

Design Example 3 Special Moment Frame

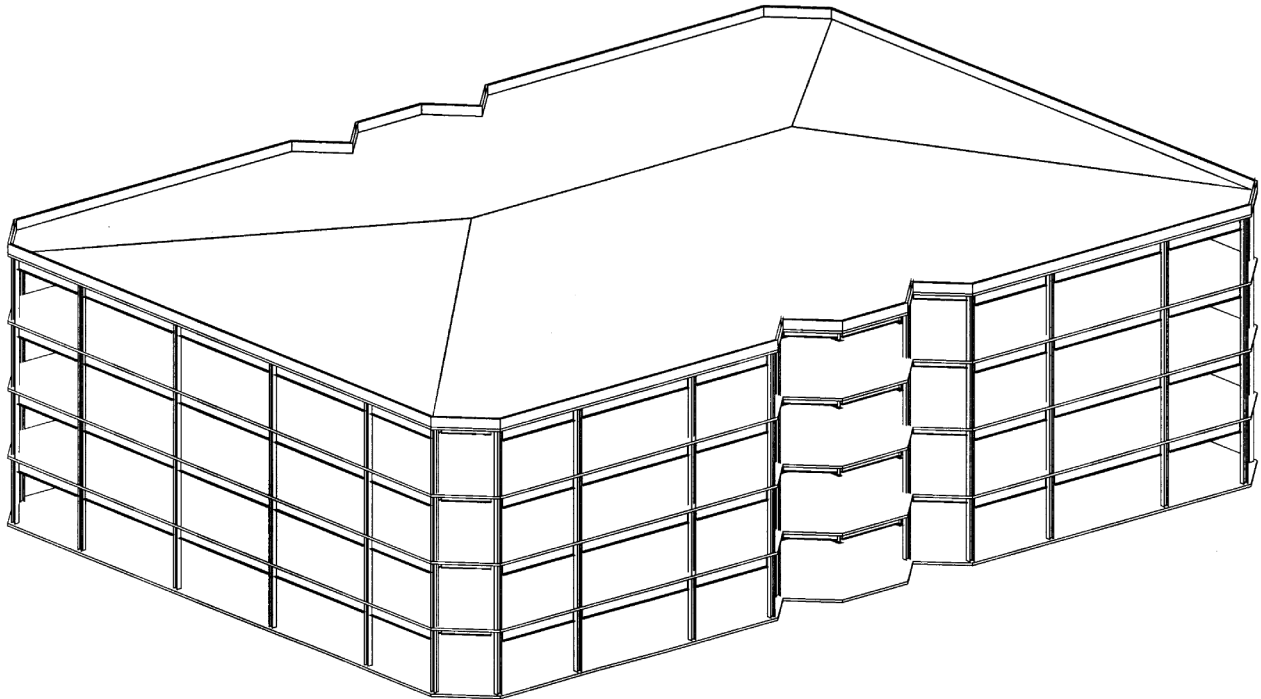


Figure 3-1. Four-story steel office building with steel SMF

Foreword

This design example illustrates the use of the 2009 IBC and ASCE/SEI 7-05 provisions for design of a steel special moment frame (SMF). During the course of the development of this Volume 3, the American Institute of Steel Construction published new editions of three Standards. These standards are

1. The use of wood diaphragms as part of the lateral force resisting system.
ANSI/AISC 341-05, Seismic Provisions for Structural Steel Buildings, Including Supplement No. 1 (AISC 341),
2. ANSI/AISC 358-05, Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications (AISC 358),
3. ANSI/AISC 360-05, Specification for Structural Steel Buildings (AISC 360).

These standards comprise the regulations that govern the design of structural steel special moment frames. Many of the provisions in AISC 358 and AISC 341 are rooted in the seminal SMF publication FEMA-350 *Recommended Seismic Criteria for New Steel Moment-Frame Buildings*.

