Analysis of pre-tensioned structures by means of a constitutive Serial-Parallel rule of mixtures

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ABSTRACT

The main purpose of this paper is to develop a reliable method based on a three-dimensional (3D) finite-element (FE) model to simulate the constitutive behavior of reinforced concrete structures strengthened with post-tensioned tendons. A 3D FE model was used, where the nonlinear material behavior and geometrical analysis based on incremental–iterative load methods were adopted.

The pre-tensioned concrete is modelled as a composite material whose behavior is described with the serial-parallel rule of mixtures (S/P RoM). The effective pre-tensioning stress was applied as an initial strain imposition in the steel material used to model the tendons.

By means of the S/P RoM [1,2] equilibrium is reached at each integration point between the passive and active steel and concrete and the strain tensor of the steel is updated with the contribution of the concrete. In posterior global iterations the structural displacements are updated and global convergence is reached for the applied load.

The S/P RoM allows the use of different constitutive models for each component (active and passive steel and concrete) and by using a Generalized Maxwell model for the steel tendons the viscoelastic stress relaxation can be accounted for throughout the service life of the pre-tensioned concrete.

The methodology is valid for both straight and curvilinear steel tendons. Examples of both cases will be shown. Validation by comparison with the analytic solution will be done for the case of a concrete beam with a straight pre-tensioned steel tendon embedded. Other examples will be included.

REFERENCES

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