TOWARDS MODELING OF PROGRESSIVE COLLAPSE IN FRAME STRUCTURES

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Introduction

This study numerically investigates the performance of frame structures using a nonlinear finite element analysis method in the event of a column loss. **Progressive collapse** typically occurs when a column fails and creates a "domino effect", which can collapse a multistory building. Three mechanisms occur after a column loss:

(a) Arching action: Rising axial compression and load capacity.

(b) Plastic hinge action: Diminishing load capacity due to concrete cracking and rebar yielding.

(c) Catenary action: Rising load capacity when the beam and reinforcing goes under pure tension.

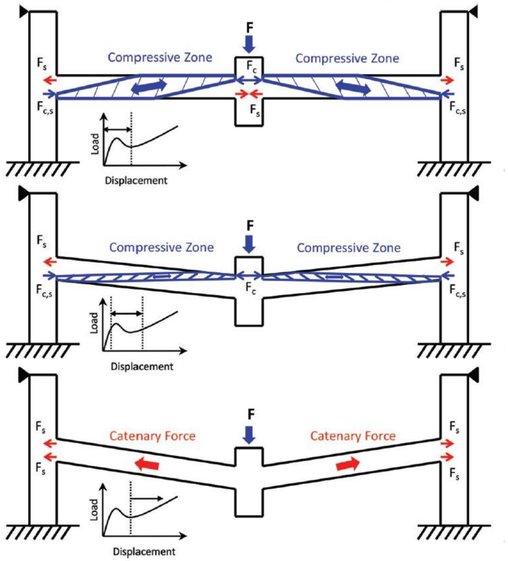

Fig. 1. Load Transfer Stages (Lew *et al.,* 2014)

Methodology

Nonlinear analysis was conducted with **VecTor5** (Guner and Vecchio, 2010), a computer program developed for reinforced concrete frames. It employs the Distributed Stress Field Model (Vecchio, 2000) along with the following material behavior models:

(1) Concrete cracking
(2) Tension stiffening
(3) Tension softening
(4) Compression softening
(5) Concrete confinement
(6) Concrete shear slip
(7) Geometric nonlinearity
(8) Rebar buckling
(9) Rebar dowel action
(10) Nonlinear rebar hysteresis

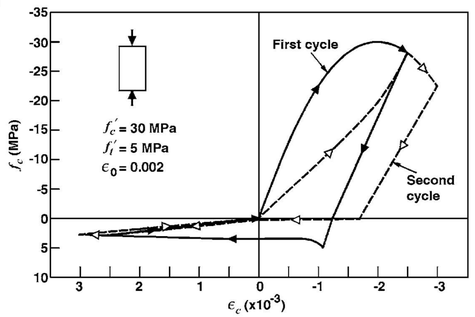

Fig. 2. Concrete Hysteresis (Vecchio, 1999)

