DESIGN EXAMPLE 1

Determination of Seismic Design Forces

Refer to IBC, Section 1613, and ASCE 7, Chapters 11 and 12 for seismic load provisions. The following example looks at a building located in three different geographic sites.

Problem Statement:

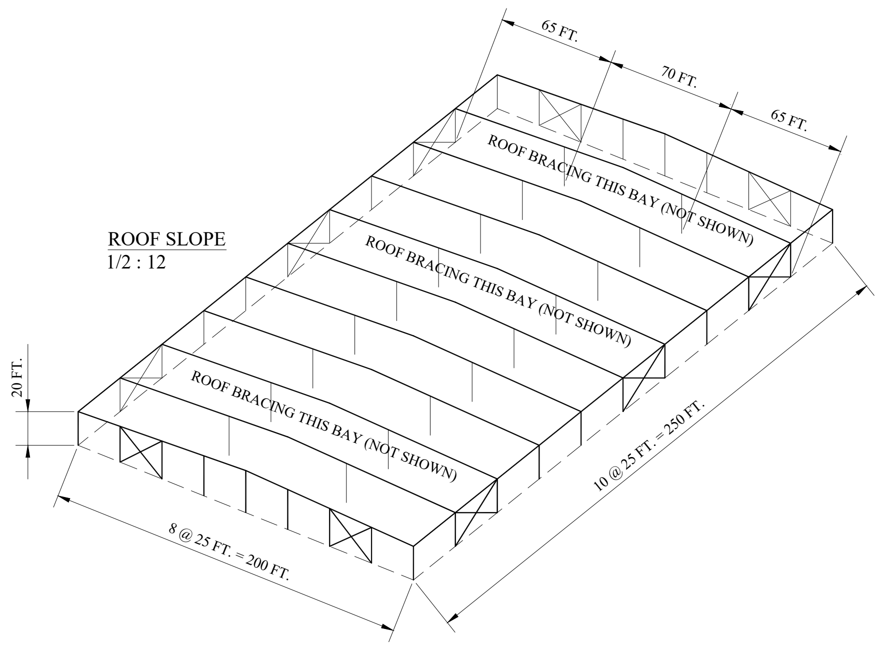
Warehouse building, normal occupancy (Risk Category II)

Ordinary steel concentrically braced frame end walls – w/ tension-only brace rods

Ordinary steel concentrically braced frame side walls – w/ tension-only brace rods

Ordinary steel moment frame interior frames – w/interior columns

No rigid interior partitions or ceilings



Metal Building Framing – Design Example 1

Locations

Site 1: 67 Winthrop Drive, Chester, CT 06412

Site 2: 2630 East Holmes Road, Memphis, TN 38118

Site 3: 1500 W. Rialto Ave., San Bernardino, CA 92410

Soils Properties

Site 1: Unknown, no geotechnical report available

Site 2: Unknown, no geotechnical report available

Site 3: Geotechnical report is available

Design Example Objective:

Determine earthquake design forces for the given building.

1 DETERMINE EARTHQUAKE DESIGN FORCES

1.1 Compute Site Ground Motion Design Values

On most projects, the end customer or his or her design professional has the responsibility to provide the site ground motion design values. The procedure provided in this section may be used to determine the site ground motion design values by those responsible for making that determination.

1.1.1 Determine the Latitude and Longitude Coordinates for each Site Address

The latitude and longitude used in this example were obtained using a website that provides this data for a given address in the United States. A search for current websites that provide this data is recommended because availability and features of these sites change periodically. It is recommended that the latitude and longitude be determined to at least three digits beyond the decimal point (which is accurate to a few hundred feet).

1.1.1.1 Site 1

67 Winthrop Drive, Chester, CT 06412

Latitude = 41.387° (N)

Longitude = –72.508° (W)

1.1.1.2 Site 2

2630 East Holmes Road, Memphis, TN 38118

Latitude = 35.007° (N)

Longitude = –89.976° (W)

1.1.1.3 Site 3

1500 W. Rialto Ave., San Bernardino, CA 92410

Latitude = 34.101° (N)

Longitude = –117.319° (W)

1.1.2 Determine the Site Class for each Site

1.1.2.1 Site 1

Soil properties not known

Therefore, use default – Site Class D as required per IBC Section 1613.3.2 (also in ASCE 7 Section 11.4.2).

1.1.2.2 Site 2

Soil properties not known

Therefore, use default – Site Class D as required per IBC Section 1613.3.2 (also in ASCE 7 Section 11.4.2).

1.1.2.3 Site 3

A soils report was prepared and based on the soil profile, it was determined to be Site Class D.

Note that the IBC site class, and ASCE 7 site class use the same soil profile classification system. See Section IIIA in the Introduction for more information regarding the potential advantages for performing a geotechnical investigation.

