Structural behavior evaluation of Brazilian glulam wood sleepers when submitted to static load

E.V.M. Carrasco a,⁎, L.B. Passos a, J.N.R. Mantilla b

a Department of Structural Engineering, Federal University of Minas Gerais, Brazil
b Department of Geotechnical Engineering, Federal University of Minas Gerais, Brazil

A R T I C L E   I N F O

Article history:
Received 7 October 2010
Received in revised form 1 June 2011
Accepted 18 June 2011
Available online 19 July 2011

Keywords:
Experimental stress analysis
Wooden sleepers
Glulam
Railroads

A B S T R A C T

This work is about the behavior evaluation of structural wooden sleepers through experimental stress analysis. The wood used for the glulam sleeper was Eucalyptus Citriodora with 9.9 kN/m³ density. The experimental program includes the assay system assembly which simulates the real situation. The static loading assay determined the deformations, through strain gages (single-element gage, two-element gage and three-element rosettes), and the displacements along the sleeper, using linear displacement transducers. Applying the elasticity theory for orthotropic materials, tensions in various parts of the sleeper were determined until 200 kN load limit and compared with a numerical model that uses MEF. The results are acceptable. The Brazilian glulam wood sleeper has a elevated performance as the collapse maximum load, when compared with predicted formula values presented by several researchers, was 110% higher.

1. Introduction

The rail transport system has been used since the beginning of the XIX century in Europe. In Brazil, the first railroad built was the Maüa Railroad in 1854 [1]. In 1820, the sleepers, or crossties, were made from stone blocks but later they were banned and replaced by wood due to hardness problems and their inability to hold the railway gage. The reason to choose wood as a replacement material is because its lower mass compared to stones being easier to handle, easier to install while has good insulate properties, as well as a capacity to resist to high vibrations.

In Brazil, are normally used high density wood sleepers [2]. In the US, they are manufactured with hard treated wood, while in Europe they are usually made of concrete [3]. Concrete sleepers have a more defined geometry which allows better alignment and standardized measures. However, they are relatively more expensive than wood sleepers, even being designed for a 40 years life time in service [4]. In contrast, steel sleepers have a superior resistance and longer durability than wood and concrete sleepers but, due to its high cost, they are moderately used [5].

Studies have indicated that wood is being used and will continue to be used as railroad sleepers [6]. The main reasons for this are: (a) adequate availability of timber resources; (b) experience that track engineers and maintenance crews have with wood sleepers; (c) compatibility of existing track equipment with wood sleepers; and (d) manufacturing and handling simplicity. Wood sleepers are cost-effective in relation to concrete and steel sleepers and their field-performance has been reasonably acceptable [3].

Some wood sleepers disadvantages are known nowadays. The most important is that they are susceptible to xylophages organisms attack that could lead to its collapse. On the other hand, the damage caused by the load distribution plaque [7] (crushing to the normal fiber compression) and by the gravel (abrasion) combined with wood fissures, caused by wood drying, results in the sleepers premature collapse and its consequent service removal. This is evidence for a need to develop modern technologies improving the performance and increasing the life time in service of wood sleepers.

According to Qiao et al. [3], many efforts are been made to improve the wood sleepers performance such as the use of more efficient and ecological preservatives and screws to avoid wood fissures. Reinforcement with fiberglass grille (FPR) increases considerably the rigidity and the resistance of wood sleepers however, a special concern should be taken in the glued interface resistance which is influenced by the wood surface texture and by the characteristics of the resin used [8,9].

A typical railroad track consists on four main elements: subgrade, ballast, sleepers (or crossties) tie-plates and connectors, and two parallel steel rails. The sleeper is the key element among these structural components. The main functions of the sleepers are: (a) transfer and distribute the rail loads to the ballast, (b) transversely secure the rail and maintain them to correct gage-width and (c) resist the cutting and abrading actions of bearing plates and ballast material.
The sleeper sizing as a structural element according to Rives et al. [10] is a notable difficult problem, which brings us to use close methodologies. Two aspects of the problem are needed to know: the ultimate loads transmitted by the rail and the reaction forces due to ballast. As the vertical load is the main influence parameter affecting the railway, it is usually considered alone to the sleepers static load analysis. One of the most commonly used methods to determine the maximum force transmitted to the sleepers is the Eisenmann method that uses the Eq. (1), [1].

\[
P_{\text{max}} = \frac{(Q \cdot a)}{2} \cdot \left( 4 \cdot \frac{c}{E \cdot I} \cdot \left( 1 + t \cdot \delta \cdot \left( 1 + \left( \frac{V - 60}{140} \right) \right) \right) \right)
\]

where \( P_{\text{max}} \) is the load on rail basis (kN); \( Q \) is the applied load per wheel (kN); \( a \) is the spacing between sleepers (cm); \( b_0 \) is the sleeper’s width (cm); \( c \) is the compact range (cm); \( E \) is the modulus of elasticity (kN/cm²); \( I \) is the inertia moment (cm⁴); \( t \) is the multiplier factor, tabled value, dimensionless; \( \delta \) is the coefficient that depends on the track conditions, dimensionless; and \( V \) is the speed (km/h).

The authors indicated that the maximum force on the rail basis shall be increased in 40% or 50% due to the superposition of the other railroad tracks [11,12].

In this study glued laminated wood (glulam) sleepers were used, manufactured with high density eucalyptus wood (Eucalyptus Citriodora) with 10 kN/m³ basic density and a water resistant adhesive (resin resorcinol formaldehyde).

The main purpose of this work is to evaluate the structural behavior of E. Citriodora glulam sleepers when submitted to static load, through experimental stress analysis using uniaxial electrical extensometers (SG), rectangular rosettes (SGR) and displacement transducers (DT) to determine tension distribution and deformations through the sleeper. Aiming to reproduce the real conditions, a wood box was used filled with sand (20 cm depth) simulating the sub-grade depth adopted was according to the demanding requirements and also noticed that all demanding specifications are satisfied. The ballast depth was 22 cm and a wood box was used filled with sand (20 cm depth) simulating the sub-grade with gravel number 3 (41 cm depth) to simulate the ballast. Using ANSYS, version 9.0 Software, the numerical simulations through the sleeper, Fig. 3.

To characterize the wood specimens were tested under compression parallel to grain, compression perpendicular to grain and bending, following [14,15]. This value is close results of the tests (EP/EN = 20. Many authors [2,4,6,21] consider this ratio (EP/EN) at around 12.5. This value is close results of the tests (EP/EN = 12.4).
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات