

POSITION STATEMENT
Redundancy / Reliability Factors

The 1998 California Building Code (CBC), based on the 1997 Uniform Building Code (UBC), required for the first time an explicit consideration of structural redundancy. The motivation and intention behind the “Reliability/Redundancy Factor,” represented in codes by the Greek letter ρ (ρ), were described in both the 1999 SEAOC Blue Book and the 1997 NEHRP Commentary (FEMA 303).

While redundancy remains difficult to define, there is general agreement that the 1997 code changes were intended to encourage structural configurations with more lateral force-resisting elements. The SEAOC Seismology & Structural Standards Committee (the Committee) shares this preference. For a given lateral force-resisting system (LFRS), the Committee encourages the use of multiple lines of resistance and multiple LFRS elements.

In September 2001, the Committee adopted certain positions (summarized below) related to the codified ρ provisions and proposed changes to applicable codes, standards, and guideline documents. The Committee’s positions and proposals do not address the value of structural redundancy. Rather, they address the codification of redundancy in terms of current ρ provisions.

In summary, the Committee’s findings regarding the 1998 CBC ρ provisions, based largely on studies performed by the SEAONC Seismology Committee in 2000-2001, are as follows:

- Are current ρ provisions hazardous? Current code provisions regarding ρ are not hazardous. That is, they do not warrant an emergency code change and will not by themselves lead to structures incapable of meeting the code’s implied performance objectives.
- Are current ρ provisions implementable? Most are implementable, but some are unclear or difficult to use.
- Is the current ρ factor rationally derived? The current factor lacks a firm, quantitatively demonstrable basis in theory or observed earthquake performance.
- Are current ρ provisions effective? In many cases, ρ fails to encourage more LFRS elements within a given system type. Instead, designers choose to incur ρ ’s “penalty” of increased design forces. In rare cases, the ρ penalty may lead designers to change structural systems rather than increase the number of LFRS elements.
- Are the current ρ provisions necessary? For some structural systems, code provisions developed and introduced at the same time as ρ have addressed poor past performance more directly and effectively than ρ . For systems without specific reliability-based code provisions, the necessity of ρ requires further study.

In light of these findings, the Committee’s long term position is that current ρ provisions should be revised or amended where they are ineffective or unusable and should eventually be deleted where they are unnecessary or non-rational. Where redundancy (or reliability) is a function of system, material, or construction quality, it should be addressed with system- or material-specific provisions. In general, the Committee recognizes that the building code should address potential effects of poor structural configuration. Therefore, ρ should eventually be replaced by provisions that more directly ensure appropriate overstrength, ductility, torsion control, deformation compatibility, construction quality assurance, and reliable failure modes.

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In the short term, the Committee has proposed code changes to address the most significant shortcomings of the current *rho* provisions. The substantive objectives of these proposals included the following:

- To eliminate confusion over the *rho* formula in buildings with setbacks, ρ_i should be calculated for each story i , with A_i taken as the area of the floor above. For the building, ρ should then be taken as the maximum of the story values. (The NEHRP, IBC, and ASCE formulations for ρ already take this recommended approach.)
- The fixed limit on ρ for SMRF systems should be replaced by a reduction in allowable drifts. The current limit was intended to address flexible structures that are not affected by the current ρ formulation, but in practice, the limit is arbitrary and sometimes prohibits the use of SMRF systems.
- The current ρ formulation is intended to yield lower ρ values when more LFRS elements are present, but it does not always achieve that result in buildings with flexible diaphragms. In those buildings, ρ should be permitted to be calculated based on a rigid diaphragm analysis. Alternatively, ρ should not have to be taken greater than 1.25 in flexible diaphragm buildings.
- The provisions should be clearer with respect to where ρ must be applied. In general, ρ should apply only to design load combinations, not to the seismic base shear V . It should be permitted to be taken equal to 1.0 for irregularity checks, deflection and drift calculations, foundations (but not connections between the foundation and LFRS elements), sliding and overturning at the foundation-soil interface, non-building structures, nonstructural components, and diaphragms (except where diaphragms transfer lateral forces in irregular structures).
- The provisions should clarify that the ρ calculation need not include effects of accidental torsion or torsional amplification.
- The provisions should clarify limits and procedures for calculating ρ when different stories have different lateral systems.

The Committee has submitted the following sets of proposals consistent with the objectives listed above:

- Proposals relative to the 1998 CBC are available to local jurisdiction building officials for their use in recommending local amendments to the California Building Code.
- Proposals relative to the 2000 IBC have been submitted through NCSEA to the ICC for incorporation into the 2003 IBC. These proposals will be voted on at the ICC hearings in Pittsburgh, April 8-19, 2002.
- The Committee did not submit proposals to the upcoming NFPA 5000. The NFPA document will adopt by reference ASCE 7. The Committee did not submit relevant proposals to ASCE 7-02, but will consider preparing similar proposals to ASCE 7-05.
- Proposals relative to the 2000 NEHRP Provisions have been submitted through SEAOC's liaison to BSSC Technical Subcommittee 2 for consideration as the 2003 Provisions are developed.