Prediction of residual stresses in bridge roller bearings using Abaqus

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Abstract: *An analysis of bridge roller bearings was performed using Abaqus as part of a failure investigation. Finite element analyses were conducted to gain an understanding of the stresses caused during operation and explain the possible cause of failure. Models of the bearings were required to represent the contact between the roller and plates, daily movement of the load and the non-linear behaviour of the material. An important output was prediction of residual stresses along the contact area of the rollers, induced by repeated rolling as the bridge expands due to daily and seasonal temperature cycles.*

Linear kinematic and non-linear isotropic/kinematic models available in Abaqus were used to model the material behaviour, both of which predicted significant tensile stresses at the roller surface that did not match experimental observations. Further, this tensile residual stress remained when the bearing load was reduced below that required to induce plasticity. Surprisingly, the residual stresses remained even when purely elastic material was used and were found to steadily increase in magnitude with further cycling. The cause of these spurious stresses is believed to be due to numerical modelling of the material combined with incremental analysis in Abaqus.

A new finite-elastic, finite-plastic (Fe-Fp) material model recently developed by Abaqus was used successfully to reduce this stress. However, at the time the analysis was performed it was only available for use with isotropic hardening, and was therefore inappropriate for modelling situations involving cyclic plasticity where kinematic effects are important. Due to the need to simulate rolling contact, geometric nonlinearity (NLGEOM option) had to be used. Caution must therefore be exercised when performing nonlinear analyses involving cyclic plasticity with geometric nonlinearity.

Keywords: *Residual stress, roller bearings, Thelwall viaduct, NLGEOM, FeFp, material hardening, isotropic, kinematic, non-linear, cyclic loads, elastic, plastic, civil, transport, user subroutines*

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