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Stable Ultimate Deformation of Confined Columns Subjected to Seismic Loads

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Summary

A method to evaluate the stable ultimate deformation of the confined concrete columns under seismic loading was proposed. In this method, stable ultimate deformation of a column was defined as the deformation reached when the axial strain at the center of the critical section was equal to half of the peak strain of the confined concrete. The validity of the proposed method was verified by comparing the theoretical ultimate deformation obtained using this method with the measured results of confined concrete columns under cyclic reversed bending moment.

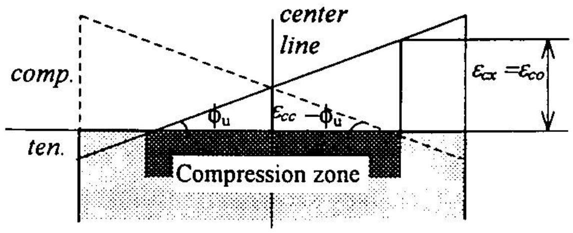
1. Introduction

The ultimate deformation plays a fundamental role in evaluating seismic performance of the reinforced concrete columns. For easiness, the deformation in which the load is dropped to 80% of the maximum value has been conventionally defined as the ultimate deformation of the column under seismic load. However, the value of 80% in the conventional definition hasn't any physical meaning relating to the damage degree that can be tolerated by the column; besides, conventional definition might overestimate the deformability of the column under high axial load [1]. Therefore, it is necessary to develop a new criterion to define the ultimate deformation of the concrete column. The purpose of this paper is to propose a criterion for defining the ultimate curvature of the concrete column confined by transverse reinforcement.

2. Stable Ultimate Deformation

Fig.1 shows idealization of the strain distribution of confined section under cyclic moment. As shown in Fig.1, under high axial load, a compression zone exists in the section, this zone always subjects to compressive deformation while the moment is a reversed cyclic type. It is apparent that in order for the concrete section to provide stable resistance, the maximum compression strain (the strain in the center) at this zone should be limited below the peak strain ε_{co} ($\varepsilon_{co}/2$) of the concrete (see Fig.2), beyond which the strength deterioration in the concrete will become significant.

From the above theoretical consideration, the stable ultimate curvature of the confined column can be defined as the curvature in which the compressive strain ε_{cc} in the center of the section reached half of the peak strain ε_{co} of the concrete. Authors' experimental work [1] has indicated that the envelop curve of cyclic response coincided with monotonic curve until the ultimate curvature



Notations:
ε_{cc}= axial strain at the center of section
ε_{cx}= maximum strain at the compression zone
ε_{co}= peak strain of the confined concrete

Fig. 1 Idealization of the strain distribution of column section under cyclic moment

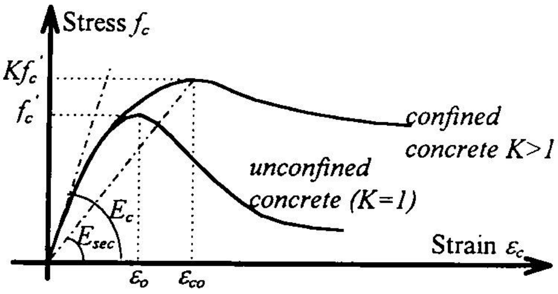


Fig. 2 Stress-strain curve for concrete

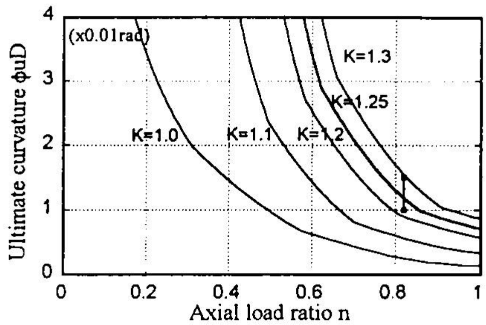


Fig.3 Stable ultimate curvatures

defined by the above-described criterion. Therefore the ultimate curvatures for the confined column can be obtained by only calculating the monotonic M-ϕ curves of the critical section of the column corresponding to various levels of axial load and confinement from transverse steels.

Fig.3 shows theoretical ultimate curvature ($\phi_u D$)-axial load ratio (n) curves for the test columns described in Ref.1. The parameter K shown in Fig.3 is the ratio of the confined concrete strength to the concrete cylinder strength, an index denoting the confinement degree, and D is depth of the section. For calculating the M-ϕ curves, a stress-strain curve for the confined concrete proposed by the first two authors [2] has been used. The solid squares in Fig.3 denote the lower and upper limit (0.01-0.015rad) of the test results of specimens. It can be seen that the theoretical solid line with K=1.25, which represents the confinement degree of the specimen presented in Ref.1 and is obtained using authors' confinement model [1], predicted the experimental results very well. On the other hand, following the conventional definition, the ultimate curvature would be 0.02-0.025rad, and clearly overestimated the ultimate deformation capacity of the test column.

3. Conclusion

A new criterion was proposed to relate the ultimate curvature to the axial deformation of the confined columns. Theoretical predictions obtained based on this criterion and authors' stress-strain model for the confined concrete exhibited good agreement with the measured result.

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