Design Example 1
Four-story Wood Light-frame Structure

OVERVIEW

This design example illustrates the seismic design of selected elements for a four-story wood-frame hotel structure. The gravity-load framing system consists of wood-frame bearing walls. The lateral-load-resisting system consists of wood-framed bearing shear walls (common box-type system). A typical building elevation and floor plan of the structure are shown in Figures 1-1 and 1-2 respectively. A typical section showing the heights of the structure is shown in Figure 1-3. The wood roof is framed with pre-manufactured wood trusses. The floor is framed with prefabricated wood I-joists. The floors have a 1½-inch lightweight concrete topping. The roofing is composition shingles.

When designing this type of "mid-rise" wood-frame structure, there are several unique design elements to consider. The following steps provide a detailed analysis of some of the important seismic requirements of the shear walls per the 2012 IBC. This design example represents a very simple wood-framed wood structure; most wood-framed structures have several unique features requiring engineering design and detailing not shown in this design example.

This design example is not a complete building design. Many aspects have not been included, specifically the gravity-load framing system, and only certain steps of the seismic design related to portions of a selected shear wall have been illustrated. In addition, the lateral requirements for wind design related to the selected shear wall have not been illustrated (only seismic). The steps that have been illustrated may be more detailed than what is necessary for an actual building design but are presented in this manner to help the design engineer understand the process. For a more detailed listing of the items not addressed see Section 10.

OUTLINE

1. Building Geometry and Loads
2. Calculation of the Design Base Shear
3. Location of Shear Walls and Diaphragms
4. Mechanics of Multi-story Segmented Shear Walls and Load Combinations
5. Mechanics of Multi-story Shear Walls with Force Transfer around Openings
6. The Envelope Process
7. Design and Detailing of Shear Wall at Line C
8. Diaphragm Deflections to Determine if the Diaphragm is Flexible
9. Special Inspection and Structural Observation
10. Items Not Addressed in This Example

1. Building Geometry and Loads — ASCE 7

1.1 GIVEN INFORMATION

The roof is 15/32-inch-thick DOC PS 1- or DOC PS 2-rated sheathing, with a 32/16 span rating and Exposure I glue.

The floor is 23/32-inch-thick DOC PS 1- or DOC PS 2-rated Sturd-I-Floor 24 inches o.c. rating, with a 48/24 span rating (40/20 span rating with topping is also acceptable) and Exposure I glue.

DOC PS 1 and DOC PS 2 are the U.S. Department of Commerce (DOC) Prescriptive and Performance-based standards for plywood and oriented strand board (OSB), respectively.

Wall framing is a "modified balloon framing" where the joists hang from the walls in joist hangers. (See Figure 1-7 detail of this and an explanation of other common framing conditions.)

Framing lumber for studs and posts — NDS T 4A

Douglas Fir Larch-No. 1 Grade:

F_b = 1,000 psi
F_c = 1,500 psi
F_t = 675 psi
E = 1,700,000 psi
E_{min} = 620,000 psi
C_m = 1.0
C_t = 1.0

Common wire nails are used for shear walls, diaphragms, and straps. When specifying nails on a project, specification of the penny weight, type, diameter, and length (example 10d common = 0.148 inch × 3 inches) are recommended.

