JOURNAL OF CHEMICAL ENGINEERING AND INDUSTRIAL BIOTECHNOLOGY
E-ISSN: 0126-8139
VOLUME 10, ISSUE 1, MARCH 2024, 1 – 16
DOI: https://doi.org/10.15282/jceib.v10i1.10292

RESEARCH ARTICLE

Sustainable Materials in Concrete Railway Sleepers: A Review of Current Developments and Future Prospects

Jia Jun Yee[1], Sheh Ching Khong[1],JiaLing Che[2], Kong Fah Tee[3], and Siew Choo Chin[1,4,*]

[1] Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Gambang, Pahang, Malaysia.
[2] School of Civil Engineering and Hydraulic Engineering, Ningxia University, Yinchuan 750021, China
[3] Department of Civil and Environmental Engineering, King Fahd University of Petroleum Minerals, 31261 Dhahran, Kingdom of Saudi Arabia
[4] Center for Research in Advanced Fluid and Processes (Fluid Centre), Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Gambang, Pahang, Malaysia

ABSTRACT - Concretes have been the favoured material to make concrete railway sleepers due to better accessibility and weathering compared to their timber counterparts. Railway sleepers are crucial infrastructure and 5% of concrete sleepers fail prematurely. Sleeper failure could result in catastrophic railway accidents. Hence, improvement is needed in the concrete sleeper mixes. Previous literature has identified two methods of improving concrete strength in concrete mixes with wastes, through replacement of concrete constituents or the use of alkali-activated materials. Use of wastes as partial concrete material replacements reduces the volume of concrete materials while alkali-activated material forms a concrete-like compound that eliminates the use of cement. These methods improve the strength performance and sustainability aspects of the concrete. While many studies have been conducted on these two types of sustainable concrete, their application in concrete railway sleepers has not been investigated. Thus, this paper looks to review the two different types of sustainable concretes through some previous literature that has been conducted on its application in concrete railway sleepers as well as those that have yet to be studied. Ultimately, identifying the best sustainable materials for concrete railway sleepers.

ARTICLE HISTORY
Received : 2nd Feb. 2024
Revised : 17th Apr. 2024
Accepted : 22nd Apr. 2024
Published : 21st Jun. 2024

KEYWORDS
Alkali-Activated Materials
Recycled Wastes
Sustainable Concrete
Construction Products
Concrete Railway Sleepers

1.0 INTRODUCTION

Railway transportation has been playing a vital role throughout history in providing connectivity for both humans and goods, boosting the economies of countries around the world [1]. This makes railway transportation an indispensable transportation mode for countries to promote economic activities and improve social connectivity [2]. The first rail transport has existed ever since the 1800s, powered by steam engines [3]. Ever since, it has been playing a crucial part in history from the First Industrial Revolution to the Fourth Industrial Revolution [4]. The world today sees these rail transports being electrified and controlled through the use of Industry 4.0 concepts. For example, artificial intelligence (AI), especially for the use of signaling trains controls various aspects of the train allowing them to operate normally without human intervention [5].

Railway transport is a mode of transportation where wheeled cartridges travel on a fixed network of rails, without the rail track, it would not be considered railway transport [6]. Figure 1 depicts the civil build-up of the railway infrastructure. When the train is traveling through the rails, the load from the train is subjected to the tracks which are held in place by the railway sleepers [7]. The load depends heavily on the support of the sleepers to maintain the track configuration before transmitting the load in a uniform manner down to the substructure [8]. Railway sleepers can be made up of 4 different materials, timber, iron, composite, and concrete [9; 10]. Back in the day, timber was the preferred material to manufacture railway sleepers [11]. With the increasing loads from the train and lack of sufficient quality timber hardwood, the timber railway sleepers quickly became unsustainable. As a result, out of the 4 different types of materials, concrete is widely preferred today due to its easily accessible raw materials and ability to carry heavy loads while not being easily susceptible to chemical attacks [12].

Nevertheless, as more innovations are being developed in rail transport, its capabilities have been more advanced than before. Presently, to meet the increasing demand for improved mobility and connectivity, corporations and governments from affluent or developing countries alike have continued investing more in rail transport, to further modernize and expand the railway networks in their respective countries [13; 14]. As a result, the railway infrastructure has been tasked to support increased loadings and frequencies causing an increased tendency of concrete sleepers to fail prematurely, which may lead to catastrophic railway disasters [15]. Annually, it is reported that 2-5% of concrete sleepers fail before

***CORRESPONDING AUTHOR | S.C. Chin** | ✉ scchin@umpsa.edu.my