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Evaluation of Mechanical Properties for Elastomeric Rubber/Steel Laminates Used as Bridges Expansion Joints

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Abstract: In this study, the mechanical properties representing by tensile strength and elongation at break for the as-received steel reinforced rubber expansion joints were measured. Shore A hardness test was also measured. The tensile specimens were prepared according to ASTM D 4014. The results showed that steel plate reinforced rubber plays a significant role in stopping the crack initiating that occurred due to the continuous applied tensile load. The maximum tensile strength was reached of 16.73 MPa with a 456 % elongation at break and a shore A hardness value of 61.5 that gives the joints a superior durability and the required displacements of 330 mm in the bridge decks they are used to.

Key words: Rubber, expansion joints, tensile strength, bridges, properties, ASTM 4014

INTRODUCTION

The bridge expansion joints are structural components designed to provide smooth passage over the gap between adjacent sides of a deck joint, permitting relative translation (and rotation) of the two sides of a bridge deck (deck movement joint). They are also designed to absorb the movements due to thermal changes (strains or deformation) and dynamic movements of machinery (live loads or transport) (Chandrasekaran, 2009). The bridge expansion joints are fabricated from rubber with one or two pieces of metal where they normally have two ends; one is a flexible end and the other is a flanged end. The flexible ends of the expansion joints contribute to absorb lateral movements with low force. The service life of the expansion joints depends on their durability and reliability. To figure out the main damage mechanics this causing failure of expansion joints and to understand types of rubber/steel expansion joints, several studies have been attempted. For instance (Busel and Krotau, 2016) studied the expansion joints fabricated from rubber and steel fastened to the reinforced concrete with studs particularly its junction area under the dynamic effects. They found that using rubber and steel expansion joints deformed under its elastic operation. They do not lead to great expenses due to its fastening mechanism. Niemierko (2016) investigated different types of expansion joints fastened on different motorways in Poland. He conducted that most damages (or failures) of the tested joints were due to the noise reducing elements equipped to these joints and due to the improper connections of bolts through the expansion joints and the beams. Besides, some joints were damaged due to the vibrations or the dynamic actions. It was suggested that avoiding using threaded bolts with a conic shape head could reduce the damage of expansion joints due to dynamic load. Additionally, Allen (2008) evaluated the effect of shear strain rate in steel reinforced rubber bearing pads used in highway applications. The results showed that the variation in shear strain rate has a negligible effect on modulus. Nevertheless, there is no study by yet, clearly nvestigated the principal mechanical properties of rubber reinforced by steel expansion joints. This study aims to experimentally address the tensile properties values of the as-received rubber expansion joints used for highways and bridges in Iraq.

MATERIALS AND METHODS

In this study, as received pre-fabricated elastomeric rubber reinforced by laminated steel plates bought from AGOM joints with dimensions shown in Table 1 and Fig. 1 were used to transfer loads in bridges or accommodate relative movement between the bridge and its supporting structure.

Testing procedure: The mechanical properties represented by tensile strength, Young modulus, elongation at break and hardness were determined for four

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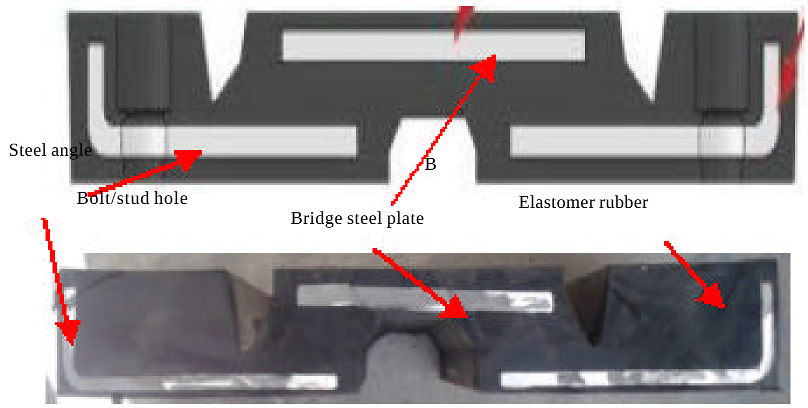

