

DESIGN OF POST-FRAME GYMS AND MULTIPURPOSE BUILDINGS

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Post-frame construction is ideal for non-code-exempt buildings of many shapes and sizes. One category of such structures that is often overlooked by post-frame builders is gymnasiums and multipurpose recreational buildings.

Gymnasiums and multipurpose recreational buildings are a perfect fit for post-frame construction for several reasons. Post-frame walls feature columns that run continuously from the foundation to the roof framing. These columns can be designed to accommodate the high ceilings that gymnasiums require. Long clear-span trusses allow for an open floor plan for basketball, volleyball and other sports, with scissors-style trusses used to create pitched ceilings that are higher in the center of the building. Large wall cavities allow plenty of room for insulation to meet or exceed energy code requirements. A variety of exterior siding and roofing materials can be used to create aesthetically pleasing architectural designs. The end result is post-frame gym and multipurpose recreational building designs that are cost efficient, highly functional, energy efficient and architecturally pleasing.

BUILDING CODE CLASSIFICATION AND REQUIREMENTS

Building codes classify buildings by type of occupancy and by type of construction. Occupancy type defines the end use of the building. Buildings (or parts of buildings) with the same end use are assumed to have similar life-safety characteristics, combustible contents and fire hazards. Construction type is used to define minimum fire ratings of building components (e.g., beams, columns)

and assemblies (e.g., walls, floors, roofs). It is the combination of occupancy type (or use group) and construction type that largely dictates maximum building height and area.

Descriptions of the various occupancy and construction types can be found in Chapter 3 of the International Building Code. Two other IBC chapters of related importance are Chapters 5 and 9. Chapter 5 contains maximum allowable building heights and areas. Chapter 9 contains requirements for fire protection systems based on the occupancy type (note: Chapter 9 requirements are independent of construction type). Chapter 9 provides the parameters of fire areas and occupant loads and is used to determine whether a project will require an automatic sprinkler system. Chapter 9 is used in conjunction with Chapter 7 to determine fire barrier and firewall requirements.

In accordance with the IBC, gymnasiums and multipurpose recreational buildings are typically assigned an Assembly (A) type of occupancy. If the building does not have spectator seating, it is classified as A-3. If it includes spectator seating, it is classified as A-4. All or part of these buildings may be classified as a Business (B) type of occupancy under the IBC if the building includes areas for training and skill development conducted outside of a school or academic program. This could include, for example, a building at a summer camp that is used for dance lessons or another business venture, rather than a typical gymnasium setting where games and practices are held.

Typical post-frame construction is classified as construction type VB, which means that the primary building

elements are wood frame elements that don't require fire protection. Assembly (A) buildings of type VB construction are limited to an allowable area of 6,000 square feet and to one story, per IBC Table 503. The maximum allowable area can be increased if all or a portion of the area surrounding the building meets access criteria (i.e., open perimeter requirements) for firefighting. The addition of an automatic sprinkler system will also provide an allowable area increase of 200 percent as well as an increase in the number of allowable stories—from one to two.

Post-frame buildings with primary structural building elements that have a 1-hour fire resistance rating can be classified as VA construction. Assembly (A) buildings of type VA construction are limited to an allowable area of 11,500 square feet and two stories, per IBC Table 503. Again, the maximum allowable area can be increased by providing firefighting access, automatic sprinklers or both. The inclusion of automatic sprinklers will also allow an increase in the maximum number of stories—from two to three.

The maximum fire area in assembly A-3 and A-4 buildings is limited to 12,000 square feet or less, per IBC Section 903.2.1, regardless of construction type. If the fire area exceeds 12,000 square feet, then an automatic sprinkler system is required. The use of 2-hour-rated fire barriers, per IBC Section 706, can create separate fire areas and eliminate the need for the sprinkler system.

Occupant load can be a major controlling factor in gymnasium and multipurpose recreational building design. The IBC bases occupant load on an allowable number of persons per square

foot (i.e., how many individuals could fit in the space), not on the anticipated number of occupants in the building (see IBC Section 1004). Regardless of construction type, the maximum number of occupants in an A-3 or A-4 fire area is 299 before a sprinkler system is required. Gymnasiums and recreational buildings typically have large open floor plans, and applying the person-per-square-foot requirement results in a very high occupant load, and thus a load that typically requires a sprinkler system. If the calculated occupant load results in a number that is unrealistic, the issue can be discussed with the building code official, who has the authority to accept a lesser number or adjust the square-foot-per-person total in order to get a more reasonable result, per IBC Section 1004.1.1. When this is done, maximum-occupant-load signs must be posted at or near the main entrance and exit doors.

The structural design of post-frame gyms and multipurpose recreational buildings must conform to the structural load requirements compiled in IBC Chapter 16. Section 2306 of the IBC requires adherence to the *National Design Specification for Wood Construction* published by the American Wood Council (2015). The NDS establishes minimum design standards for all wood frame buildings. IBC Section 2306 also requires adherence to three documents of the American Society of Agricultural and Biological Engineers: EP484. Diaphragm Design of Metal-Clad, Wood-Frame Rectangular Buildings; EP486. Shallow-Post Foundation Design; and EP559. Design Requirements and Bending Properties for Mechanically Laminated Columns. Use of the NDS and ASABE documents for post-frame building design is covered in the *Post-Frame Building Design Manual* published by

the National Frame Building Association (Bohnhoff, 2015).

