15th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering
(15ARC), 09-13 Nov 2015, Fukuoka, JAPAN

Performance Enhancement of Railtrack Ballast with Rubber Inclusions: A Laboratory Simulation

Chee-Ming Chan
Siti Farhana SM Johan

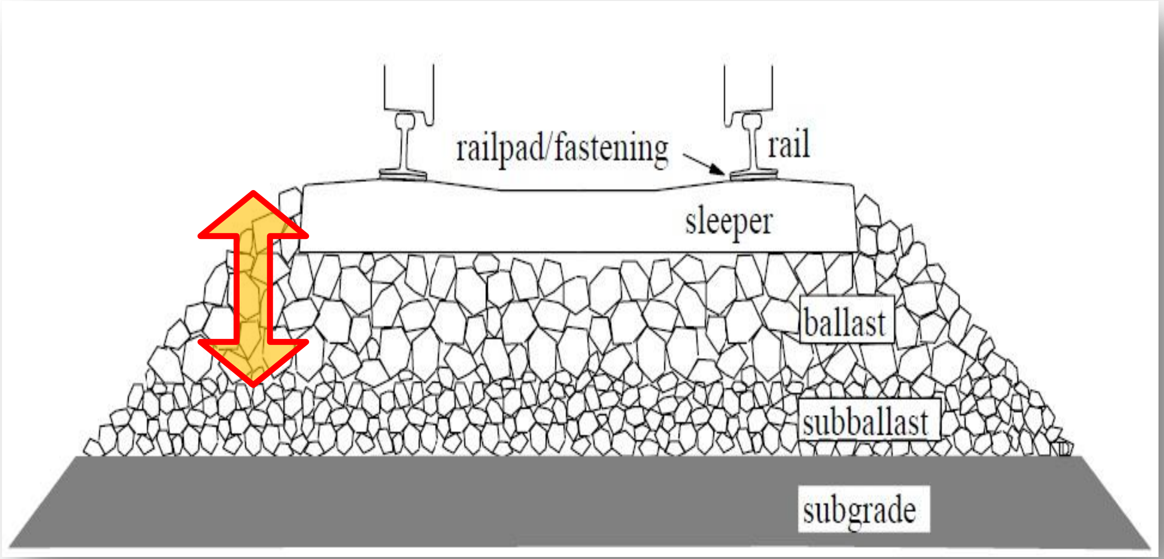
Universiti Tun Hussein Onn Malaysia

INTRODUCTION

- Railtracks: rails, sleepers, railpads, fastenings, ballast, sub-ballast and subgrade.
- All the components constitute the superstructure of a railtrack while the subgrade consists of a formation layer and the base of the track.

INTRODUCTION

- Ballast, essentially angular hard stones, could be sourced from granite, limestone, recycled slag or other crushed stones.
- The ballast layer, with depths of 30-50 cm, functions as a support to the track structure against deformation from dynamic loads transmitted by the passing trains.



INTRODUCTION

- Considering the cost-effectiveness, availability and practicality of ballast, advancement in railway technology would arguably **outrun** the material substitution or total replacement in the near future

INTRODUCTION

- Problems with ballasts:
  - vertical and horizontal movements caused by traffic loads are attributed mainly to the deformation and densification of the ballast
  - compromised ride quality, requiring either speed restrictions or maintenance to realign the tracks

INTRODUCTION

- **Expectations** of ballasts:
  - tough, dense, weather-resistant and mechanically stable…
  - …particle size of ballast significantly affect the overall resilient modulus, volumetric and shear behaviour…
  - … track settlement is very much dependent on the ballast quality and its response to traffic load.

INTRODUCTION

- **Track settlement**… volume reduction caused by

1. **Densification**: involves phases of particle rearrangement, penetration into ballast voids, particle breakdown and abrasive wear,

2. **Non-elastic behaviour of ballast-subgade system**: encompasses inter-particle microslips as well as movement of ballast and/or sleepers.

INTRODUCTION

- **Track settlement** also involves…
  - **initial packing** of the ballast: strong influence on the long term track performance
  - **crushed ballast** do not only indent and roughen the metal, but inadvertently increase the **traction** level and reduce the **residual fatigue life** of the contact

INTRODUCTION

- THIS project…
  - Prolong ballast life, enhanced long term performance of railtracks.
  - Examines the potential of rubber inclusions in increasing the shear resistance of ballast, hence reducing the wear-and-tear effect of traffic loads
  - ONLY static load was applied using a conventional shearbox tests setup in this exploratory work.

