

**EXAMPLE 3-002**

**Reinforced Concrete Column under Cyclic Load**

**1. EXAMPLE DESCRIPTION**

Figure 1 illustrates a reinforced concrete column subjected to cyclic loading at its top [Ref. 1]. Dimensions, reinforcement details and loading setup are shown in Fig. 1.a. The mesh discretization of the problem as used in ELS® is shown in Fig.1.b. Figure 2 shows the displacements at each stage.

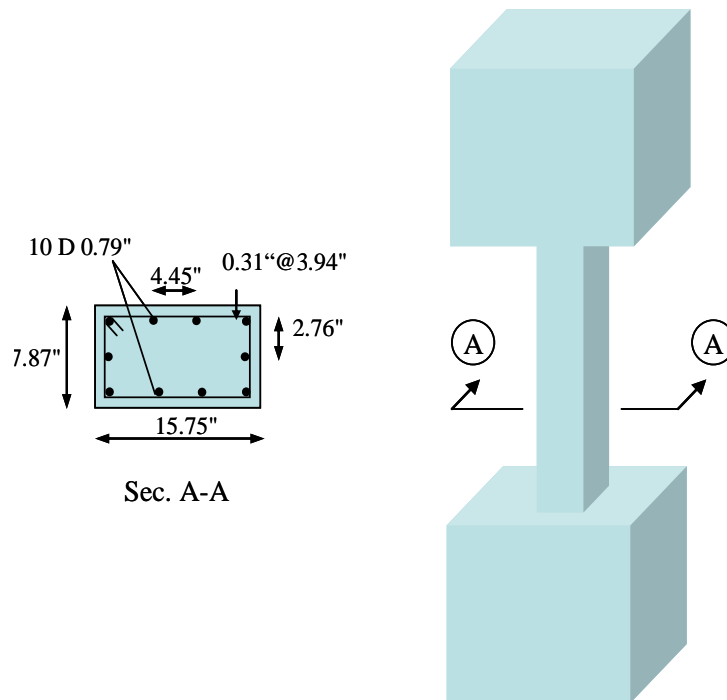


Fig. 1.a Problem geometry

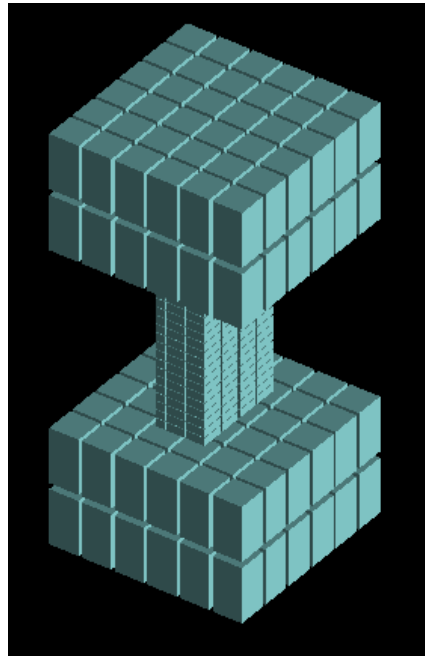


Fig. 1.b ELS mesh

Fig.1 Reinforced concrete column under cyclic load

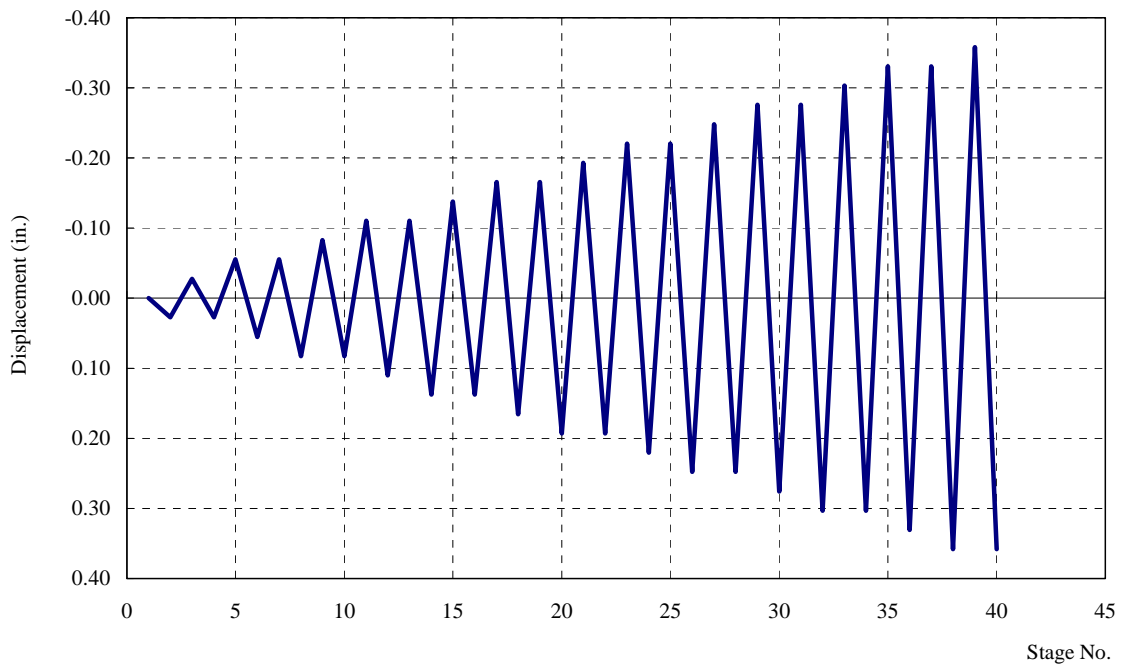


Fig. 2 Input displacements at each stage

## 2. MATERIAL PROPERTIES

The compressive strength of the column concrete is 8.90 ksi (0.06 kN/mm<sup>2</sup>), while the yield stress of the longitudinal and transverse reinforcement was 76.80 ksi (0.53 kN/mm<sup>2</sup>) and 42.76 ksi (0.29 kN/mm<sup>2</sup>).

