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RESEARCH ARTICLE

# ANALYSIS OF A CANTILEVER COLUMN SUBJECTED TO CYCLIC LOADING

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**ABSTRACT**

In a seismic incident, the structural steel columns are commonly damaged with local buckling formulation at either the top or bottom ends. This study analyzes and simulates the hysteretic behavior of a hollow square steel column under cyclic loading by adopting the fiber-element approach. This method discretizes the hinge zone into a series of fibers and considers buckling behavior of those fibers along the column wall. The analytical result was achieved in good agreement with the component test.

**KEYWORDS**

cantilever column, local buckling, fiber element

## 1. Introduction

A full-scale four-story steel building specimen was experimented to collapse using strong ground motions on the E-Defense shake-table in Miki city, Japan (Nam et al., 2011). Collapse occurred due to a side-sway mechanism in the first story with local buckling of columns at the top and bottom ends (Figure 1). The main reason for column failure was bi-axial bending effect, due to concurrently large bending moments in both directions. Yielding also occurred in other members but they did not govern the collapse. However, behavior of the specimen involving column yielding and buckling is still very difficult to simulate. This paper, therefore, presents an analytical study on column behavior with the formulation of plastic hinges subjected to cyclic loading, in comparison with the component test result.

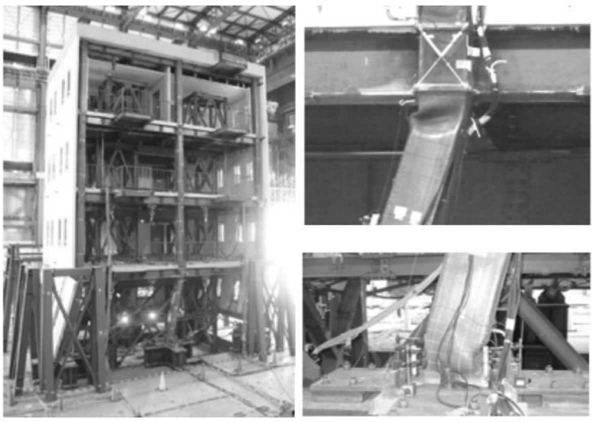

**Figure 1:** Collapse cause by column failure after the experiment

## 2. Cantilever Column Analysis

### 2.1 Experiment data

Experiment data are taken from the cyclic loading test of a cantilever column subassembly (Figure 2). The specimen is a tubular cross-section column RHS-300x9 of BCR295 material, the same as those used in the collapse building. The column is subjected to both constant compression axial force (N=500kN) and cyclic lateral force (P). Two cases of 0-degree loading and 45-degree loading were tested.

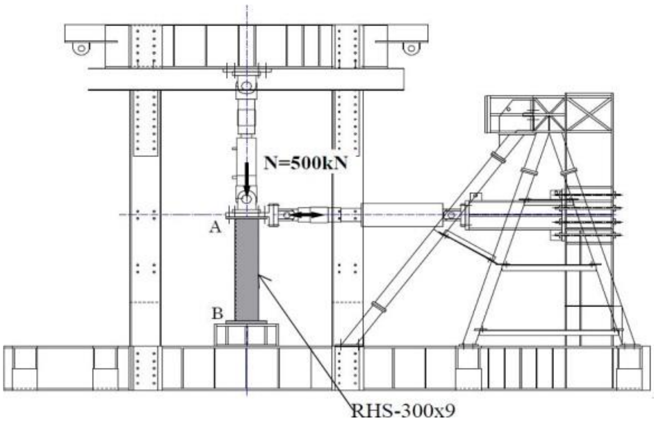


**Figure 2:** Cyclic loading test of a cantilever column

### 2.2 Fiber approach in analysis

The most difficult portion to the analysis is the hinge zone. Fiber approach was employed in this study, where the hinge zone is modeled as two rigid plates connected by fibers distributed over the cross section (Figure 3). Fiber elements are modeled to have zero length, which means the two nodes, A and B, have the same coordinates. But its rotation characteristics are defined by considering finite length of buckling zone, and stress-strain properties are based on the finite length.

To compute stiffness of fiber hinge element, the hinge length is typically set equal to the column cross section depth. Fiber strains are assumed constant over the hinge length. The fibers have nonlinear stress-strain relationships. Figure 4 indicates the behavior rule of fiber elements (Black

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et al., 1980), where $\sigma_y^+$and $\sigma_y^-$ represent yield stress due to tension and buckling stress due to compression, respectively. $\varepsilon_1,\varepsilon_2,\varepsilon_3$ are negative strains associated with each gradually reduced buckled stiffness of the member, and $\alpha$, $\beta$, $\gamma$ are factors used to define the stresses corresponding to some control points on the curve.

