5.0 Detailed Evaluation Phase (Tier 3)

5.1 General

For buildings requiring further investigation, a Tier 3 Evaluation shall be completed in accordance with this Chapter. A Tier 3 Evaluation shall be performed either for the entire building after the requirements of Chapter 2 have been met or for those elements identified to be deficient in a Tier 1 and/or Tier 2 Evaluation.

Commentary:

Tier 1 and Tier 2 evaluations have the potential for being conservative because of the simplifying assumptions involved in their application. More detailed and presumably more accurate evaluations may employ less conservatism and may therefore reveal that buildings or building components identified by Tier 1 and/or Tier 2 evaluations as having seismic deficiencies are satisfactory to resist seismic forces.

The decision as to whether to employ a Tier 3 evaluation requires judgment regarding the likelihood of finding that Tier 1 and/or Tier 2 evaluations are too conservative and whether there would be a significant economic or other advantage to a more detailed evaluation.

No evaluation procedures more detailed than the Tier 1 and Tier 2 are presently available. Therefore, in order to make more detailed evaluations, it is necessary to adapt procedures intended for design.

Provisions intended for design may be used for evaluation by inserting existing conditions in the analysis procedures intended for design. Expected performance of existing components can be evaluated by comparing calculated demands on the components with their capacities.

5.2 Available Procedures

A Tier 3 Evaluation shall be performed using one of the two following procedures:

5.2.1 Provisions for Seismic Rehabilitation Design

A component-based evaluation procedure developed for seismic rehabilitation of existing buildings shall be used for a Tier 3 Evaluation. Acceptable analysis procedures for such a detailed evaluation include linear and nonlinear methods for static or dynamic analysis of buildings. Acceptance criteria for such detailed evaluations for various performance levels are based on stiffness, strength, and ductility characteristics of elements and components derived from laboratory tests and analytical studies. The more accurate analysis method and more realistic acceptance criteria developed specifically for rehabilitation of existing buildings shall constitute the detailed evaluation phase. Such a component-based detailed evaluation procedure shall be used in accordance with the authority having jurisdiction.

Force levels used for analysis in provisions for seismic rehabilitation of existing buildings shall be multiplied by 0.75 when used in a Tier 3 Evaluation. If a linear analysis method is selected, the analysis shall implicitly or explicitly recognize nonlinear response.

Commentary:

The only nationally applicable provisions for seismic rehabilitation of existing buildings are the *NEHRP Guidelines and Commentary for the Seismic Rehabilitation of Buildings* (FEMA 273 and 274). Regionally applicable provisions may be available such as *Seismic Evaluation and Retrofit of Concrete Buildings* (SSC 96-01) and *Division 95* of the City of Los Angeles Code, both of which were developed specifically for use with reinforced concrete buildings in California. Several procedures for nonlinear static analysis and nonlinear dynamic

nonlinear dynamic analysis have been developed which also could be used for Tier 3 Evaluations with the approval of the authority having jurisdiction.

The *NEHRP Guidelines and Commentary for the Seismic Rehabilitation of Buildings* is the recommended design procedure for adaptation to evaluation. All analysis procedures described in the *Guidelines* except for the Simplified Procedure may be used as permitted by the *Guidelines*.

The 0.75 reduction factor can be applied to seismic forces because the force levels in these documents are intended for rehabilitation design. For evaluation of existing buildings, the 0.75 reduction factor provides a "break" due to expected component capacities rather than design capacities. Note that the 0.75 factor applies to the evaluation of the building only. Any mitigation or rehabilitation as a result of the evaluation must use the full seismic force level for design.

5.2.2 Provisions for Design of New Buildings

Well-established provisions for the design of new buildings approved by the authority having jurisdiction shall be used to perform a Tier 3 Evaluation of an existing building. Acceptable provisions for such a detailed evaluation include Section 9, Earthquake Loads, *Minimum Design Loads for Buildings and Other Structures (ASCE 7-95)*. Such a detailed evaluation shall be performed in accordance with the authority having jurisdiction.

Force levels used for analysis in provisions for seismic design of new buildings shall be multiplied by 0.75 when used in a Tier 3 Evaluation. If a linear analysis method is selected, the analysis shall implicitly or explicitly recognize nonlinear response.

Commentary:

Provisions for design of new buildings may not be well suited for evaluation of existing buildings because they are based on construction details and building configurations meeting specific standards which may not describe the construction details and configurations or the archaic materials of construction frequently found in existing buildings.

The 0.75 reduction factor can be applied to seismic forces because the force levels in these documents are intended for new design. For evaluation of existing buildings, the 0.75 reduction factor provides a "break" due to expected component capacities rather than design capacities. Note that the 0.75 factor applies to the evaluation of the building only. Any mitigation or rehabilitation as a result of the evaluation must use the full seismic force level for design.

5.3 Selection of Detailed Procedures

Buildings with one or more of the following characteristics shall be evaluated using linear dynamic or nonlinear static or dynamic analysis methods:

- Height exceeds 100 feet;
- The ratio of the building's horizontal dimension at any story exceeds 1.4 times the horizontal dimension at an adjacent story (excluding penthouses);
- The calculated drift along the side of any story, where the diaphragm above is not flexible, is more than 150% of the average story drift (torsonial stiffness irregularity);
- The average drift in any story (excluding penthouses) is more than 150% of the drift of the story above or below (vertical stiffness irregularity);
- The lateral-force-resisting system is non-orthogonal.

Commentary:

The procedure selected should be based on the judgment as to which procedure is most applicable to the building being evaluated and is likely to yield the most useful data.

Because procedures that explicitly recognize the nonlinear response of building components in earthquakes are likely to yield the most accurate results, nonlinear analysis methods should be selected for complex or irregular buildings and for higher performance levels.