1.1.3 Determine the Maximum Considered Earthquake (MCE) Ground Motion Values for each Site

Values of the mapped spectral accelerations for short periods (0.2 second) and a 1-second period, S_S and S_1, can be obtained from either the maps in IBC Figures 1613.3(1) through 1613.3(8), or more accurately from the United States Geological Survey (USGS) website. The website location, http://earthquake.usgs.gov/designmaps, provides a U.S. Seismic Design Maps Web Application for seismic design values from the ASCE 7. This tool utilizes the web based program to compute mapped spectral acceleration values for user entered latitude and longitude coordinates. When selecting the parameters to be calculated for this example, the user should select:

1. 2015 IBC as the Building Code Reference Document
2. Site Class D Soil Classification
3. Structure Risk Category II
4. Site Latitude/Longitude or option to enter physical address of the site location.

The values of S_{DS} and S_{D1} may be obtained directly from this website.

It should be noted that even though one may obtain the calculated values of S_{DS} and S_{D1} directly from the website in lieu of calculating these values *from S_S and S_1, the procedure for calculating S_{DS} and S_{D1} is shown below for completeness.*

Based on the site class, the adjusted maximum considered earthquake spectral response acceleration parameters for short periods, S_{MS}, and at 1-second period, S_{M1}, are defined in IBC Section 1613.3.3 as follows:

$S_{MS} = F_a S_S$ (IBC Equation 16-37)

$S_{M1} = F_v S_1$ (IBC Equation 16-38)

Where,

F_a is the site coefficient defined in IBC Table 1613.3.3(1)

F_v is the site coefficient defined in IBC Table 1613.3.3(2)

The long-period transition period, T_L, is obtained from ASCE 7 Figures 22-12 through 22-16.

Note that values of spectral response acceleration parameters "S" are factors multiplied times g, but consistent with ASCE 7, g is not always explicitly shown but understood to be present for technical accuracy.

1.1.3.1 Site 1 coordinates and Site Class D

$S_S = 0.172$ $F_a = 1.6$ $S_{MS} = 0.275$

$S_1 = 0.060$ $F_v = 2.4$ $S_{M1} = 0.145$

$T_L = 6$ seconds

1.1.3.2 Site 2 coordinates and Site Class D

$S_S = 0.819$ $F_a = 1.17$ $S_{MS} = 0.960$

$S_1 = 0.290$ $F_v = 1.82$ $S_{M1} = 0.528$

$T_L = 12$ seconds

1.1.3.3 Site 3 coordinates and Site Class D

$S_S = 2.563$ $F_a = 1.00$ $S_{MS} = 2.563$

$S_1 = 1.175$ $F_v = 1.50$ $S_{M1} = 1.762$

$T_L = 8$ seconds

1.1.4 Determine the Site Design Spectral Response Acceleration Parameters

From IBC Equations 16-39 and 16-40 in Section 1613.3.4 (also in ASCE 7 Equations 11.4-3 and 11.4-4) determine S_{DS} and S_{D1}.

1.1.4.1 Site 1

$$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.275 = 0.183$$

$$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0.145 = 0.097$$

1.1.4.2 Site 2

$$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 0.960 = 0.640$$

$$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 0.528 = 0.352$$

1.1.4.3 Site 3

$$S_{DS} = \frac{2}{3} S_{MS} = \frac{2}{3} \times 2.563 = 1.709$$

$$S_{D1} = \frac{2}{3} S_{M1} = \frac{2}{3} \times 1.762 = 1.175$$

1.2 Determine the Risk Category, Importance Factor, and Seismic Design Category for each Site/Building

1.2.1 Determine the Building Risk Category and Importance Factor

The building risk category is determined per IBC Table 1604.5 and the importance factor is based on ASCE 7 Section 11.5.

Based on the problem description, the buildings at all three sites are warehouses with normal occupancy. Therefore, at all sites the building risk category is "II" and the seismic importance factor, I_e, is 1.0 (See Table 1.5-2, ASCE 7).

1.2.2 Determine the Seismic Design Category (SDC) for each Building

The seismic design category (SDC) is based on IBC Tables 1613.3.5(1) and 1613.3.5(2), with risk category = II (also in ASCE 7 Tables 11.6-1 and 11.6-2), and the S_{DS} and S_{D1} site values.

The SDC in both tables needs to be determined and the highest SDC is required to be taken as the SDC for the building. Note that ASCE 7, Section 11.6 and IBC Section 1613.3.5 have specific requirements for SDC when S_1 is greater than or equal to 0.75. This will be applicable to Site 3.

1.2.2.1 Site 1

From IBC Table 1613.3.5(1): SDC = B

From IBC Table 1613.3.5(2): SDC = B