TERTIARY CREEP IN CONCRETE

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Abstract: Time dependent concrete fracture is simulated using a rate type creep model coupled with a discrete concrete model. The numerical study uses experimental data, of various tests, three point bending, relaxation, tensile, performed on concrete. This contribution demonstrates the capability of the model to capture the time dependent fracture behavior of concrete, and predicts the critical time of failure.

1. Introduction

Tests performed by Zhou [4], shows a progressive damage evolution in concrete, in course of time, that ultimately leads to failure after certain time, depending on the load level. This behavior is caused by nonlinear creep, tertiary creep, of concrete, and thus a complete model that accounts for creep and damage is required. In this contribution it is utilized a rate type creep model based on the MicroPrestress-Solidification theory (MPS) [1] implemented in a discrete formulation, the Lattice Discrete Particle Model (LDPM) [2]. The aforementioned mechanical model is selected, due to its capability to capture the experimental mechanical behavior of concrete in a quite good accordance to many different experimental data. Similar numerical investigation has be done using a rate type creep model with a continuum concrete model [3]. However, the purpose of this contribution is to study the performance of a rate type creep model coupled with a discrete model.

2. Results

Various experimental tests related to different aspects of the mechanical response of concrete are used for calibration of the numerical model. In particular, uniaxial compression of cubical specimens of 100x100 mm, tensile, and relaxation tests, on notched cylinders of 64x60 mm, with a notch width of 4mm, and three point bending of 840x100x100mm, with a notch height of 50mm and width of 4mm, are used. The latter are also used for time to failure tests, loaded under sustained load at 75, 80, 85, and 90% of the peak load. Concrete mix design has a cement content of 420 kg/ m^3, a water to cement ratio of 0.55, a sand (0-2mm) to aggregate content of 1000 kg/m^3, and crossed stone aggregates (2-4mm) to aggregate content of 600 kg/m^3. Concrete has compressive strength at 28days, f_{cm28}=38MPa, and at age of testing, tensile strength, f_t = 2.8 MPa, Young Modulus, E = 36GPa, and fracture energy, G_F = 82 Nm/m^2.

First we calibrate parameters of the mechanical model, in such way that we are acquiring the aforementioned mechanical response. Afterwards, creep parameters are calibrated using data of relaxation test. Finally, three point bending tests are simulated, loading and sustain the loads at load levels of 75%, 80%, 85%, and 90% of peak load. The time to failure response, caused by damage propagation, due to nonlinear creep is estimated. The preliminary numerical study shows creep response of crack width, similar to the experimentally observed. Addi-

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tionally, critical time at which the specimen fails seems to be in the same order of magnitude with the measured.

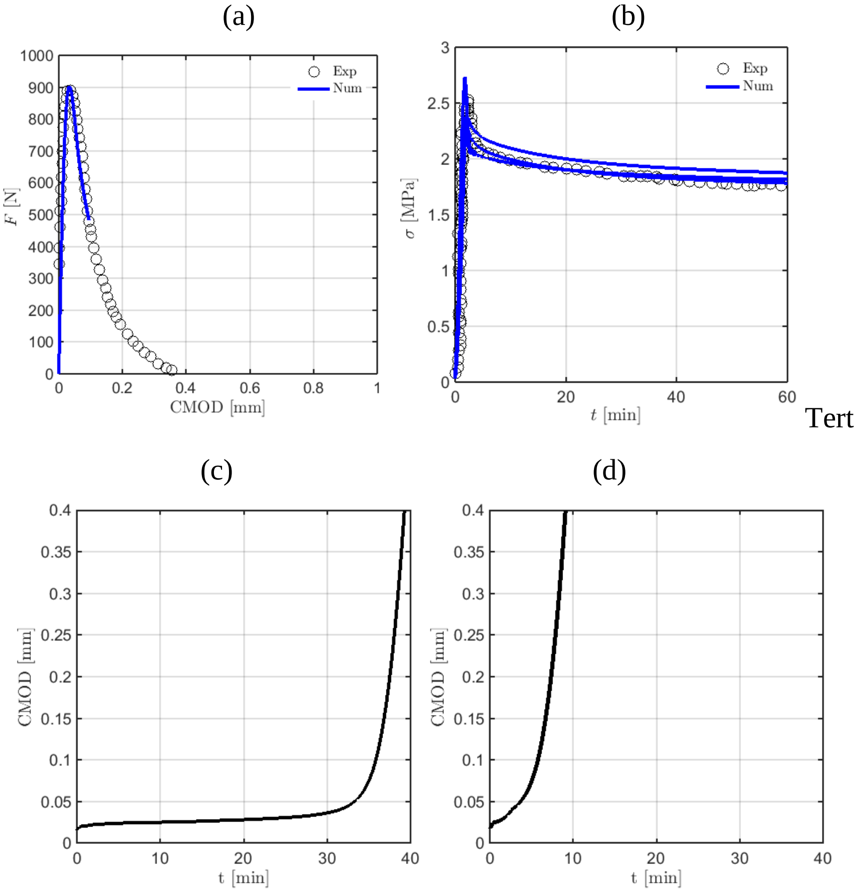

Figure 1. (a) Calibration of mechanical properties on TPB test and (b) of creep model on relaxation test, creep response in TPB under sustained load for (c) 80% and (d) 90% of peak load, respectively.

3. Conclusions

A rate type creep approach accounting also for damage by means of a discrete model is adopted. After calibrating the mechanical parameters on standard tests, and the creep parameters using relaxation tests data, the model is used to simulate time to failure on three point bending sustained load tests, as a validation of model.

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