In seismic design, a diaphragm must be designed for the larger of the following two different design forces that are specified by The American Society of Civil Engineers’ Minimum Design Loads for Buildings and Other Structures (ASCE 7-05):

- The seismic design forces, \( F_x \) at Level \( x \), determined from elastic analysis of the vertical seismic force-resisting system; these forces are typically determined using either the Equivalent Lateral Force Procedure of Section 12.8 or Modal Response Spectrum Analysis of Section 12.9.

- Inertia forces determined from Equation 12.10-1:

\[
F_{px} = \frac{\sum F_i}{\sum w_i} \cdot w_{px}
\]

Equation 12.10-1 gives the diaphragm design forces as a function of story shear in the story below the diaphragm and the ratio of the weight of the diaphragm to the weight of all the diaphragms resisting the story shear below the diaphragm.

A (non-mandatory) upper-bound value and a (mandatory) lower-bound value are also given as \( 0.4S_{DS}Iw_{px} \) and \( 0.2S_{DS}Iw_{px} \), respectively.

The inertia force equation is simply an approximation of the response acceleration at the level of the diaphragm times its distributed mass. Equation 12.10-1 (with the lower-bound value of \( 0.2S_{DS}Iw_{px} \)) typically results in a higher diaphragm design force than the seismic design force from structural analysis.

The detailing of diaphragms is generally independent of the type of seismic force-resisting system selected for a building; therefore the system \( R \)-value does not appear in the upper- and lower-limit equations.

In addition to these diaphragm design forces, in multistory structures there may be seismic design forces to be transferred from vertical resisting elements above the diaphragm to other vertical resisting elements below the diaphragm. For structures assigned to SDC D, E, or F, the redundancy factor, \( \rho \), as applicable to the whole structure, is to be applied to the transfer forces, but it need not apply to forces obtained from Equation 12.10-1.

Table 1 illustrates the determination of the diaphragm design forces for the three-story building shown in Figure 1 where \( S_{DS} = 1.0 \) and \( I = 1 \).

![Figure 1: Plan and elevation of example building](image)

---

### Table 1: Calculation of diaphragm forces for structure in seismic design category D based on ASCE 7-05

<table>
<thead>
<tr>
<th>Level, ( i )</th>
<th>( F_i )</th>
<th>( \sum F_i ) ((i = x \text{ to } n))</th>
<th>( \sum w_i ) ((i = x \text{ to } n))</th>
<th>( F_{px} )</th>
<th>Max.</th>
<th>Min.</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>roof</td>
<td>54.9</td>
<td>54.9</td>
<td>390</td>
<td>390</td>
<td>54.9</td>
<td>156</td>
<td>78</td>
</tr>
<tr>
<td>2</td>
<td>44.1</td>
<td>99.0</td>
<td>390</td>
<td>780</td>
<td>49.5</td>
<td>156</td>
<td>78</td>
</tr>
<tr>
<td>1</td>
<td>24.4</td>
<td>123.4</td>
<td>390</td>
<td>1170</td>
<td>41.1</td>
<td>156</td>
<td>78</td>
</tr>
</tbody>
</table>

S.K. Ghosh Associates Inc., is a structural seismic and code consulting firm located in Palatine, Ill., and Aliso Viejo, Calif. Presidents S.K. Ghosh, Ph.D., and Susan Dowty, S.E., are active in the development and interpretation of national structural code provisions. They can be contacted at skghosh@aol.com and susandowty@gmail.com, respectively, or at www.skghoshassociates.com.