Overview

In 2005, AISC published a standard (AISC 358) that provides design, detailing, fabrication and quality criteria for prequalified SMF connections. This standard comprises documentation meeting the requirements of ASIC 341, Appendix P. The following is an excerpt from the AISC 358 introduction.

This Standard specifies design, detailing, fabrication and quality criteria for connections that are prequalified in accordance with the AISC Seismic Provisions for Structural Steel Buildings (herein referred to as the AISC Seismic Provisions) for use with special moment frames (SMF) and intermediate moment frames (IMF). The connections contained in this Standard are prequalified to meet the requirements in the AISC Seismic Provisions only when designed and constructed in accordance with the requirements of this Standard. Nothing in this Standard shall preclude the use of connection types contained herein outside the indicated limitations, or the use of other connection types, when satisfactory evidence of qualification in accordance with Appendix S of the AISC Seismic Provisions is presented to the authority having jurisdiction.

This design example follows the provisions of AISC 358 for the RBS connection type for the steel SMF (the only prequalified SMF connection type).

The 4-story steel office structure shown in Figure 3-1 has a lateral force resisting system comprising structural steel special moment frames. The typical floor framing plan is shown in Figure 3-2. A typical frame elevation is depicted in Figure 3-3, and a general floor plan is shown in Figure 3-4. This design example utilizes simplifying assumptions for ease of calculation, consistency between seismic-force-resisting systems, and computational efficiency. While the example is accurate and appropriate for the design of steel SMF structures, different methodologies for analysis, connection design, and inelastic behavior can be utilized, including the use of proprietary SMF connection design; this example does not explore every possible option.

Outline

This example will illustrate the following parts of the design process.

1. **Earthquake loads general; scope.**
2. **Seismic ground motion values. (2009 IBC)**
3. **Building weights and mass distribution.**
4. **Seismic design requirements for building structures. (ASCE/SEI 7-05)**
5. **SMF member design. (ANSI/AISC 341, 358, 360)**
6. **SMF beam-column connection design. (ANSI/AISC 358, 341, 360)**

Given Information

Roof weights (dead load):

Roofing	5.0 psf
Insulation	2.0
Concrete fill on metal deck	43.0
Ceiling	3.0
Mechanical/electrical	3.0
Steel framing	<u>6.0</u>
Total	62.0 psf

Live load (Table 1607.1): 20.0 psf

Floor weights (dead load):

Floor covering	1.0 psf
Concrete fill on metal deck	43.0
Ceiling	3.0
Mechanical/electrical	3.0
Steel framing	9.0
Partitions (seismic DL)	<u>10.0</u>
Total	69.0 psf

Live load (Table 1607.1): 80.0 psf

Exterior wall system weight; steel studs, gypsum board, fascia panels 10.0 psf

Structural materials

Wide flange shapes	ASTM A992 ($F_y = 50$ ksi)
Plates	ASTM A572, Grade 50
Weld electrodes	E70X-XX

