

PROPOSAL 2-1 (2009)

SCOPE: Sec. 12.2.5 of the 2009 Provisions

PROPOSAL FOR CHANGE:

1 **Add the following new Section 12.2.5.5, and renumber subsequent**
2 **sections:**

3 **12.2.5.5 Minimum Flexural Strength of Columns in Special Moment Frames**

4 The flexural strengths of columns of special moment frames shall satisfy Equation 12.2-1 in each
5 plane of lateral resistance and at each level.

6
$$\Sigma M_c \geq \Sigma M_b \quad (12.2-1)$$

7 where:

8 ΣM_c = sum of nominal flexural strengths of all columns framing into the underside of the
9 level, evaluated at the faces of the joints, for all moment frame columns acting to resist
10 lateral forces in the direction under consideration. Column axial force shall be calculated
11 for the factored axial force, consistent with the direction of the lateral forces considered,
12 that results in the lowest flexural strength. It is permitted to neglect axial forces in
13 columns due to the effect of earthquakes.

14 ΣM_b = sum of nominal flexural strengths at each end of each beam at the level, evaluated
15 at the faces of the joints, for all beams acting to resist lateral forces in the direction under
16 consideration. M_b for each beam end shall include the contribution of the slab to flexural
17 strength.

18 EXCEPTION: In evaluating Equation 12.2-1, it is permitted to include framing not designated as
19 part of the seismic force-resisting system.

20 Equation 12.2-1 shall be checked separately for earthquake lateral forces acting in two
21 orthogonal horizontal directions using positive or negative member moment strengths as
22 appropriate. Flexural strengths shall be summed such that the column moments oppose the beam
23 moments.

24 Equation 12.2-1 need not be satisfied at the roof level, or for special steel truss moment frames,
25 or for dual systems where the shear walls or braced frames have a lateral strength at least equal
26 to 75 percent of the design story shear at each story.

27 Where a special moment frame column extends above a level, the flexural strength shall be at
28 least 65% of the column flexural strength below.

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31 **REASON FOR PROPOSAL:**

1 In moment frame structures, inhibiting story mechanisms is important for good seismic
2 performance and is accomplished through increasing aggregate column strength at each level
3 compared to aggregate beam strength. This is a system issue, applicable to both concrete and
4 steel structures, and is best addressed in Section 12.2.5 of NEHRP and ASCE 7-05.

5 Currently, the steel and concrete material codes each have strong-column weak beam
6 requirements. Adding the proposed section to the general building code provides a consistency
7 of requirements between the two materials¹.

8 The proposal represents a fundamental modification of requirements for strong-column/weak-
9 beam because column and beam moment strengths are to be summed for all columns at each
10 level for each plane of resistance. The sum of column strengths framing *into the underside of a*
11 *level only* are compared to the sum of beam strengths at that level. For example, in the three-bay
12 planar frame of Figure A, the formula compares the sum of four column moment strengths to the
13 sum of six girder moment strengths.

14 The story approach is shown by plastic analysis studies to be an appropriate provision against the
15 formation of undesirable story mechanisms. Desirable and undesirable plastic mechanisms are
16 shown in Figure B.

17 Traditionally the material codes have required that the column strengths be compared to 1.2
18 times the beam strengths at each joint, a criterion that is inadequate in preventing story
19 mechanisms. Plastic and non-linear analyses of frame structures confirm that current strong-
20 column/weak-beam provisions typically do not prevent story mechanisms [Paulay 1977, Jury
21 1978, Paulay and Priestley 1992, SEAOC 1999, ATC 2007].

22 Compared to current requirements, this proposal requires, on average, stronger columns and/or
23 weaker beams. The proposal can provide design flexibility and economy by allowing individual
24 columns to be weaker than adjacent beams, provided that there is enough strength in other
25 columns to prevent a story mechanism. (See upper right of Figure B)

26 References:

27 Paulay, T., 1977, "Seismic Design of Ductile Moment Resisting Reinforced Concrete Frames, Columns:
28 Evaluation of Actions," *Bulletin of the New Zealand National Society for Earthquake Engineering*,
29 Vol 10, No. 2, June pp. 85-94

30 Jury, R. D., 1978, *Seismic Load Demands on Columns of Reinforce Concrete Multistorey Frames*,
31 Research Report 78-12, Department of Civil Engineering, University of Canterbury, Christchurch,
32 New Zealand, February