MATERIALS AND METHODS

Downsized particles **(granitic aggregate 5-20 mm)**: to fit in shearbox.

Average crushing strength of the aggregates: at **85 kN**.

Simulation of aggregate-rubber mixture under **poor drainage conditions** (in prolonged wet weather), a batch of aggregates only were **soaked in water for 7 days** prior to mixing and testing.

Aggregates *(Ballast)*

MATERIALS AND METHODS

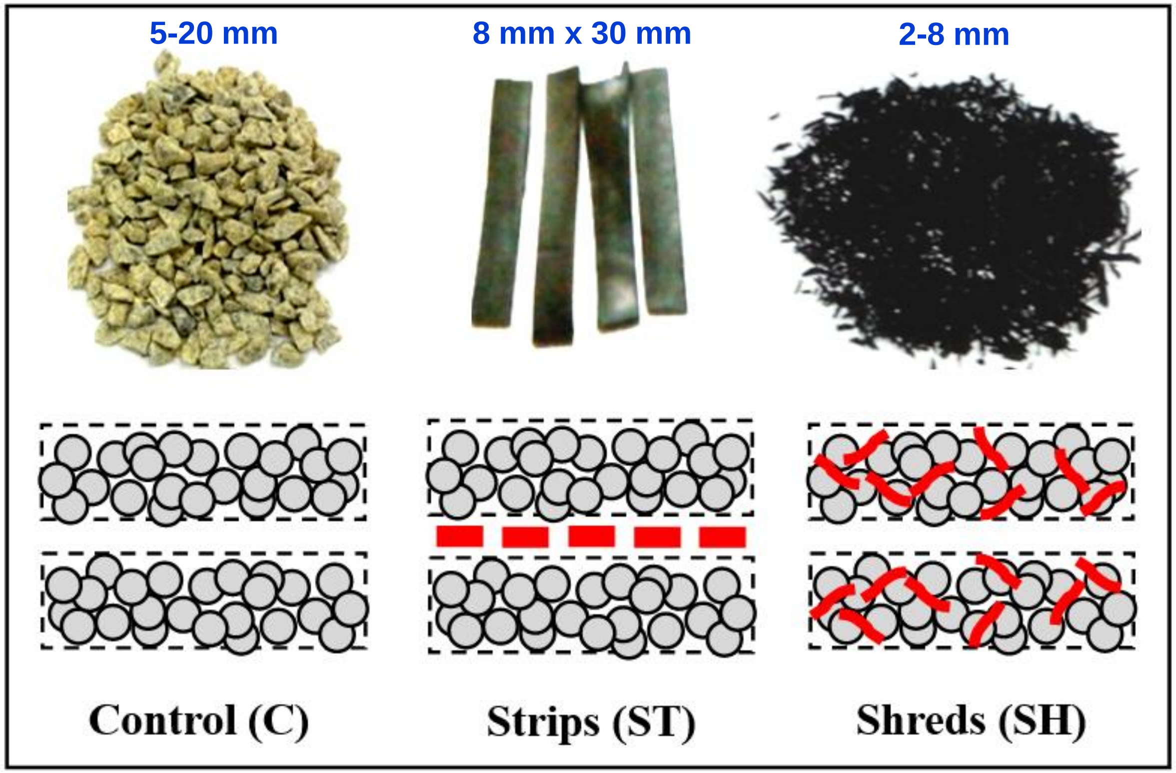
The rubber inclusions, in strips and shreds, were prepared from new **inner tubes** of motorcycles.

The thickness of the inner tube was approximately **1 mm**.