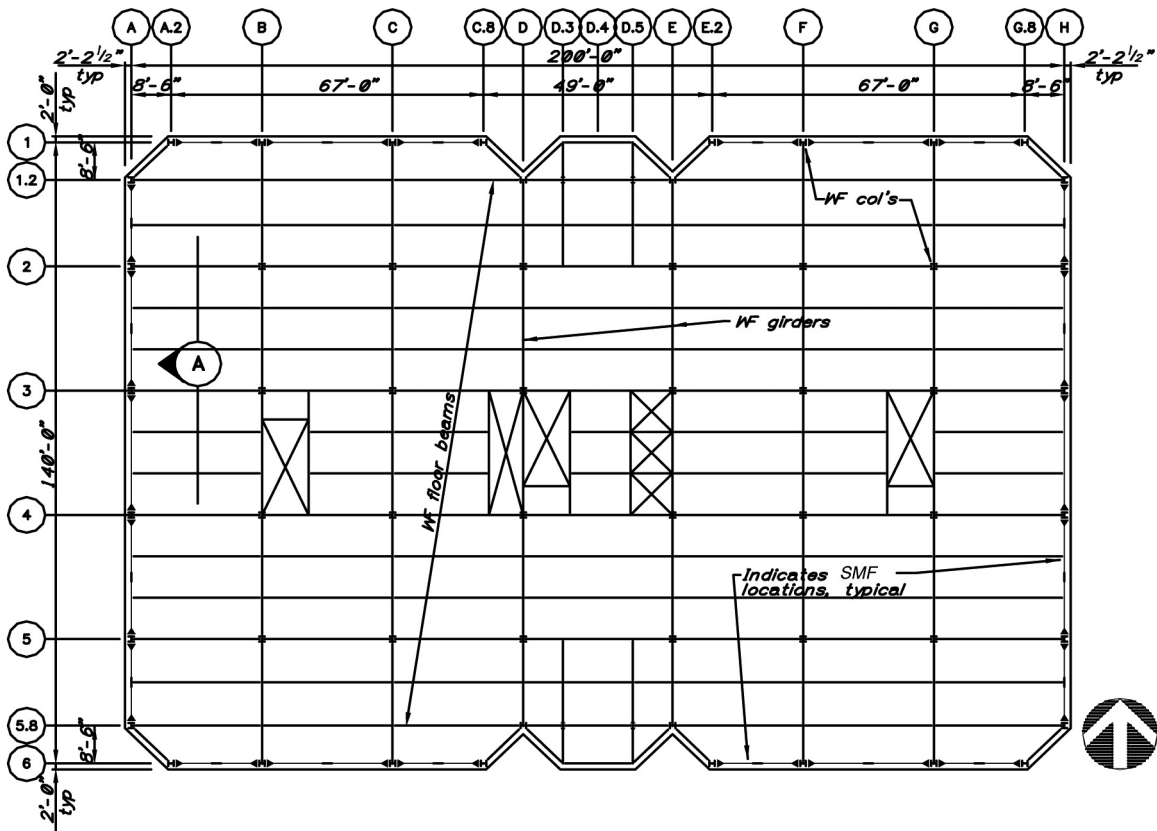


Figure 3-2. Typical floor framing plan

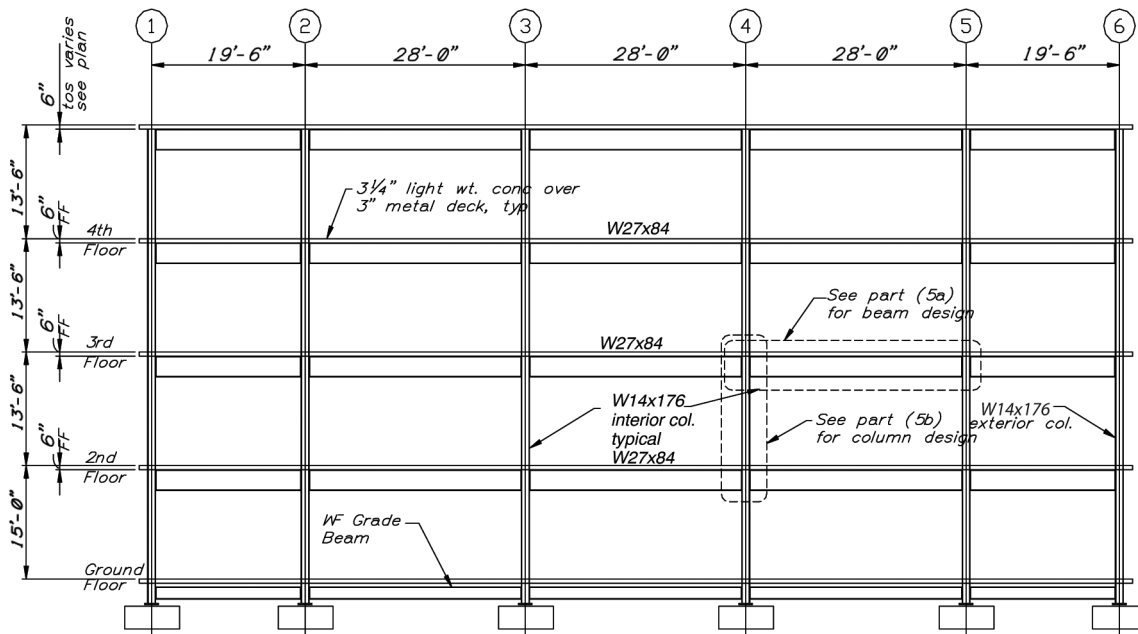


Figure 3-3. Frame elevation at Line A

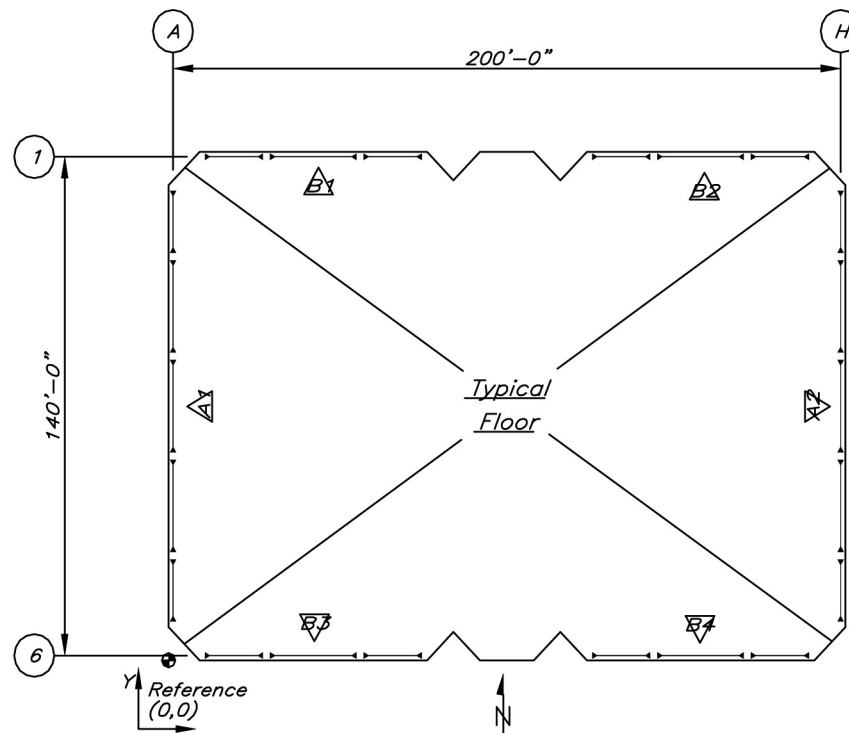


Figure 3-4. Typical floorplan

Calculations and Discussion

Code Reference

1. Scope

§1613.1

Note: As promulgated in the 2009 IBC, every structure, and portion thereof, including nonstructural components that are permanently attached to structures and their supports and attachments, shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE/SEI 7-05, excluding Section 14 and Appendix 11A. The Seismic Design Category for a structure is permitted to be determined in accordance with Section 1613 of the 2009 IBC or ASCE/SEI 7-05.

Section 2 of this example comprises seismic design requirements associated with the 2009 IBC Section 1613 and pertinent design parameters and equations from ASCE/SEI 7-05. Both the 2009 IBC and ASCE/SEI 7-05 require the use of pertinent AISC standards (listed above). Please note that not every aspect of this design example follows all best practices for system design, especially in the selection of member sizes related to expected inelastic behavior; representative sizes are depicted for the articulation of methods and procedures required for the adequate and accurate design of a steel SMF per accepted national standards.