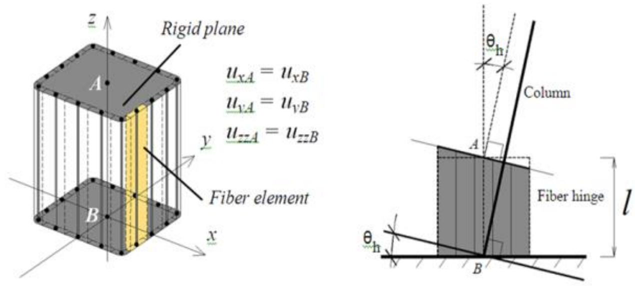


**Figure 3:** Fiber hinge model

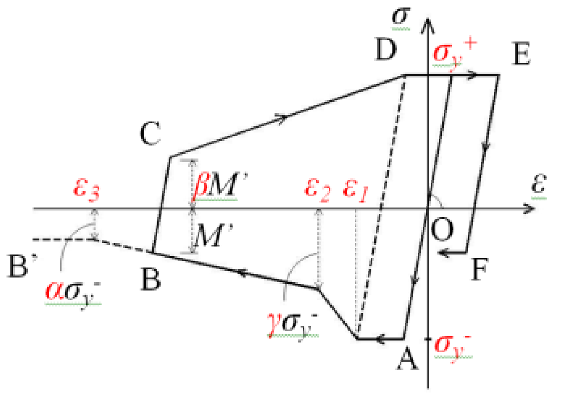


**Figure 4:** Fiber hysteresis curve

The first zone O-A indicates compressive loading of the element which approaches the critical buckling stress (assumed to be equal to yield stress) at point A. Zone A-B is characterized by a decreasing load accompanied by element shortening. Zone B-C-D-E is the compressive unloading and tensile loading of the fiber element. Subsequent hysteretic loops have the same characteristic except that the consecutive peak compressive stresses are reduced due to deterioration caused by the previous inelastic cycling of the material. Hence, the compressive yield stress at point F, where the element begins to yield in compression, is set equal to the value of compressive stress at point B. Point B is named for the reversal location of the curve when the element shortening stops. This location changes depending on each load cycle. Accordingly, the curve c**3.**

## 3. Analysis Results

The target is to mimic the same behavior of the column in the experiment. Initially, considering all fibers have the same properties, the obtained hysteresis curve for 0-degree case is quite good. Then, the same model is used for 45-degree loading case. The result seems to be satisfied for some beginning cycles. However, the curve degrades laterally. Therefore, the model is improved by dividing fibers into corner and plate ones. Corner fibers are those located at the curved corner of the cross section (Figure 5). Plate fibers are the rest. The corner fibers need to be modified appropriately so as to cover up the effect of work hardening.

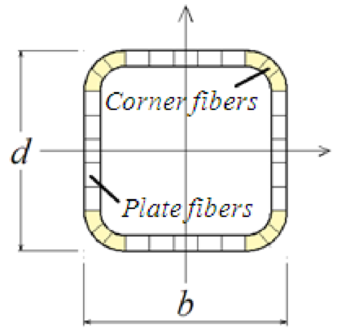


**Figure 5:** Fiber distribution

Based on the shape of the hysteretic curve presented above, we can adjust those major parameters characterizing corner and plate fibers to obtain the best fitness between test data and analysis output. A number of trials were done afterwards; the most acceptable obtained results are shown in Figure 6. The curves seem to be well matching along the initial cycles. However, degradations appear in the final cycles. A more perfect model is still expected in the coming time.

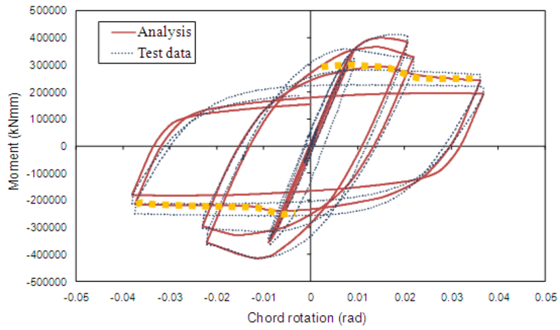


**Figure 6:** Column behavior during cyclic loading

## 4. Concluding Remarks

This study is the first part of a full research in which a proper simulation and analysis of the collapse mechanism of the tested specimen is expected. In this first stage, behavior of a simple cantilever column is studied. The next steps are studying behavior of various kinds of column configuration, involving beam-column connection also. After this step, results from the study will be applied in an analytical interpretation of the observed collapse mechanism.

## References

Black, G.G., Wenger, W.A., Popov, E.P. 1980. Inelastic Buckling of Steel Struts under Cyclic Load Reversals, Report No. UCB/EERC-80/40, University of California, Berkley.

Nam, T.T., Kasai, K. 2011. Dynamic analysis of a full-scale four-story steel building experimented to collapse using strong ground motions. Proceedings of the International Symposium on Disaster Simulation and Structural Safety in the Next Generation DS'11, Kobe, Japan, pp.311–318.