Fig. 1: The as-received rubber expansion joints used in this study (transverse section)

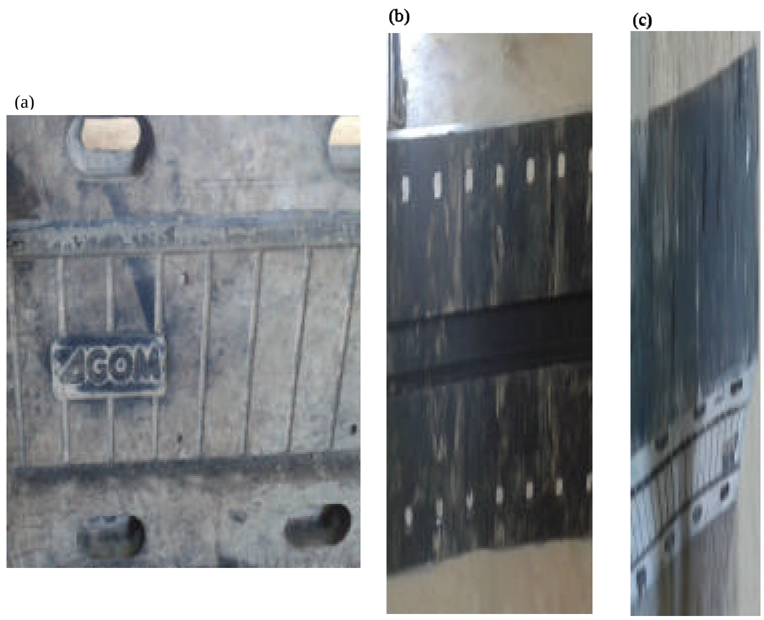

Fig. 2: The as received rubber expansion joints (Longitudinal section): a) Top-view of the sample; b) Top-view of the sample-long section and c) Side-view of the sample

Table 1: Details of the as-received rubber expansion joints samples

Width (mm)	Weight/m (kg/m)	Total thickness (mm)
390	46.07	54

Table 2: Results of the mechanical properties for the expansion joints

Tensile strength (MPa)	Elastic Modulus (GPa)	Elongation at Break (%)
16.73	3.66	456.72

prepared samples of elastomeric rubber expansion joints. The samples were prepared according to ASTM D4014 (Anonymous, 2018) (Fig. 2).

RESULTS AND DISCUSSION

The mechanical properties represented by tensile strength, elastic modulus and elongation at break of the elastomeric rubber-steel samples were listed in Table 2. The force-displacement curve of the rubber joint sample under the tensile test was shown in Fig. 3. The ultimate tensile strength was determined by dividing the maximum tensile force by the cross-sectional area of the test specimen. The ultimate load of the rubber joint reached 15.4 kN at a maximum displacement of 66.39 mm to give an ultimate tensile strength of the rubber expansion joint is 16.73 MPa and tensile modulus is 3.66 GPa at 456.72% elongation at break. The elastomeric samples before and after applying the tensile load were shown in Fig. 4 and 5.

