2.9 Design for earthquake action

Single storey industrial buildings are usually governed by wind loads rather than earthquake loads. This is because their roofs and walls are light in weight and often pitched or sloping and also because the buildings are permeable to wind which results in uplift of the roof. However, it is always safe to check any building for both wind and earthquakes.

Earthquake loading is different from wind loading in several respects and so earthquake design is also quite different from design for wind and other gravity loads. Severe earthquakes impose very high loads and so the usual practice is to ensure elastic behaviour under moderate earthquake and provide ductility to cater for severe earthquakes. Steel is inherently ductile and so only the calculation of loads due to moderate earthquake is considered. This can be done as per the IS 1893 code. According to this code, a horizontal seismic coefficient times the weight of the structure should be applied as equivalent static earthquake load and the structure should be checked for safety under this load in combination with other loads as specified in IS 800. The combinations are as follows:

1. 1.5 (*DL* + *IL*)
2. 1.2 (*DL* + *IL* $\pm$ *EL*)
3. 1.5 (*DL* + *EL*)
4. 0.9 *DL* $\pm$ 1.5 *EL*

The horizontal seismic coefficient A_h takes into account the location of the structure by means of a zone factor Z, the importance of the structure by means of a factor I and the ductility by means of a factor R. It also considers the flexibility of the structure-foundation system by means of an acceleration ratio Sa/g , which is a function of the natural time period T. This last ratio is given in the form of a graph known as the response spectrum. The horizontal seismic coefficient A_h is given by

$$A_n = \frac{ZIS_a}{2R_g}$$

Where Z = Zone factor corresponding to the seismic zone obtained from a map (Table 2.3); *I* = Importance factor; *R* = Response reduction factor.

Table 2.3 Zone factor, Z

Seismic Zone	**II**	**III**	**IV**	**V**
Seismic Intensity	Low	Moderate	Severe	Very Severe
Z	0.10	0.16	0.24	0.36

For industries using hazardous materials and fragile products the importance factor may be taken as 1.5 but for most industries it may be taken as 1.0. The Response reduction factor R may be taken as 4 for buildings where special detailing as per section 12 of IS 800 has not been followed.

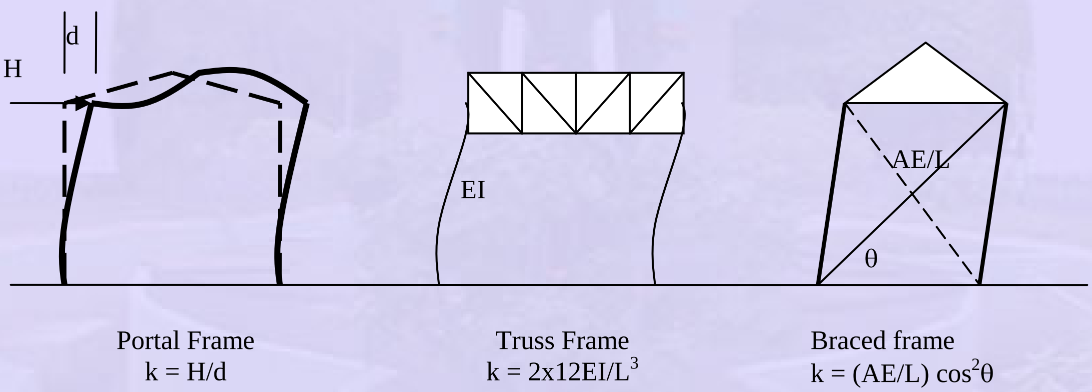

Fig. 2.30 Lateral stiffness for various

The natural time period T is very important and should be calculated correctly. For single storey structures, it may be taken as T = $2\pi\sqrt{(k/m)}$ where k is the lateral (horizontal) stiffness of the supporting structure and m is the mass of the roof usually taken as the sum of the roof dead load plus 50% of the live load divided by the acceleration due to gravity g. Guidelines for calculating k in some simple cases are given in Fig. 2.30.

Finally, the acceleration ratio Sa/g can be obtained from the graph corresponding to the soil type as shown in Fig. 2.31. In this figure, medium soil corresponds to stiff clay or sand and soft soil corresponds to loose clay and loamy soils.

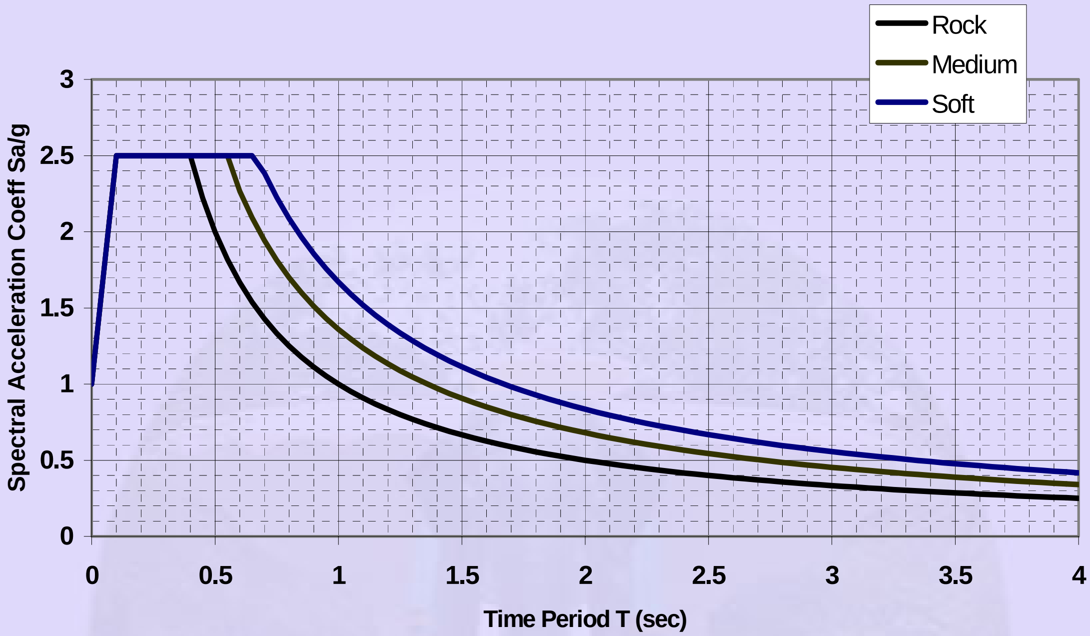

Fig. 2.31 response spectrum for 5% damping