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Economical solutions for short-span bridges using reinforced glue laminated timber and steel

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Abstract

The aim of this research was to develop new composite bridge concepts that are easily buildable and have a high grade of prefabrication by using reinforced glue laminated timber beams and steel trusses. All structural parts are designed so that minimal assembly is required and all elements are easily transportable.
Glue laminated timber reinforced with synthetic straps was chosen due to its superior resistance, enhanced elastic behaviour under loading-unloading cycles, and other good mechanical properties, all based on previously conduced experimental studies, as well as other known advantages of classic glue laminated timber elements.
A modular prefabricated bridge model was proposed that could cover small and medium spans and is both economic and easy to build.
These timber beams combined with the rigidity and light weight of steel trusses could make an affordable and strong alternative for concrete slabs or other prefabricated elements that are mostly used for short-span bridges.

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1. Introduction

In modern civil engineering, efficiency and economy are key words that describe successful structural designs. By respecting these two guidelines and combining them with the use sustainable materials such as glue laminated timber and other recycled products we would like to promote a simple bridge structure that uses best of timber and steel as structural materials.

As an alternative to classic internal reinforcements such as steel rods, or external reinforcements FRP(fiber reinforced polymers), CFRP(carbon fiber reinforced polymers)[1] this paper promotes the use of plastic straps commonly used in the shipping and packaging industries witch are significantly cheaper, have a great tensile strength and are easily recyclable.

Glue laminated timber, further referred to as glulam, and proves to be the most efficient way of using wood with minimal waste in order to produce superior quality beams and other structural elements while providing a more homogenous dispersion of natural defects in the woods fibers throughout the length of the element.

2. Materials

As stated before the aim of this paper was to promote the use of sustainable and recyclable materials for a more eco friendly approach to building bridges. The main materials that were used in this study are as follow:

- Glue laminated timber
- Synthetic reinforcements
- Steel

2.1. Glue laminated timber

Glue laminated timber beams were used as main elements of the proposed structure for its superior strength to weight ratio though lowering the dead weight of the bridge by over 50-60%. Pressure treating the beams is highly recommended for an extended life span of the bridge.

Using timber for the construction of bridge decks offer several advantages compared to conventional methods, such as form-in-place concrete decks, mainly that no form work or lost time during the concretes curing process is required once the abutments are done so that the new or replacement structure can be deployed rapidly.

Other advantages are the use of lightweight and smaller erection equipment due to it's lower dead weight as compared to similar steel or reinforced concrete structural elements, and most of all the elimination of problems associated with the corrosion of steel deck elements or reinforcing steel in used in the concrete deck that is caused by the use of deicing salts.

2.2. Synthetic reinforcements

PET and bonded polyester yarns straps are two cheaper alternatives to standard reinforcements and form previous studies [2] proved to add significant amount of strength and elasticity to glue laminated timber beams.

These straps are relatively cheap and are used worldwide in the packaging industry and are really easy to recycle with minimal energy use. They have a great amount of tensile strength witch is exactly what it was required for this project and are only sensible to the sun's UV radiation from witch they are heavily protected between the wooden laminates.

The main advantages over standard steel reinforcements are: the price since they are made out of one of the cheapest materials that exist, superior resistance to corrosion and other harmful agents and also low self weight since it is important to use the lightest materials possible in order to lower the bridge's dead weight.

Experimental results regarding flexural behavior under loading-unloading cycles and until failure made on reinforced and non-reinforced glue laminated timber beams are presented and compared in the following figures.