NEES GRAND CHALLENGE RESEARCH: MITIGATION OF COLLAPSE RISK OF OLDER CONCRETE BUILDINGS

EVALUATION OF NON-DUCTILE REINFORCED CONCRETE BUILDING CORNER JOINTS EXPERIENCING EARLY COLUMN FAILURE

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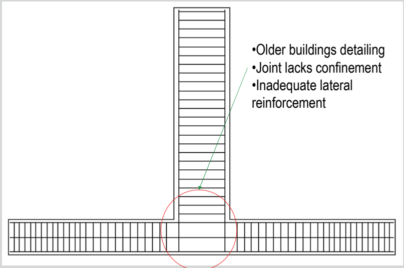
A. Introduction

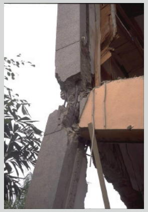
Column-beam joints of reinforced concrete buildings designed prior to the adoption of the modern design code are susceptible to failure when subjected to seismic action.

A.1 Deficient Specimen Detailing



A.2 Earthquake Joint Failures

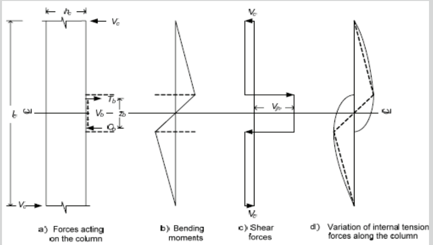
Non-ductile corner joints are at higher risk.



A.3 Previous Joint Tests

Paulay and Priestley in 1992 showed that the shear in the joint (V_{jh}) is on average four to six times larger than that of the column (V_c).

Characteristics of column and joint behavior



$$V_{jh} = T_b - V_c = [V_c(l_c - Z_b) - (V_b h_c)]/Z_b \qquad V_c = (T_b Z_b + V_b h_c)/l_c$$

Paulay, T. and M. J. N. Pristley, 1992, *Seismic Design of Reinforced Concrete and Masonry Buildings,* John Wiley & Sons, New York.

B. Joint Shear Strength

B.1 ASCE 41 Joint Shear Strength Model

The joint shear strength model presented by ASCE 41 is simple to use, but it is very conservative. It doesn't consider column compression force and it lacks corner joint geometry recommendations. This experiment aims to generate test data to develop a more accurate corner joint shear strength model.

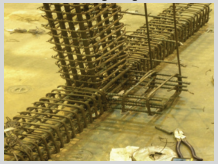
C. Specimen Construction

C.1 Wood Form


Column-transverse beam


Column-longitudinal beam

C.2 Reinforcing Cage


Reinforced joint


Reinforcing in form

C.3 Specimen


Beam side of specimen


Slab side of specimen

D. Test Program

D.1 Instrumentation

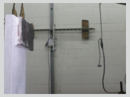
- 10 strain gauges on column longitudinal reinforcement
- 22 data acquisition channels


Strain gauge


Strain gauges connected to channels


Displacement transducers-back side of joint


Displacement transducers-bottom side of joint


Displacement transducers-out of plane

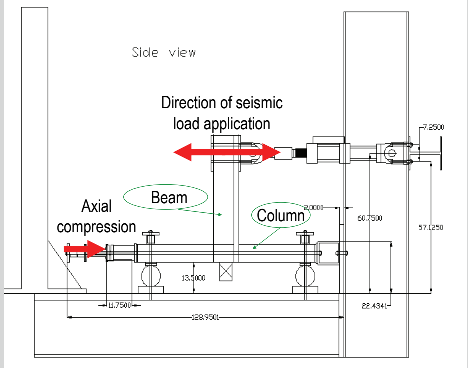

Displacement transducer- column movement

D. Test Program

D.2 Test Setup and Loading Protocol

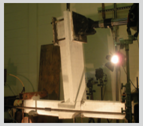
•Constant column axial compression loading of **.2AgF'c**

•Longitudinal beam subjected to a quasi-static reverse cyclic transverse loading with predetermined drifts of .25% .5% .75% 1% 1.5% 2% 3% 5% 7% & 10%




Compression pump


Manual pump gauge

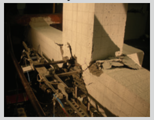

Displacement Actuator

D.3 Test Results

•Results proved that corner joints fail bore the beam or column in older type concrete buildings

•Corner joints weaker than exterior joints


Initial joint cracking


Column damage

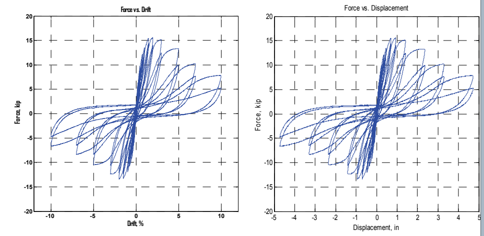

Significant spalling

2008 Vs 2009 TEST RESULTS COMPARISON

Specimen	Joint Type	Column Axial Load	Max transverse load Vby (kips)	Joint shear at yield Vjy (kips)	Gamma (γ)
08-specimen 1	Exterior	.4AgF'c	19.5	1.513	21
08-specimen 2	Exterior	.2AgF'c	17.5	1.358	19
09-specimen	**Corner**	**.2AgF'c**	**15.5**	**1.203**	**16**

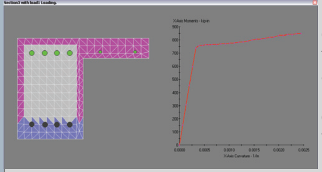
D. Test Program

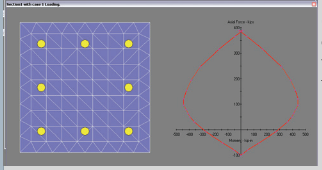
Hysteresis

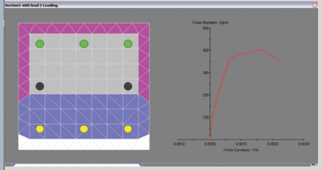


Max transverse load of 15.5 kips during the 1.5% drift and a displacement of .709 in

E. Computer Analysis


Beam moment capacity: XTRACT the beam yielded at approximately 730 kip-in. From experiment beam yielded at 728.5 kip-in.


Column interaction diagram: column yielded in the tension control portion of the interaction diagram


Column moment capacity: weak column as required by design code prior to 1970

Additional analysis and a more precise model of this joint is being done using OpenSees

F. Conclusion

The experimental results show that the primary mode of failure occurred in the joint as predicted. These results prove that corner joints of buildings built prior to the adoption of the new design code are susceptible to failure if expose to seismic action. Thus, causing total structural collapse. Therefore, rehabilitation of non-ductile reinforce concrete buildings is necessary.

G. Acknowledgement

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For additional information about the grand challenge project please visit: http://peer.berkeley.edu/grandchallenge/