The applied element method follows a discrete crack approach, in which, the material is represented by a group of springs located at the surfaces of the element. The springs represent the axial and shear behavior of the material. For more details about material constitutive models refer to the ELS® technical manual.

## 3. RESULTS

Figure 3 illustrates the analytical load-deflection curve compared to the experimental one. As can be obviously seen, the analytical results are in a good agreement with the experiments. The behavior is reasonably predicted in the elastic stage, post cracking stage, post-yielding stage, and in the hysteretic loops. The overall response could be generally well obtained by ELS. Fig. 4 shows the observed experimental cracking pattern of the column compared with the ELS®. The experimental cracks are generally in a good agreement with the ELS results.

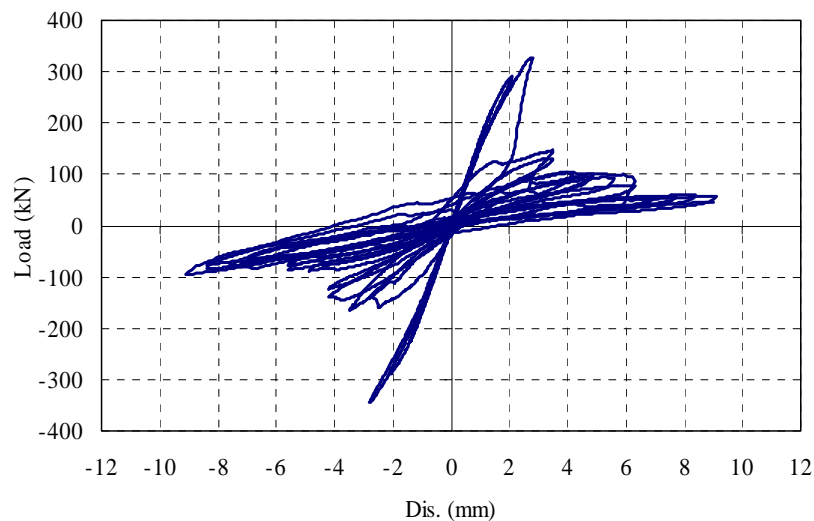


Fig. 2.a ELS results

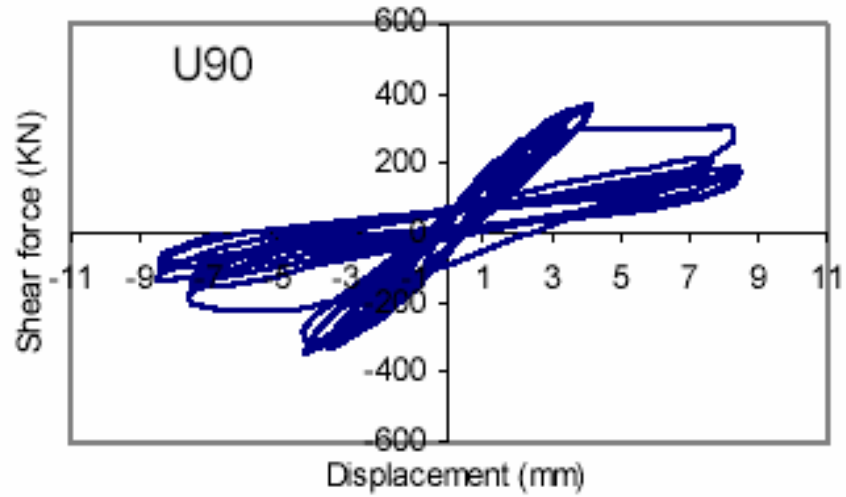
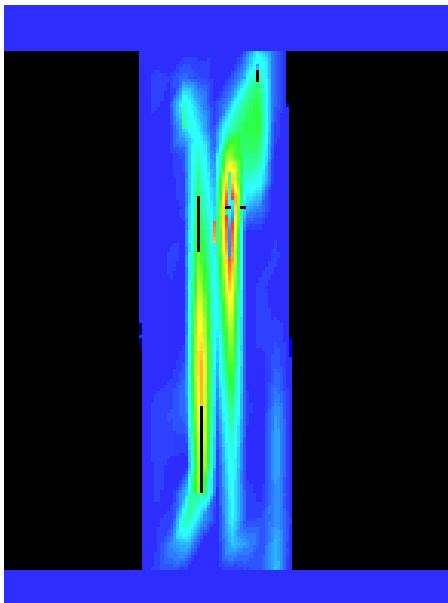


Fig. 3.b Experiments [Ref.1]

Fig. 3 Load-deflection predicted by ELS in a comparison to the experimental results.



ELS



Experimental

Fig. 4 Cracking Patterns Predicted by ELS in a comparison to the experimental results

#### 4. CONCLUSIONS

Based on the analytical and experimental results, it can be concluded that the ELS can successfully analyze and predict a close-to-reality nonlinear behavior of reinforced concrete structures under cyclic loading.

#### 5. REFERENCES

- 1- Nguyen, X.H. and Irawan, P. (2003). "Experimental Study on Shear Capacity of RC Short Columns under Multi-directional Loading", Proceedings of the FIB Symposium on Concrete Structures in Seismic Regions,, Athens, Greece, Paper No. 163.
- 2- Technical manual of extreme loading for structures.