Rubber inclusions

MATERIALS AND METHODS

Test configurations

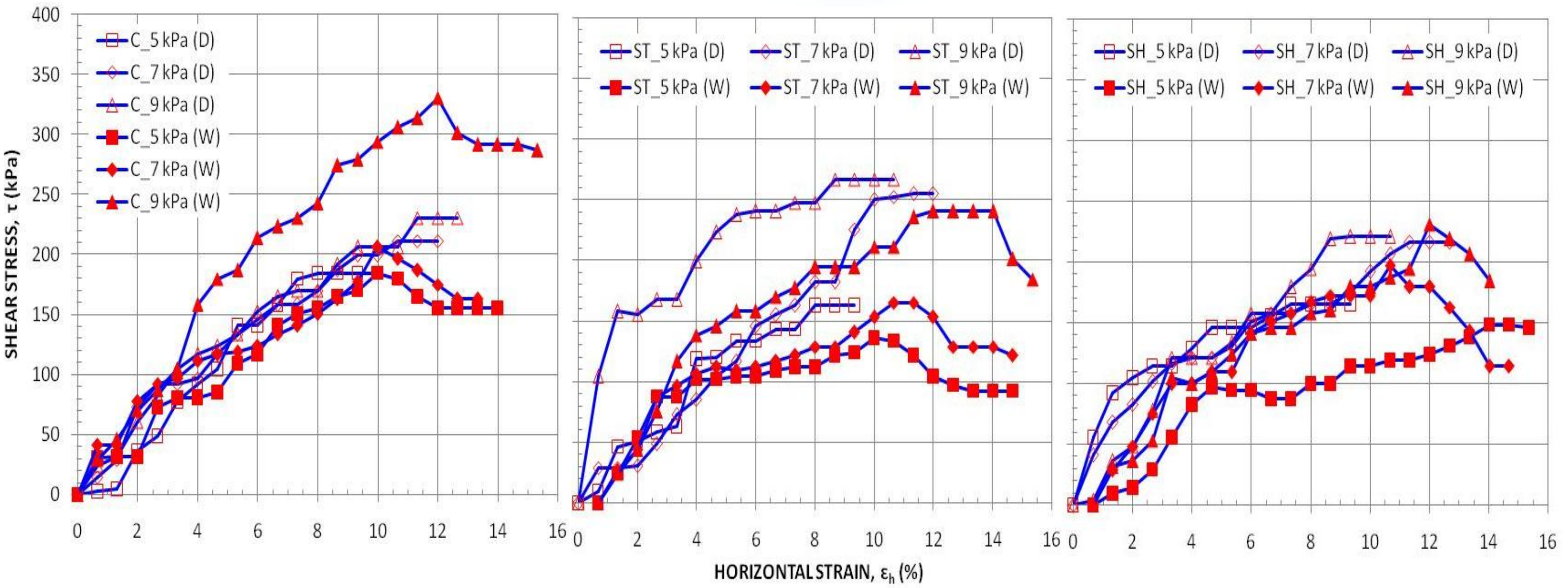


MATERIALS AND METHODS

Shearbox Test

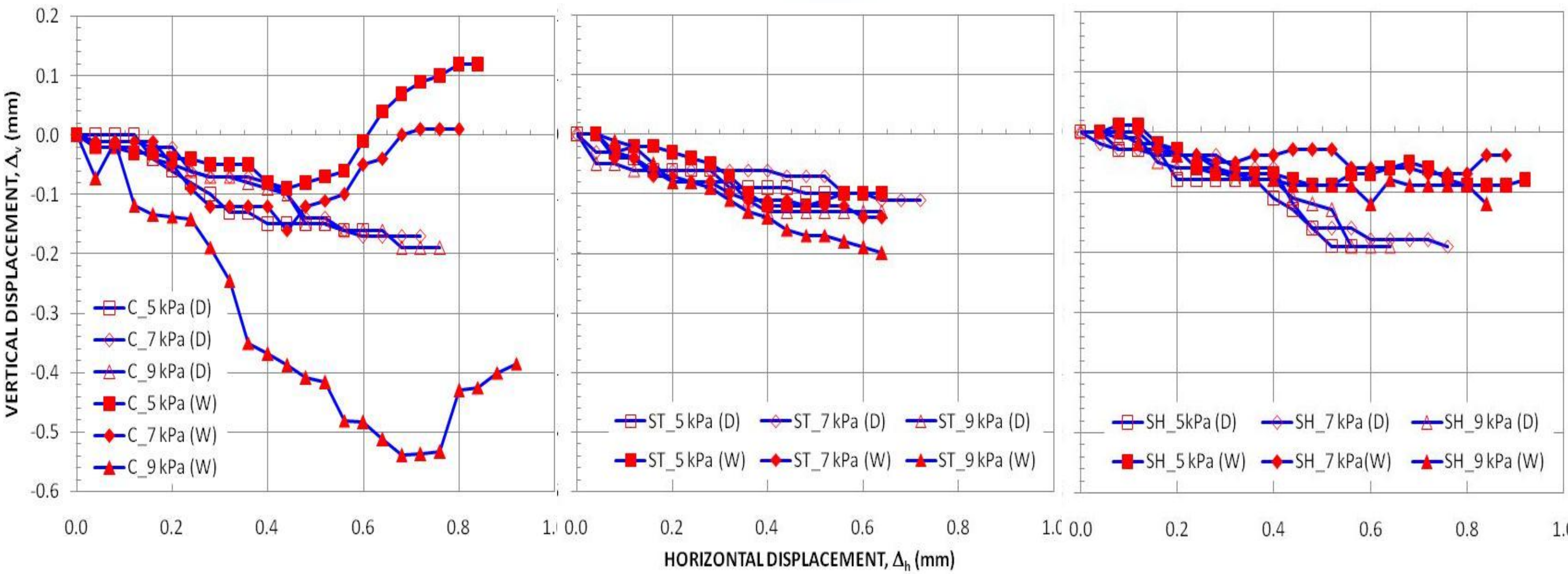
- Shearbox: **60 mm x 60 mm x 25 mm**; shearing rate: **0.2 mm/minute**
- Width to thickness ratio of **2.4** (large width compared to the thickness): eliminates **edge effects** and ensures **shearing on the flat contact surfaces**.
- Minimum specimen **width** and initial **thickness** should be kept ≥10 times and ≥6 times the maximum particle diameter respectively, while the minimum width should be at least twice the thickness.
- The 3 **vertical stresses** applied for each test was 5, 7 and 9 kPa.

