

# On the residual energy toughness of prestressed concrete sleepers in railway track structures subjected to repeated impact loads

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**ABSTRACT:** Installed as the cross-tie beam support in railway track systems, the prestressed concrete sleepers (or railroad ties) are designed in order to carry and transfer the wheel loads from the rails to the ground. It is nowadays best known that railway tracks are subject to the impact loading conditions, which are attributable to the train operations with either wheel or rail abnormalities such as flat wheels, dipped rails, etc. These loads are of very high magnitude but short duration, as well as there exists the potential of repeated load experience during the design life of the prestressed concrete sleepers. These have led to two main limit states for the design consideration: ultimate limit states under extreme impact and fatigue limit states under repeated impact loads. Prestressed concrete has played a significant role as to maintain the high endurance of the sleepers under low to moderate repeated impact loads. In spite of the most common use of the prestressed concrete sleepers in railway tracks, their impact responses and behaviours under the repetitions of severe impact loads are not deeply appreciated nor taken into the design consideration. This experimental investigation was aimed at understanding the residual capacity of prestressed concrete sleepers in railway track structures under repeated impact loading, in order to form the state of the art of limit states design concept for prestressed concrete sleepers. A high-capacity drop weight impact testing machine was constructed at the University of Wollongong as to achieve the purpose. Series of repeated impact tests for the in-situ prestressed concrete sleepers were carried out, ranging from low to high impact magnitudes. The impact forces have been correlated against the probabilistic track force distribution obtained from a Queensland heavy haul rail network. The impact-damaged sleepers were re-tested under static conditions in order to evaluate the residual energy toughness in accordance with the Australian Standard. It is found that a concrete sleeper damaged by an impact load could possess significant reserve capacity sufficient for resisting the axle load of about 1.05 to 1.10 times of the design axle loads. The accumulative impact damage and residual energy toughness under different magnitudes of probabilistic impacts are highlighted in this paper. The effects of track environment including soft and hard tracks are also presented as to implement design guidance related to the serviceability or fatigue limit states design.

*Keywords: Prestressed concrete sleeper; Repeated impact behaviour; Impact fatigue; Accumulative damage; Residual energy toughness; Ballasted railway track*