Frame Modeling

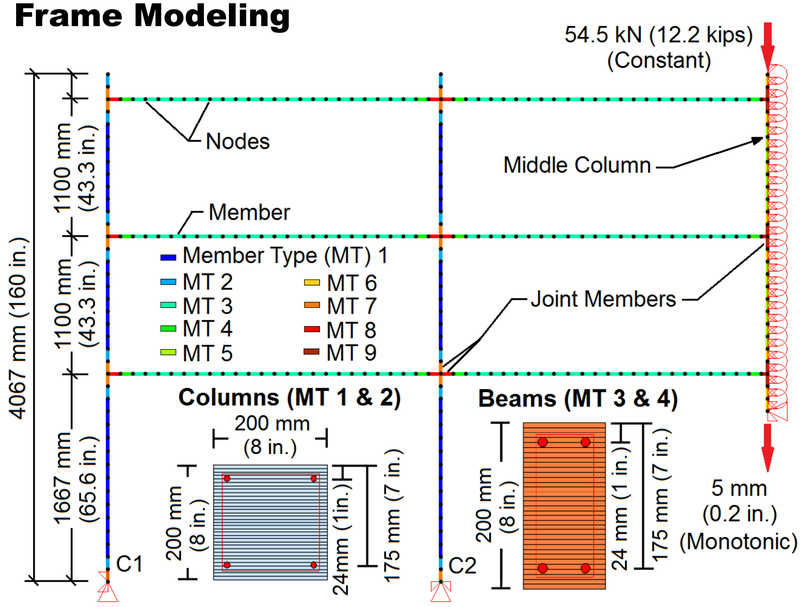

Fig. 3. Analytical Model (Half of the Frame) and Cross Sections

Eight frame specimens were modeled in this study, but only the frame tested by Yi *et al.* (2008) is examined in this poster. A concrete strength of 21 MPa (3 ksi) was used. The finite element mesh was created (**Fig. 3**) using a pre-processor program, FormWorks Plus (Sadeghian, 2012).

Results

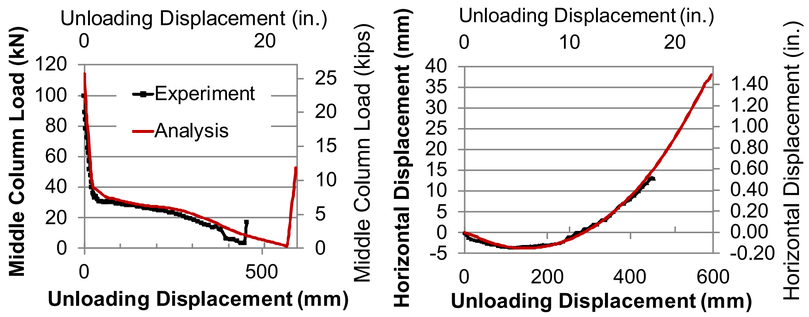

Fig. 4. (a) Load-Deflection Responses **(b)** Column C2 Horizontal Displacement

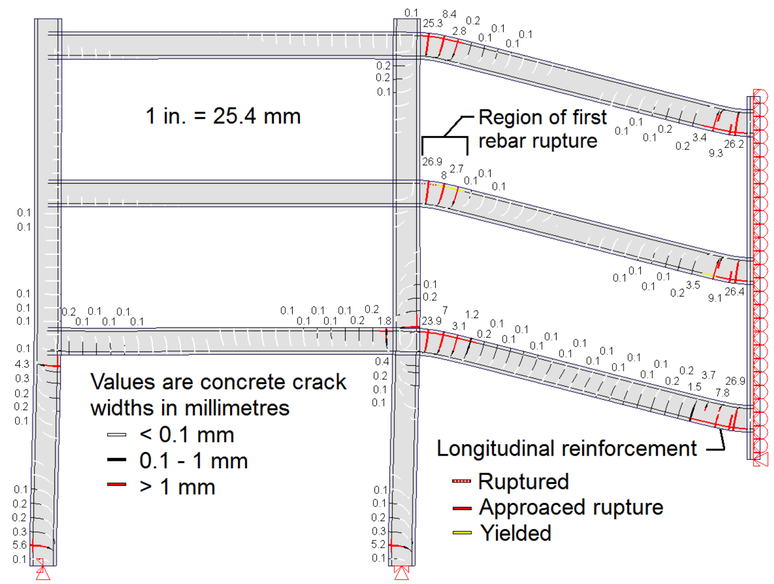

Fig. 5. Analysis: Cracking and Rebar Conditions at Failure

The analysis successfully captured the experiment behavior (**Fig. 4**). The ruptured rebar in the beam and major flexural cracking were simulated well (**Fig. 5** & **6**).

Conclusions

(1) The computational procedure captured the progressive collapse mechanisms and failure modes, including concrete cracking and rebar ruptures.

(2) The experimental behaviors relied heavily on the beam-column joint response. A more accurate joint model incorporating bond-slip should be developed in a future study.

Fig. 6. Experiment: Collapse Limit State (Yi *et al.*, 2008)

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