Construction and Building Materials 27 (2012) 126–129

Contents lists available at SciVerse ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Evaluation of using waste timber railway sleepers in wood–cement composite materials

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ARTICLE INFO

Article history:
Received 18 June 2011
Received in revised form 3 August 2011
Accepted 4 August 2011
Available online 30 August 2011

Keywords:
Timber railway sleeper
Construction material
Wood–cement composite
Physico-mechanical properties

ABSTRACT

In present study, the suitability of using waste timber railway sleepers (WTRSs) as filler in wood–cement composites was investigated. The effects of two variable factors namely press temperatures (25 and 60 °C) and calcium chloride contents (3%, 5% and 7% w/w cement) on some physico-mechanical properties were also investigated. The following experimental parameters were constant: wood/cement ratio (40:60), board thickness (15 mm), press pressure (40 kg/cm^2), and press time (5 min). Press temperature, calcium chloride and the interaction of both variables had significant effects ($p < 0.01$) on all the studied properties. Test results showed that addition of calcium chloride tends to enhance both the physical and mechanical properties of boards. All properties of the boards were improved when the calcium chloride content was increased from 3% to 7%. The results also showed that as the press temperature was increased from 25 to 60 °C, significant increased in water absorption and thickness swelling occurred. Water absorption and thickness swelling (at 2 h and 24 h) compared favorably with values reported for cement-bonded composites produced from virgin wood particles. In general, the strength properties of the boards were found to be a maximum when press temperature and calcium chloride were 25 °C and 7%, respectively. These properties can be exploited in many applications where lightweight concretes are required. Therefore, WTRS is technically suitable for building construction such as paneling, ceiling and partitioning.

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1. Introduction

Traditionally, wood has been an essential construction material. However, with the invention of reinforced concrete, its application has been reduced [1]. In recent years, there has been a growing interest in utilizing wood for making low-cost building materials [2–5]. The primary advantages of using woody materials as fillers in cement are the low density, low cost, nonabrasive nature, high filling levels possible, low energy consumption, and wide variety of wood species available throughout the world [6]. On the other hand, increasing demand for forest resources in various applications has led to the shortages of wood supply. Thus, there is a need to look for innovative ways of using non-traditional forest resources to substitute wood raw materials for wood-based industries. Among the possible alternatives, using recycled wood is currently at the center of attention [1,7–9]. Every year, a large number of old and deteriorated structures such as railways, buildings, fencing poles, furniture items and bridges are being demolished. Most of the timbers used in construction are being treated with chemical preservatives (such as chromated copper arsenate and creosote) during their service life to protect them from biological deterioration. These chemical materials contain toxic or polymeric substances which are not easily biodegradable. Presently these wastes are either burnt or land filled. These approaches cause various environmental issues like air pollution, emission of green house gases and occupation of useful land. The increasing charges of landfill are further aggravating the problem. Moreover, these methods of disposal are certainly wastage of a primary natural resource. Therefore attempts have been made by researchers, both in industry and academia, to reuse these wastes as the building materials (i.e. wood–cement composites) [1,6].

Studies on the waste wood in the forms of fibers, particles or strands suggest that these materials have the potential for use as reinforcing agent or filler in cement composites. Kasai et al. [10] used wood particles from construction waste in Japan for making wood-chip concrete. They made concrete with a density range of 0.92–1.25 g/cm^3. They found the flexural strength of the product in the range of 4–7 MPa and compressive strength 5–8 MPa. The ratio between flexural strength and compressive strength was 0.5–0.9, greater than that for normal concrete. This indicates the reinforcing effect of wood particles. They further reduced the density to about 0.78 g/cm^3 by adding synthetic lightweight aggregates. This resulted in comparatively lower bending and

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doi:10.1016/j.conbuildmat.2011.08.016