



STRUCTURAL ENGINEERS ASSOCIATION OF CALIFORNIA SEISMOLOGY AND STRUCTURAL STANDARDS COMMITTEE Position Statement – February 2000

Acceptable Diaphragm-Rigidity Assumptions for Distribution of Horizontal Forces in Light-Frame Construction

The 1997 Blue Book, on pp. 257-259, presents a discussion of issues related to the determination of when it is appropriate to use either rigid or flexible diaphragm assumptions in the distribution of lateral forces to the vertical elements of the lateral force resisting system.. Briefly, it states that UBC Section 1630.6 defines a condition (diaphragm deflection greater than 2 times the average story drift) when a flexible diaphragm assumption must be used. For other conditions, it states "... UBC provisions require that the distribution of lateral forces be in proportion to the relative rigidity of the vertical resisting elements." It then goes on to discuss a number of pros and cons related to whether wood diaphragms should be assumed to be rigid. Notable statements include:

"For small, substantially regular buildings that have a good distribution of lateral resistance and are well tied together, earthquake performance to date suggests that design using flexible diaphragm assumptions is adequate for Life-Safe Performance. It has been suggested that one and two-family residences be given blanket exemption from consideration of the applicability of rigid diaphragm analysis. Such a blanket exemption does not, however, make sense from an engineering standpoint because many one and two-family residences have highly irregular configurations with low redundancy and significant discontinuities in the structural system."

Further to this, the SEAOC Seismology Committee concluded during discussions that it is probably adequate to use flexible diaphragm for most small one and two-family residences. For the relatively small diaphragm spans and complex interior partition layouts involved in residential construction, the inability to accurately calculate the rigidity of the various elements, including the rigidities contributed by finishes and nonstructural elements, can cause a wide disparity between the analysis results and the actual behavior. The results of an elaborate diaphragm analysis are not likely to be significantly better than that produced by the conventional "flexible" assumption. In comparison, a "flexible" assumption offers the benefit of often encouraging designers to locate vertical resisting elements in better proportion with the structure mass. When inelastic horizontal seismic deflections occur, a redistribution of forces between the vertical resisting elements will tend to produce relatively similar results, irregardless of the assumptions of rigidity that were used.

Applicable code language found in the 1997 UBC states that the design must be:

Sect. 1605.2 "*based on a rational analysis in accordance with well-established principles of mechanics*" and that Sect. 1605.2.1 "*The total lateral force shall be distributed to the various vertical elements of the lateral-force-resisting system in proportion to their rigidities considering the rigidity of the horizontal bracing system or diaphragm.*"

The term "considering," as defined in the dictionary, means "to think about with care or caution" and "to come to judge or classify." Therefore, it means that the engineer should review the particular circumstances of the structure at hand, including the overall shape and span of the diaphragm, the presence of stiffening attributes such as glue or surfacing materials, and the relative accuracy of equations and methods available for determining the rigidities of the various components, to determine the method of analysis that is most appropriate. The SEAOC Blue Book provides commentary intended to provide some guidance to the engineer in this regard. However, the selection of the most appropriate analysis method is a matter that requires considerable judgement, and is more complex than can be defined by simple code provisions. For some structures, a diaphragm might be characterized as rigid in one direction and flexible in another. For others, the diaphragm in a portion of the building may be relatively rigid, but flexible in another. In these situations, neither a purely flexible nor a rigid assumption may be appropriate.

The intent of the Blue Book Commentary is to provide engineers with an understanding of the basis for the provisions, and to provide additional guidance on specific design issues that merit consideration during the design process. The engineer of record is encouraged to exercise judgement, based on their individual knowledge of the specific circumstances of the design to select the most appropriate design approach for any specific project, within the constraints of the building code.