

1 **PROPOSAL 2-4R (2009)**

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4 **SCOPE: Part I, Section 1.4, Exception 1 of the 2009 Provisions**

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8 **PROPOSAL FOR CHANGE:**

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10 **I. Revise Provisions Section 1.4 Exception #1 as follows:**

11 **Exception #1**

12 Sec. 5.2.6.2 of the 2003 NEHRP on *P-delta limit* will be retained in place of Sec. 12.8.7 of ASCE 7-05 as follows:

13 ~~12.8.7~~ ~~5.2.6.2~~ **P-delta limit.** Stability coefficient, θ , as determined for each level of the structure by the
14 following equation, shall not exceed 0.10:

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$$\theta = \frac{P_x \Delta I}{V_x h_{sx} C_d} \tag{5.2-16}$$

19 where:

- 20 P_x = the total vertical design load at and above Level x . Where calculating the vertical design
21 load for purposes of determining P-delta effects, the individual load factors need not
22 exceed 1.0.
- 23 Δ = the design story drift calculated in accordance with Sec. ~~12.8.6~~ ~~5.2.6.1~~.
- 24 I = the occupancy importance factor determined in accordance with Sec. ~~11.5.1~~ ~~4.3~~
- 25 V_x = the seismic shear force acting between Level x and $x - 1$.
- 26 h_{sx} = the story height below Level x .
- 27 C_d = the deflection amplification factor from Table ~~12.2-14.3~~ ~~4~~.

28 **Exception:**

29 **EXCEPTION. The stability coefficient, θ , shall be permitted to exceed 0.10 if either of the**
30 **following applies:**

- 31 1. ~~The stability coefficient, θ , shall be permitted to exceed 0.10 if the~~ resistance to lateral forces
32 is determined to increase continuously in a monotonic nonlinear static (pushover) analysis to
33 150% of the target displacement as determined in Sec. ~~12.15.6~~ ~~A5.2.3~~. P-delta effects shall be
34 included in the analysis. Modeling, analysis, and design review shall conform to Sec.
35 12.15.2-12.15.6 and 12.15.10
- 36 2. Compliance with the provisions of the nonlinear response history procedure in Chapter 16 is
37 demonstrated.

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40 **II. Add Commentary for Section 12.8.7 as follows:**

41 Part 1 of the Provisions takes exception to portions of ASCE-7 Section 12.8.7 that allow the stability
42 coefficient, θ , to exceed 0.10. The SAC Steel Project has introduced recommendations in FEMA-350 for
43 the consideration of P-Delta effects. The recommended requirements may be interpreted as requiring
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1 explicit modeling of geometric effects for steel moment-resistant frames when values of the stability
2 coefficient, θ , exceed approximately 0.04, and thus are more restrictive than the Provisions. The
3 application of the FEMA-350 approach to other structural systems and materials (e.g. dual systems,
4 braced frames, or wood buildings) has not been defined.

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6 ASCE-7 allows amplified forces to be used in a linear elastic analysis where θ exceeds 0.10. In such
7 cases, there is a very real possibility that the tangent stiffness of the structure may become negative,
8 leading to the possibility of significantly increased dynamic displacement demands (Gupta and
9 Krawinkler, 2000). Depending on the progression of plastic hinging and strain hardening, limiting θ to
10 0.10 will maintain a positive tangent stiffness throughout much or all of the expected response. The
11 proposed changes allow structures to exceed this limit only if a positive slope is maintained in a nonlinear
12 static analysis that accounts for P-delta effects or if adequate resistance to instability is demonstrated by
13 nonlinear dynamic analysis.

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15 The occupancy importance factor, I , was inserted into Eq. 5.2-16 to ensure that the permissible axial load
16 level does not increase as the importance factor increases.

17 **REFERENCES**

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19 Gupta, A., and Krawinkler, H., (2000), "Dynamic P-delta effects for flexible inelastic steel structures,"
20 Journal of Structural Engineering, American Society of Civil Engineers 126(1), Jan., pp 145-154.

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23 FEMA-350 (2000). Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings,
24 prepared by the SAC Joint Venture, Report Number FEMA-350, Federal Emergency Management
25 Agency, Washington, D.C., June.

26 **REASON FOR PROPOSAL:**

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29 Section references were updated to use ASCE 7-05 section numbers as applicable.

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32 The change to 150% of the target displacement was considered necessary to have increased confidence
33 that story mechanisms will not occur at the MCE level of shaking.

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35 Exception #2 was added to allow for dynamic analysis, in response to a negative vote from the PUC on an
36 earlier version of this proposal.

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38 This proposal makes reference to section numbers as revised in pending Proposal 2-3. If Proposal 2-4
39 should pass and Proposal 2-3 fails, it will be necessary to bring the existing 2003 Appendix into Part 1,
40 with updated section and equation numbering. References to sections of the nonlinear static procedure in
41 the present proposal will have to be updated to reflect these changes.