DISCUSSION OF PAPER

'A STUDY OF THE INELASTIC SEISMIC RESPONSE OF REINFORCED CONCRETE COUPLED FRAME – SHEAR WALL STRUCTURES'

W.J. Goodsir, T. Paulay and A.J. Carr

(Vol 16, No. 3, September 1983, -)
(pp 185-200)

Discussion by - R.L. Williams:
(Ministry of Works and Development, Hamilton)

I notice the system used strong column-weak beam philosophy. As the presence of walls controls drift it appears that the necessity to avoid column hinging is not necessary. Have the authors considered allowing ductile column hinging in such a structure? I feel that the ductile column system would be more economical when long span beams are present.

Authors' reply:

The question is one of choice between column sway and beam sway mechanisms. In terms of overall behaviour, column hinging in buildings in which deformations due to earthquake effects are controlled by structureal walls, should not be objectionable. However, the authors would offer the following points for consideration.

(i) Due to axial compression it is a little more difficult to achieve significant ductility in columns than it is in beams.

(ii) Ductility demand in column hinges necessitates confining transverse reinforcement, the quantity of which is generally more than the additional transverse reinforcement required in potential hinges of beams.

(iii) When the elastic response of column is assured, up to 50% reduction of transverse reinforcement in the end region may be obtained.

(iv) Lapped splices must not be used in potential plastic hinge regions. However, they may be placed immediately above floor levels in columns with sufficient strength in excess of the adjoining beam or beams.

The authors agree that with long span beams it would be more economical to design for plastic hinges in columns rather than increase both column size and reinforcement content in order to produce flexural strength in excess of the strength of the beams.

Discussion by S. Otani (University of Tokyo):

Would the authors comment on the displacement response waveform which indicated residual displacement as large as one-half the maximum displacement amplitude. It is appreciated if the damage calculated by the analysis is described with respect to the cause of this large residual displacement. If the two earthquake motions gave similar characteristics, there must be something inherent to the structure rather than accidental drift.

Authors' reply:

Time-history analyses were performed for the first 10 seconds only of the accelerograms. This length of analysis was chosen because previous work had indicated that maximum member actions and structural deformation occur for both the El Centro and Pacoima Dam motions in this time. Some (plastic) deformations do occur after the 10 second mark and these may or may not help to restore the structure to its initial position. It is an observed fact that many buildings are left with residual displacements after a large seismic event. Thus the authors feel that the results obtained are credible, and that the structures investigated possess no inherent susceptibility to the development of large locked in deformations. Similar permanent inelastic deformations were predicted by numerous previous analyses also for framed buildings without structural walls.

Letter to the Editor

from Charles Clifton*

Dear Sir,

re: Volume 15, No. 3 Structural Steel Test Photographs(1)

The comments contained in this letter correct false impressions which, in my opinion, are obtained when one studies the structural steel test photographs and accompanying comments in the bulletin, Volume 15, No. 3. The factual content in this letter is obtained from the paper in bulletin Volume 15, No. 2.(2)

The reading of these comments in conjunction with the photographs should give a correct interpretation of the behaviour of the members tested and the overall performance of these joints under cyclic loading.

The overall cyclic behaviour of a beam

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column joint depends upon the interaction of the joint components, each of which has its individual failure mode. To assist research into the joint behaviour, and ultimately the issuing of a comprehensive design guide for these joints, a particular joint component may be under-designed to force premature failure of that component and study its behaviour pattern and effect on the whole joint. The first and second photographs show specimen 3, which is such a joint, with the endplate having only 39% of its design strength.

Theory predicts that this under-designed joint will be very ductile, failure of the beam-column subassemblage will be largely confined to the endplate and final failure will occur by the endplate tearing along the beam flange to end plast outer weld face. This is exactly what happened in practice.

The capacity of this joint, however, was quite remarkable, and beam B, in which the end plate fractured at a displacement ductility factor of 10 in the 5th cycle of loading, still carried a moment slightly greater than the yield moment with only the inner row of tension bolts carrying the load!

The third photograph shows specimen 1 after testing to 5 and a half cycles of increasing displacement ductility factors of 1 for cycle 1 up to 6 for cycles 5 and 5 and a half. Both beams exhibited stable and expanding hysteresis loops throughout the tests. This is typical of a beam-column bolted endplate joint with no under-designed components. The buckled beam flanges are a stable and useful phenomenon of a beam with proper lateral bracing; stable in that they will occur unchanged early in a test and behave in a similar manner throughout the test.

Thus a well designed beam-column joint is ideally suited to withstand cyclic loading and hence seismic loading.

References:

1. ——— Structural Steel Tests. Photographs of steel beam-column connections under test at Canterbury University, NZNSEE Bull. Vol. 15, No. 3, September, 1982, pp 102-104.

2. Johnstone, N.D. and Walpole, W.R., "Behaviour of Steel Beam-Column Connections Made Using Bolted End Plates", NZNSEE Bull. Vol. 15, No. 2, June, 1982, pp. 82-92.

General Information -

PROCEEDINGS AVAILABLE - 4TH CANADIAN CONFERENCE ON EARTHQUAKE ENGINEERING:

Proceedings of the 4th Canadian Conference on Earthquake Engineering, which was held in Vancouver, B.C. in June 1983, are now available at a cost of $40 Cnd., including mailing and handling charges.

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UNITED STATES AWARD FOR CONCRETE RESEARCH IN THE DEPARTMENT OF CIVIL ENGINEERING OF THE UNIVERSITY OF CANTERBURY -

The Board of Direction of a learned society in the United States, the American Concrete Institute, has selected Mr B.D. Scott, Professor R. Park and Dr M.J.N. Priestley to receive the Reese Structural Research Award.

This prestigious award of the American Concrete Institute is normally made annually and is to the author or authors of a paper published by the Institute in the period subsequent to the last award that describes a notable achievement in research related to structural engineering and which indicates how the research can be used. Mr Scott, Professor Park and Dr Priestley have been invited to attend the 80th Annual Convention of the American Concrete Institute in Phoenix, Arizona, in March 1984 where the presentation will be made.

The award paper is entitled "Stress-Strain Behaviour of Concrete Confined by Overlapping Hoops at Low and High Strain Rates". It was published in the January-February 1982 issue of the Journal of the American Concrete Institute. The research was conducted as a Master of Engineering degree project in the Department of Civil Engineering of the University of Canterbury during 1979/80 by Mr Scott under the supervision of Professor Park and Dr Priestley.

The paper presents the results of an experimental study of the strength and ductility of confined concrete in reinforced concrete columns, including an assessment of the effect of the eccentricity of load, strain rate, and the