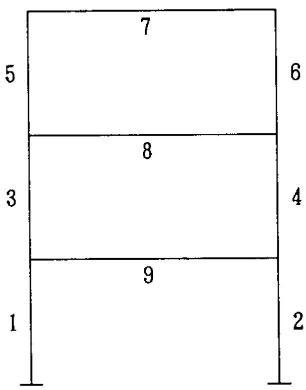
I-518 INELASTIC EARTHQUAKE RESPONSE OF BEAMS IN DIFFERENT FRAME DESIGNS

William TANZO grad. student, Kyoto University
Yoshikazu YAMADA professor, Kyoto University
Hirokazu IEMURA assoc. prof., Kyoto University

Ductility Demand on Beams Any inelastic behavior in a frame during a severe earthquake should desirably be initiated at the critical sections of beams. The beams should, therefore, be able to sustain large deformation as the columns continue to take in more loads. However, the rotational ductility ratio required has not yet been clearly established. Tests of isolated beam-specimens have used a wide variety of arbitrarily-defined displacement loading histories in the range of 2-10% beam shear span.

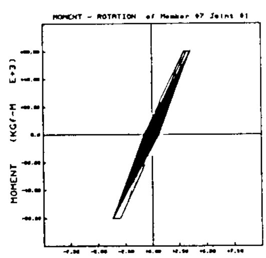
Substructure-Based Hybrid Test of Beams Using the proposed substructure-based on-line hybrid system, loading program for beam specimens does not have to be prescribed in terms of arbitrarily-defined deformation histories. Member deformations are obtained from a step-by-step inelastic analysis. That corresponding to the simulated member is sent through a D-A (digital to analog) converter and imposed on the specimen. Restoring forces developed on the loaded specimen are measured and then fed into the equations of motion through an A-D (analog to digital) converter. The solution proceeds recursively to get the next displacements and, in turn, the next restoring forces.

Numerical Simulation A 7m-bay 10.5m-high frame configuration, subjected to 30 seconds of the NS-component of the 1940 El Centro earthquake, is investigated. Frame-1 is a very stiff structure with T = 0.77 sec. Beam member 9 in frame-2 (T=1.0 sec) is considerably weaker. Frame-3 (T=1.26 sec) is a strong-column weak-beam design.

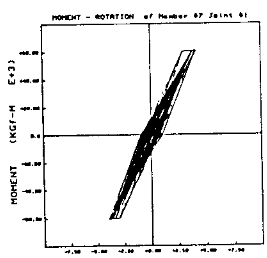


member	frame-1	frame-2	frame-3
1 & 2	356 x 914 mm top: 8 D28 bot: 12 D28	356 x 914 mm top: 8 D28 bot: 12 D28	356 x 914 mm top: 8 D28 bot: 12 D28
3 & 4	356 x 914 mm top: 8 D28 bot: 12 D28	356 x 914 mm top: 8 D28 bot: 12 D28	356 x 914 mm top: 8 D28 bot: 12 D28
5 & 6	356 x 787 mm top: 4 D28 bot: 5 D28	356 x 787 mm top: 4 D28 bot: 5 D28	356 x 787 mm top: 4 D28 bot: 5 D28
7	660 x 533 mm top: 5 D28 bot: 5 D28	660 x 533 mm top: 5 D28 bot: 5 D28	254 x 635 mm top: 2 D25 bot: 4 D25
8	660 x 533 mm top: 7 D28 bot: 7 D28	660 x 533 mm top: 7 D28 bot: 7 D28	254 x 635 mm top: 2 D25 bot: 2 D25
9	660 x 533 mm top: 7 D28 bot: 7 D28	254 x 635 mm top: 2 D25 bot: 4 D25	254 x 635 mm top: 2 D25 bot: 4 D25

