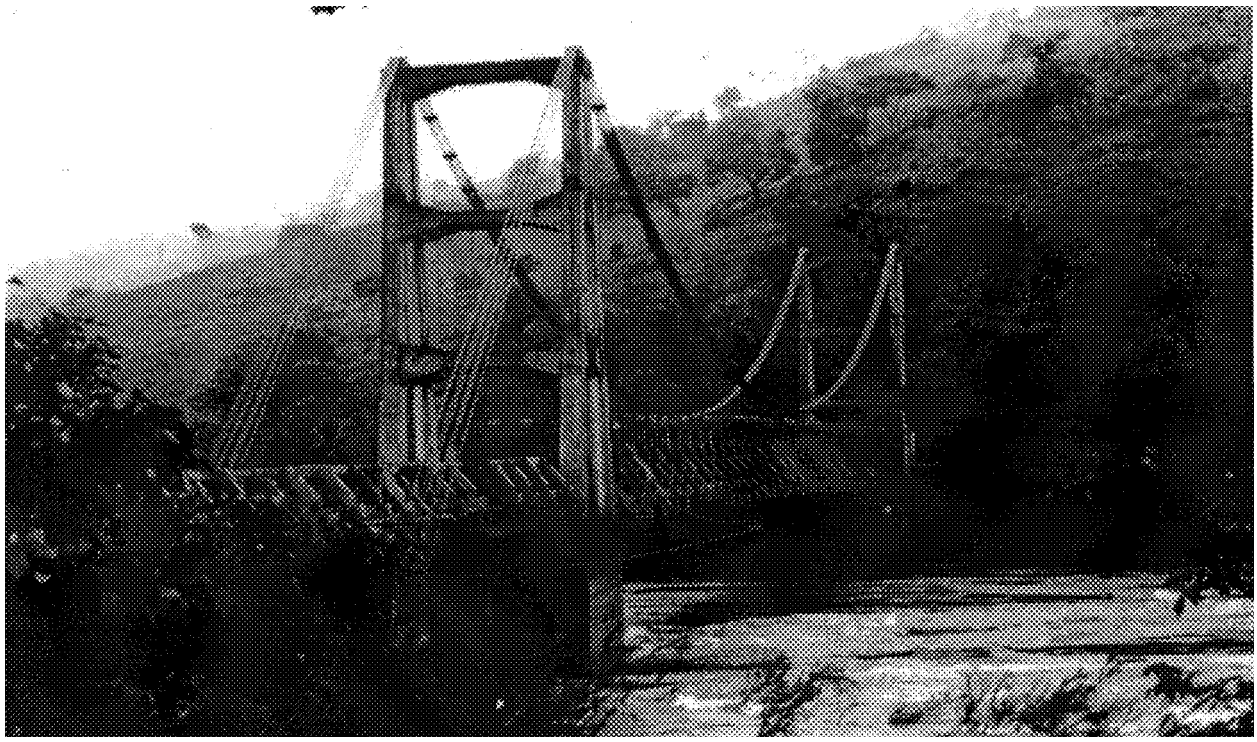

Figure 15. Suspension bridge over Paranapanema river. This bridge is 132 meters long, 80 meters span, consists of two longitudinal parallel truss beams of Itauba specie, was built in 1920, reconstructed in 1985 and repaired by LaMEM in 1989.

Figure 16. Suspsnsion bridge over Tiete river. This bridge is 62 meters long, 31 meters span, consists of two longitudinal composite log beams of Eucaliptus specie, was designed by LaMEM in 1977.

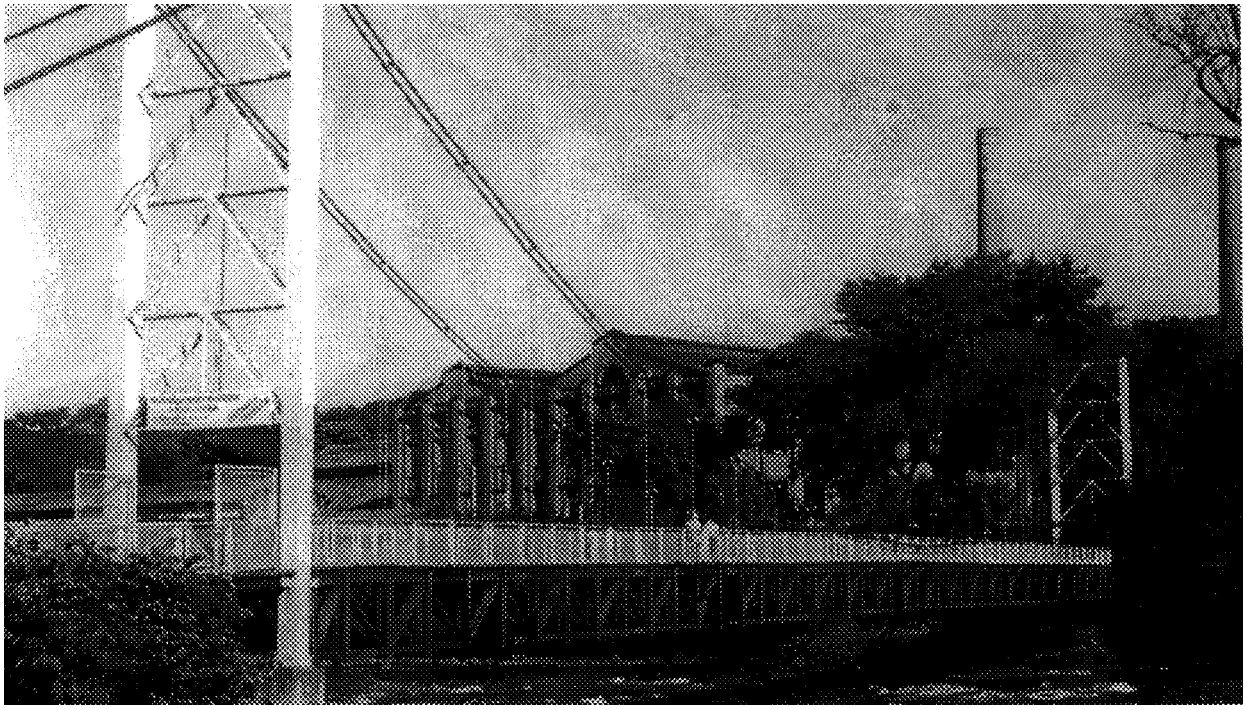

Figure 17. Suspension pedestrian bridge over Piracicaba river. This bridge is 105 meters long, 78 meters span, consists of two longitudinal parallel truss beams of Eucalyptus specie and was designed by LaMEM in 1992.

Concluding Remarks

LaMEM is one of the most important laboratories of timber structures research in Brazil. We developed research, design and construction on the subject of timber bridges. In this year we are constructing the first prestressed timber bridge in South America in Sao Paulo state in Brazil. Our recent draft code in limit states design give the new guidelines to be followed in design and construction of timber bridges. Our reforestation specie recommended to bridges construction is the Eucalyptus Citriodora. Prospectives species are pinus.

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