Numerical Modelling of Prestressed Concrete Sleepers for Kenyan Railway

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Abstract

Railway sleeper is an essential component of the railway track structure in ensuring vertical, lateral and longitudinal stability of the track. The technological practices in design and construction ensure its success to take up the challenge of faster and heavier traffic.

Following the recent challenges concerning frequency of maintenance, derailment, need to increase axle load, vandalism of steel sleepers and other sleeper-related problems in Kenya, a proposal to modernize the Kenyan railway track with prestressed concrete sleepers has been made. Its introduction needs clear validation procedures to ascertain its structural performance.

Traditionally, experimental programmes have been used at design and construction stages to determine the capacity of concrete sleepers. This thesis explores the use of homologation procedures as a tool in verifying the performance of prestressed concrete sleepers in Kenya. The static tests in the procedure is then simulated using a commercial finite element software package, DIANA release 9.4 following a calibration of the finite element model with secondary experimental data.

The finite element model was developed using CHX60 solid brick elements in which the compressive crushing of concrete and the concrete cracking in tension zone is accommodated by the total strain fixed crack model. Additionally, embedded reinforcement elements were utilized in modelling the prestressing tendons. The pretensioning is modelled via an initial stress in the tendon elements and assuming perfect bonding between concrete and prestressing wires.

The thesis further demonstrates the interpretation of the finite element analysis results to simulate the homologation procedures. It is shown that DIANA release 9.4 can simulate homologation procedure within the acceptable 2% margin. From the findings, continued research on simulating dynamic and fatigue tests described in homologation procedure is recommended.