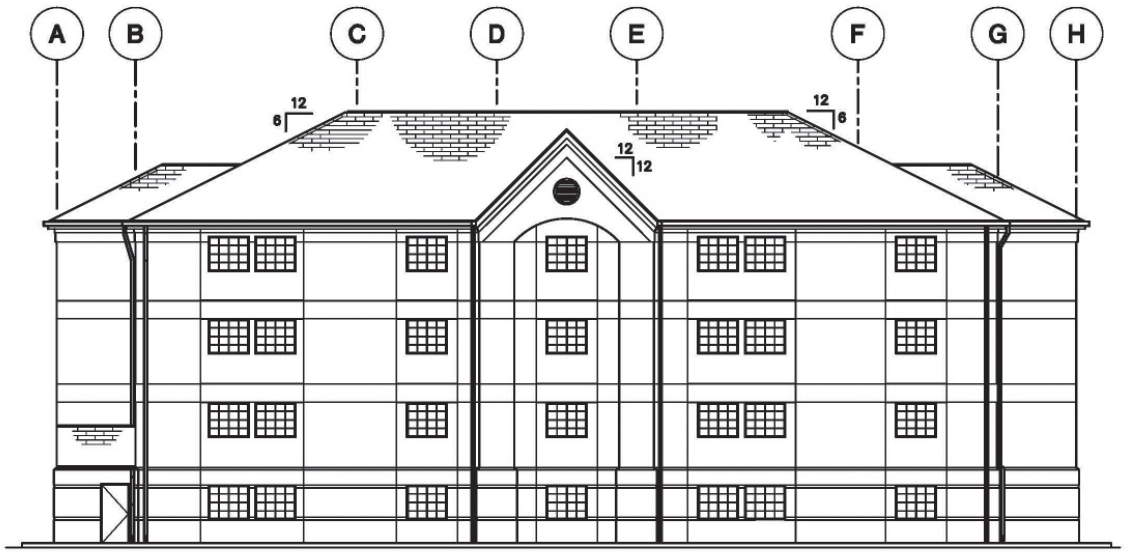

Figure 1–1. Building elevation

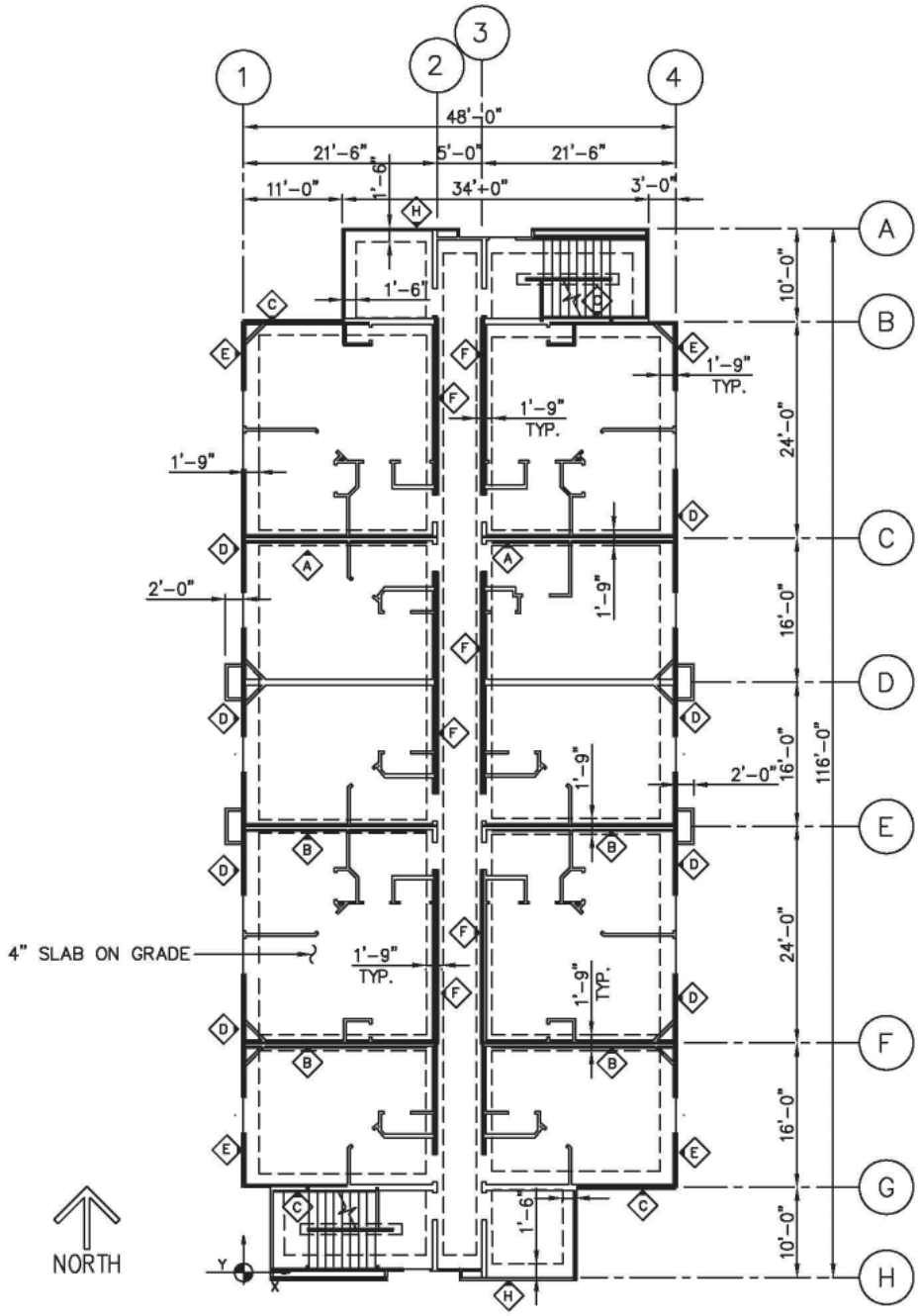

Figure 1–2. Typical foundation plan

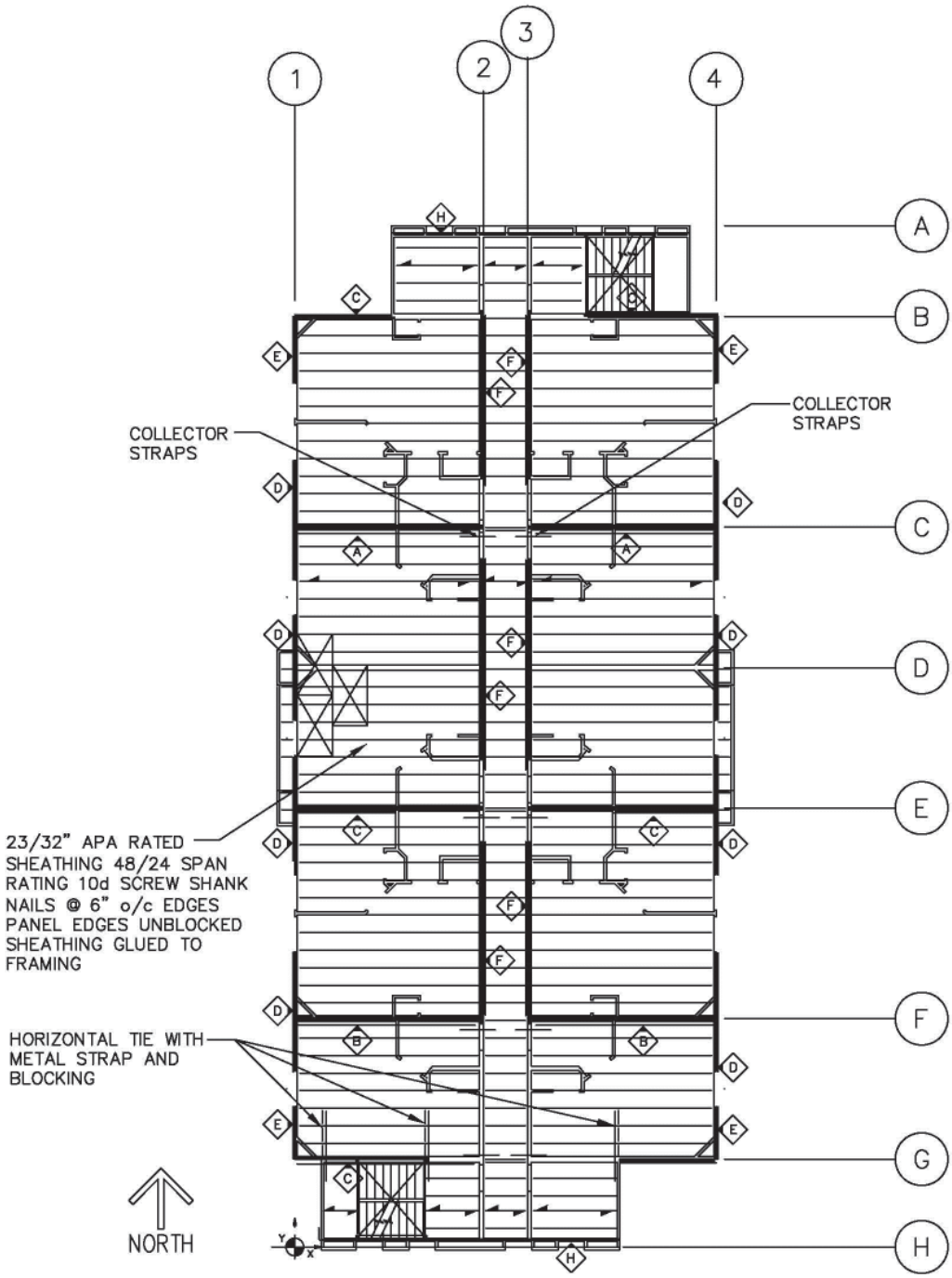

Figure 1–3. Typical floor framing plan