RESULTS & DISCUSSIONS



$\tau - \varepsilon_v$ plots.

RESULTS & DISCUSSIONS

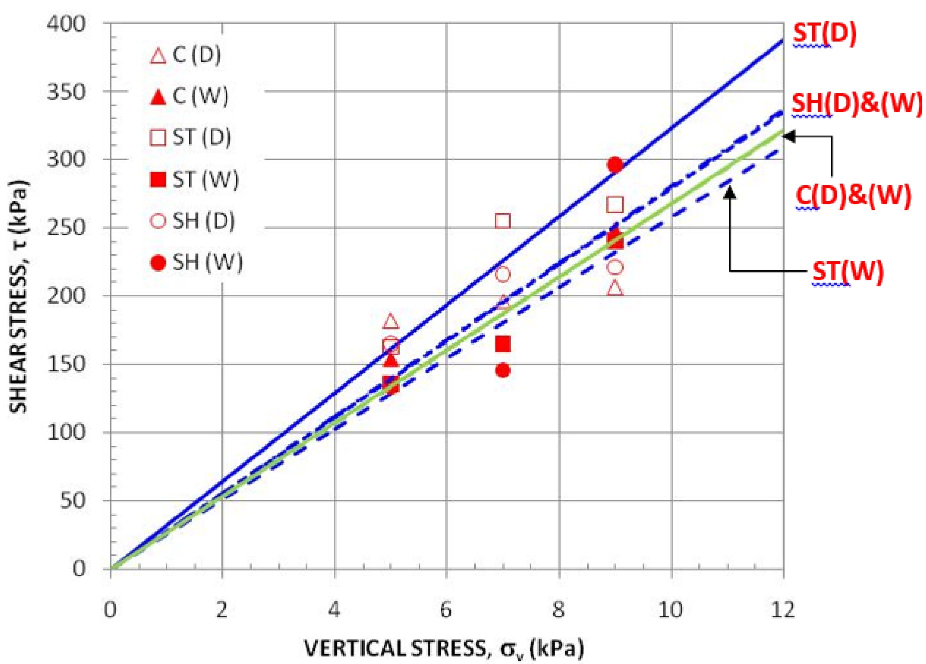


$\varepsilon_v - \varepsilon_h$ plots.

RESULTS & DISCUSSIONS

Table 1. Summary of friction angle (ϕ).

Specimen	tanϕ		ϕ (°)	
	DRY (D)	WET	DRY (D)	WET
Control (C)	26.83	26.76	87.87	87.86
Strip (ST)	32.30	25.82	88.23	87.78
Shred (SH)	27.94	28.11	87.95	87.96



$\tau - \sigma_v$ plots.

CONCLUSIONS

- Rubber inclusions are **effective** in enhancing shear resistance of ballast.
- Wet condition somehow **impeded** the mobilization of shear resistance, but the overall deformation of the composites was reduced, with higher shear resistance mobilized too.
- **Future work** could include more detailed rubber-aggregate configurations, surface treatment of the rubber elements to improve the frictional contact, protection of the train's metal wheels with reduced ballast breakage from the cushion effects of the rubber elements.

THANK YOU