Analysis of Strain Rate Dependent Tensile Behaviour of Palm-Based Elastomeric Polyurethanes

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Abstract: The stress-strain behaviour of elastomeric polymers, such as polyurethane (PU), exhibit high rate dependency, stress–strain non-linearity, and high pressure dependency when compared to other construction materials. Since these polymers exhibit the potential to be applied as retrofitting and protective material for various types of structural materials, in enhancing their load-carrying capacity, ductility and structural survivability under different loading regimes, it is essential to comprehensively investigate their mechanical behaviour at varying strain rates. This study was undertaken to investigate the tensile stress-strain characteristics of elastomeric PU at varying strain rates, ranging from 0.001 s^{-1} to 0.1 s^{-1} (low to intermediate). The primary emphasis of this study was on the strain rate sensitivity of the tensile properties, including the Young's modulus, tangent modulus, ultimate tensile stress, fracture strain, and strain energy modulus. The findings indicated that stress-strain behaviour of the PU exhibited high dependence to variations in strain rates and stress–strain non-linearity. The behaviour of PU also provided good concurrence with recent studies, which explored the strain rate dependency of other elastomeric polymers.

Keywords: Dynamic loading, Polyurethane, Strain rate, Stress-strain behaviour, Tensile behaviour.

1. Introduction

Elastomeric polymers, such as polyurethane (PU), are currently considered amongst promising materials for several types of structural applications, where these polymers provide extra structural capacity, and resistance against severe environmental conditions. Typical examples for applications of elastomeric polymers in numerous industries vary from building structural elements (masonry, concrete, steel and composite elements), vehicles, infrastructures including underground structures (such as pipelines), marine constructions, etc. [1-3]. The conventional technique of enhancing the capacity of a structural element is by increasing the mass in order to enhance the stiffness of the element. Though it is used commonly, it forms obstacles such as; high initial cost, high materials and resources consumption, and inappropriateness for the existing structures [3]. Consequently, structural and material engineers have been investigating to find more appropriate solutions as alternative for those techniques.

Based on the prior investigations, it can be observed that increasing the energy absorption capacity of the element is an efficient technique to reduce the level of destruction and fragmentation effect of failures under impulsive loading conditions [2,3]. To achieve high energy absorption in structural elements, it is essential to use materials which possess high stiffness and strain capacity. Although cementitious materials are known to have high stiffness values, they fail via tensile cracking when overloaded, since cementitious materials have low tensile strain capacity (with tensile strain of about 0.0001, nearly one-tenth that of compressive strain), and with low fracture toughness approximately 0.01 kJ/m^2, compared with other construction materials such as mild steel (100 kJ/m^2), they are extremely brittle [4]. Elastomeric polymers including PU have been of great interest among the structural and material engineers, and are also considered for the blast