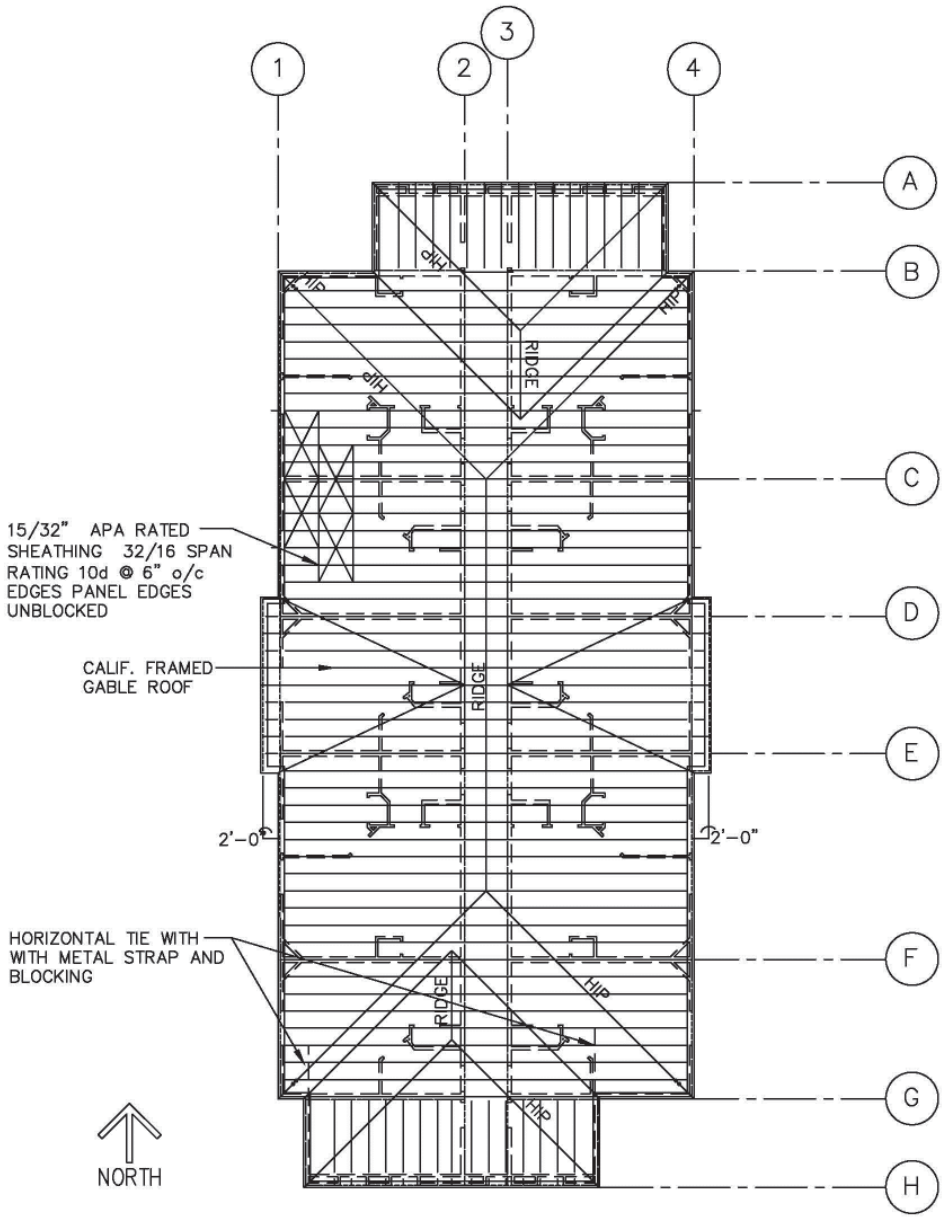

Figure 1–4. Typical roof framing plan

Notes for Figure 1-2 through 1-4:

1. Non-structural "pop-outs" on the exterior walls at lines 1, 4 need special detailing showing the wood structural panel sheathing running continuous at lines 1, 4 and the pop-outs framed after the sheathing is installed.

2. All walls stack from the foundation to the fourth floor.

3. ◇ Designates sheathed wall per shear-wall schedule (see Table 1-32).