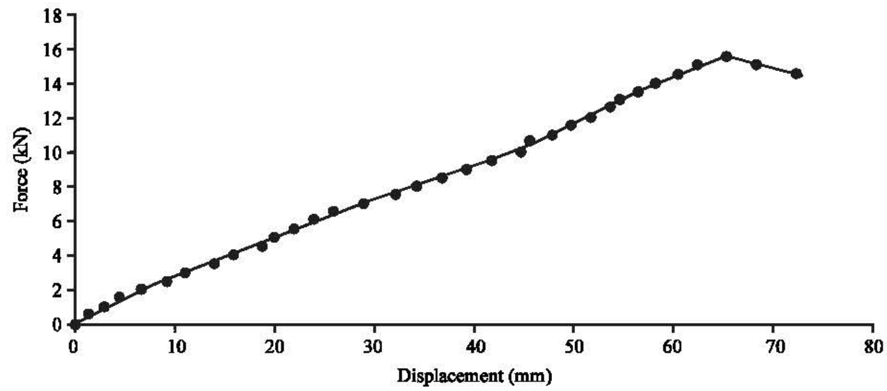

Fig. 5: a-c) Steps of rubber expansions under tensile test

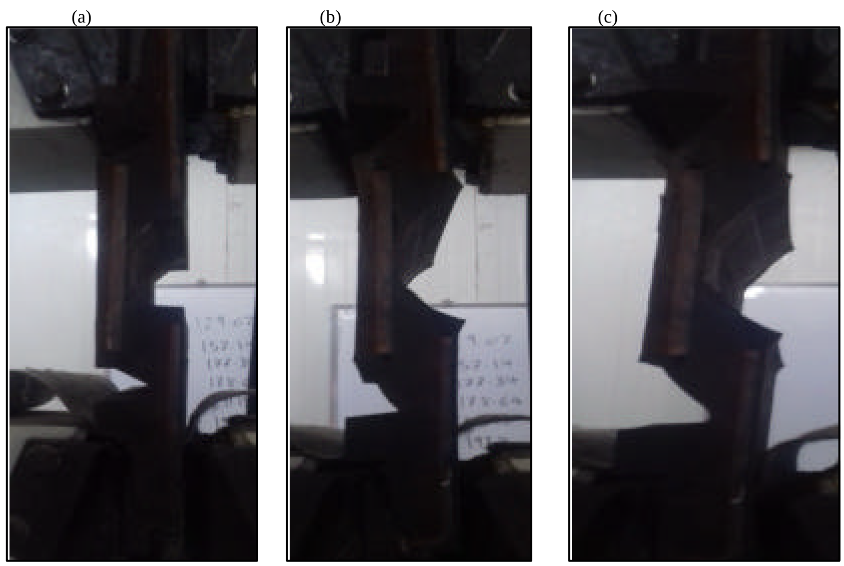

Fig. 3: a-c) The force-displacement curve of the rubber joint sample

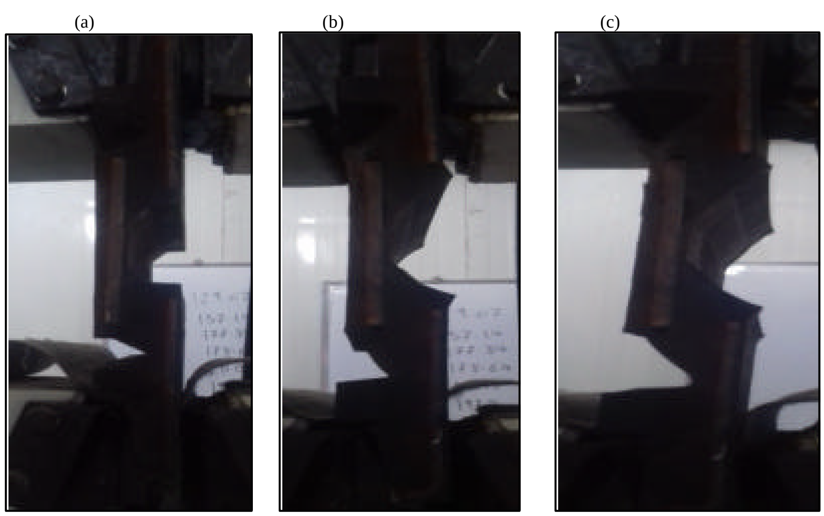

Fig. 4: Rubber expansion joints before and after tensile test

Result of the shore A hardness test of the rubber-steel expansion joints was 61.5. This value is the average of three tests that is sufficient to with stand large lateral movements (displacements) according to the standard requirements of the expansion joints for the bridge or highways applications (Sen and Adeli, 2006; Xiang *et al*., 2017).

CONCLUSION

In this study, the mechanical properties represented by tensile strength, Elastic modulus, elongation at break and hardness of the as-received elastomeric rubber reinforced by steel laminate were experimentally investigated. The results showed the following: The tensile strength of the expansion joints reached as maximum as 16.73 MPa which is in conformance with the standard requirements. The elongation at break reached it maximum at 456.72 %. The steel plate played a major role in stopping the propagation of elongation occurred in the rubber under the excessive tensile load. Shore A hardness value was 61.5 which is able to withstand the lateral movement or applied load due to crushing or fastening by bolts.

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