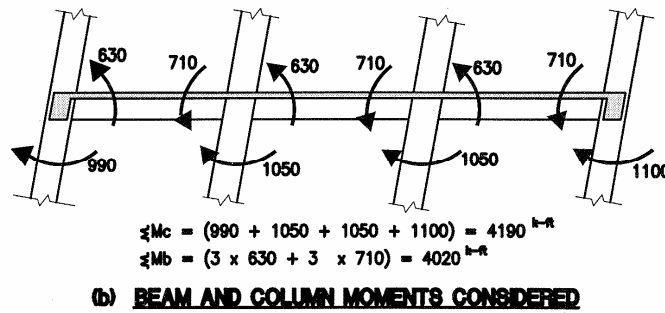
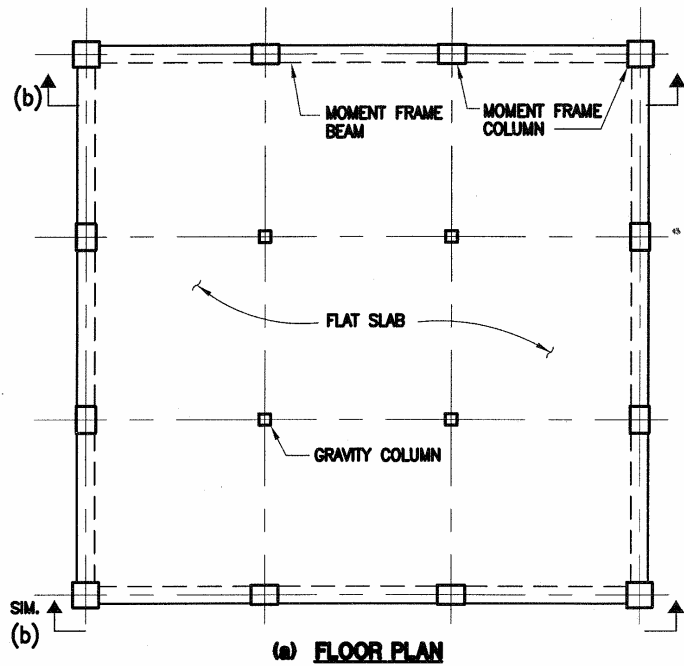
33 Paulay, T. and M. J. N. Priestley, 1992, *Seismic Design of Reinforced Concrete and Masonry Buildings*,
34 John Wiley and Sons, New York

35 SEAOC, 1999, *Recommended Lateral Force Requirements and Commentary*, Seismology Committee,
36 Structural Engineers Association of California, Sacramento California.

37 Applied Technology Council, 2007, *Recommended Methodology for Quantification of Building System*
38 *Performance and Response Parameters*, ATC-63 report, 75 % draft, March

¹ After adoption of this proposal, material codes may choose to remove or modify their strong-
column/weak-beam requirements. In the interim, structures would need to meet both the
NEHRP/ASCE-7 requirement, which would tend to govern the overall amount of column strength
required, and the material code requirement, which in some cases could govern individual columns

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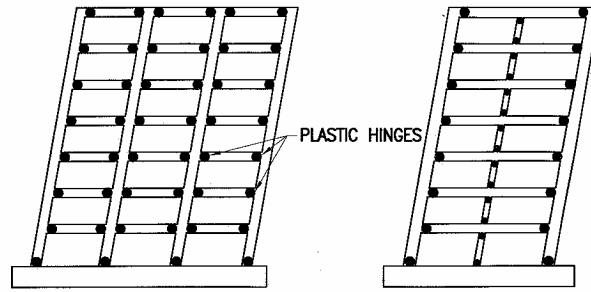
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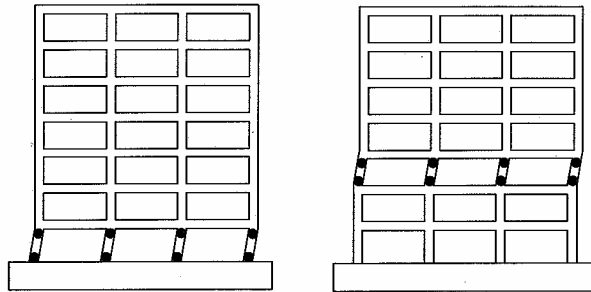
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Figure A



(a) **DESIRABLE PLASTIC MECHANISMS**



(b) **UNDESIRABLE PLASTIC MECHANISMS**

Figure B

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TS 2 VOTE:

YES = 8 Yes with Reservations = 0 No = 0 Not Voting = 1