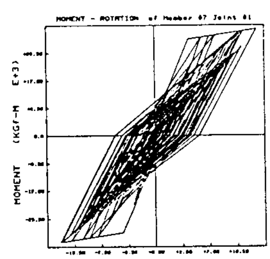
frame-1



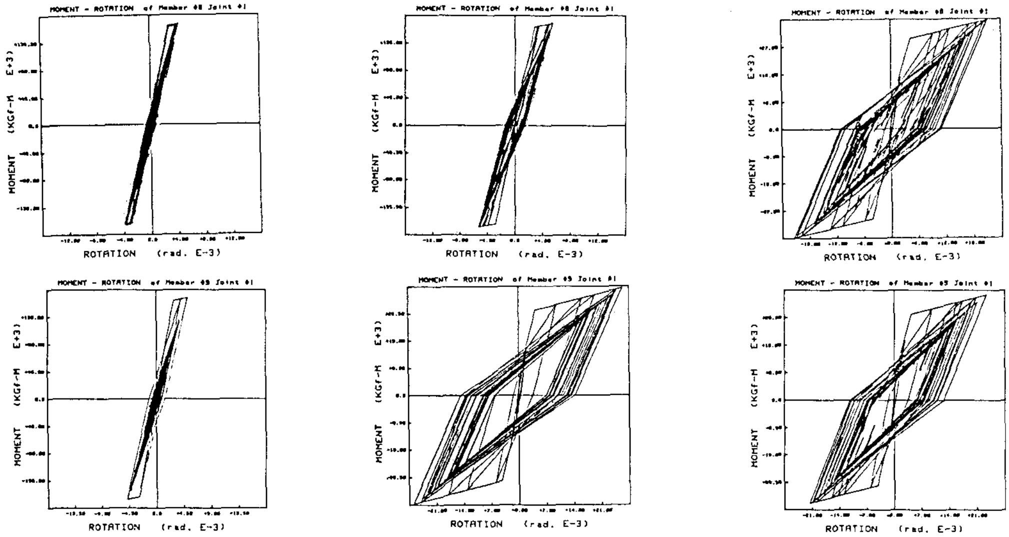
frame-2



frame-3



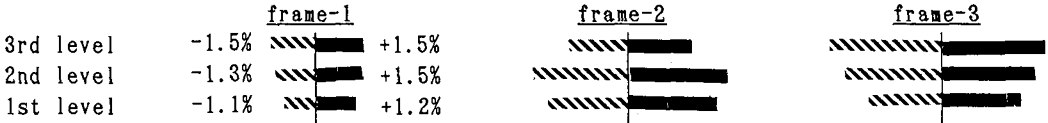
frame-1 frame-2 frame-3



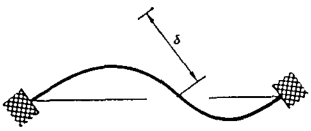
In relation to the hysteretic moment-rotation behavior of the beam critical sections given above, rotational ductility demand on beams for the three frame models are tabulated as follows (for positive and negative curvatures):

	frame-1		frame-2		frame-3	
beam 7	1.2	1.2	1.9	1.9	3.0	2.9
beam 8	1.5	1.4	1.4	1.4	4.9	5.0
beam 9	1.8	1.7	6.1	6.3	5.4	5.1

Interstory drifts given below are expressed as percentages of story height.



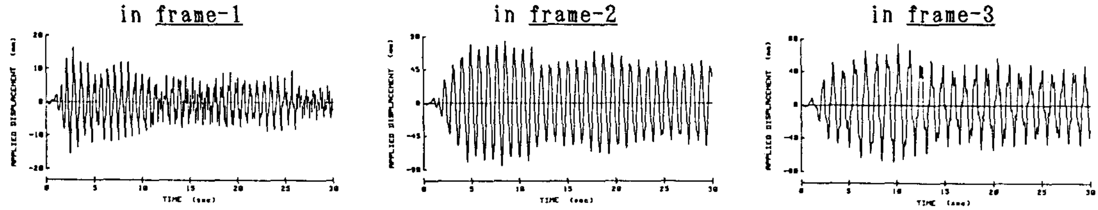
Maximum amplitudes corresponding to tip deflection of a cantilever beam-specimen are expressed as percentages of beam shear span.



	frame-1		frame-2		frame-3	
beam 7	+0.3%	-0.3%	+0.4%	-0.4%	+1.2%	-1.1%
beam 8	+0.4%	-0.3%	+0.5%	-0.5%	+1.9%	-1.9%
beam 9	+0.5%	-0.4%	+2.4%	-2.4%	+2.1%	-2.1%

Simulated load histories applied on beam member 9 for each frame model are shown.

in frame-1 in frame-2 in frame-3



Concluding Remarks A beam may experience a wide variety of earthquake loads depending on factors such as: the relative member stiffnesses, the extent of its deformability, and also the deformability in adjoining members. Maximum deflection-amplitude criterion for isolated-beam testing is not easily correlated to percentages of beam shear span, nor to percentages of interstory drifts, especially in a framed structure in which members undergo varying degrees of inelastic deformation.