DESIGN EXAMPLES

Following are three examples of gym or multipurpose recreational building designs that use post-frame construction. The scope of this article does not include the entire building analysis; only a few key concepts specific to post-frame design (including some structural design tips and some code-related details) are provided. Please keep in mind that two of these examples were designed in accordance with the 2006 IBC and one in accordance with the 2003 IBC. The IBC is constantly being updated and revised. The status of the latest code adoption varies from state to state and sometimes from municipality to municipality. As always, be sure to check which edition of the code is currently in use before starting a project.

EXAMPLE 1: SMALL SCHOOL GYMNASIUM



FIGURE 1. Example 1: Small school gymnasium in an urban setting



FIGURE 2. Example 1: Side wall

Designed in accordance with the 2006 IBC and built in 2007, Example 1 (Figures 1–9) is an 80- by 94- by 20-foot post-frame gym featuring bleachers, a locker room and restrooms. It is located in an urban area next to a school building. Another building was removed to open up space for this gym. Two walls were designed to bear on an existing retaining wall, and one sidewall was fire-rated because of its proximity to a property line. This building was designed to meet VA construction type requirements (i.e., it was designed with 1-hour-rated walls and ceiling) and an A-4 occupancy.



FIGURE 3. Example 1: Gable wall with retaining wall

EXAMPLE 1: SMALL SCHOOL GYMNASIUM *Continued*



FIGURE 4. Example 1: Gable wall, full height



FIGURE 5. Example 1: Interior view



FIGURE 6. Example 1: Interior view

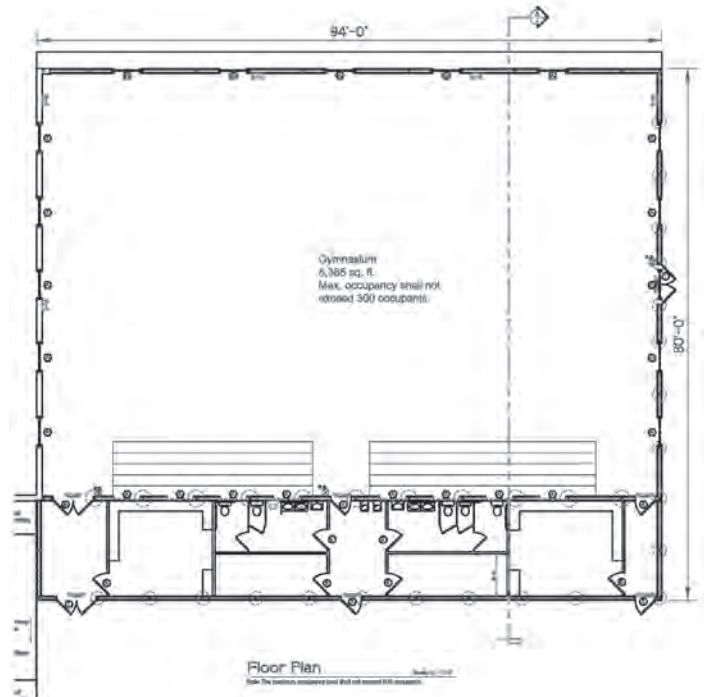


FIGURE 7. Example 1: Floor plan

The actual area of the building was 7,520 square feet. Because this was less than the maximum allowed value of 11,500 square feet for an A-4 building of type VA construction, per IBC Table 503, there was no need (from the perspective of maximum allowable area) to increase perimeter access for firefighting or to add a sprinkler system. However, the occupancy load calculation (based on an IBC Table 1004.1.1 value of 7 square feet per person for an A-4 occupancy) provided an occupant load of greater than 300,

so a sprinkler system would have been required, according to IBC Section 903.2.1.4. The school board met with the building official to review the sprinkler system requirement and requested a variance. A variance was granted, with the requirement that an interconnected fire alarm system and additional exit doors be added to this one-story building.

The structural design used embedded post foundations on some walls and posts fastened to the top of retaining walls on others. The embedded post

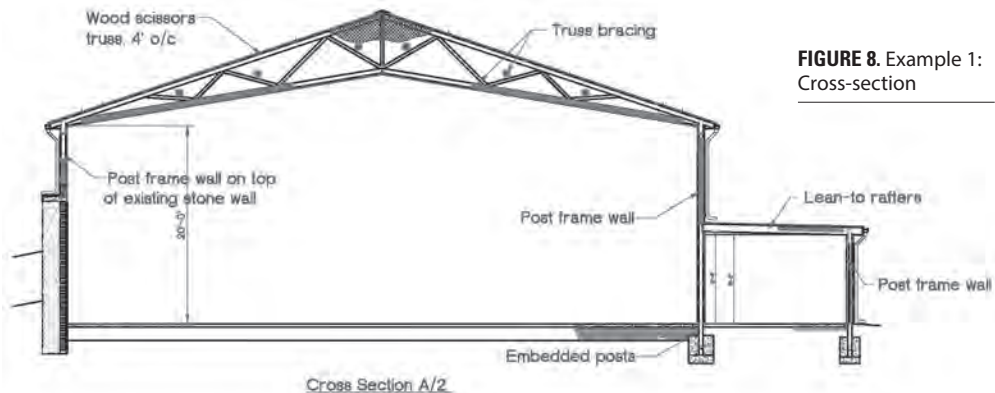


FIGURE 8. Example 1: Cross-section

EXAMPLE 1: SMALL SCHOOL GYMNASIUM *Continued*

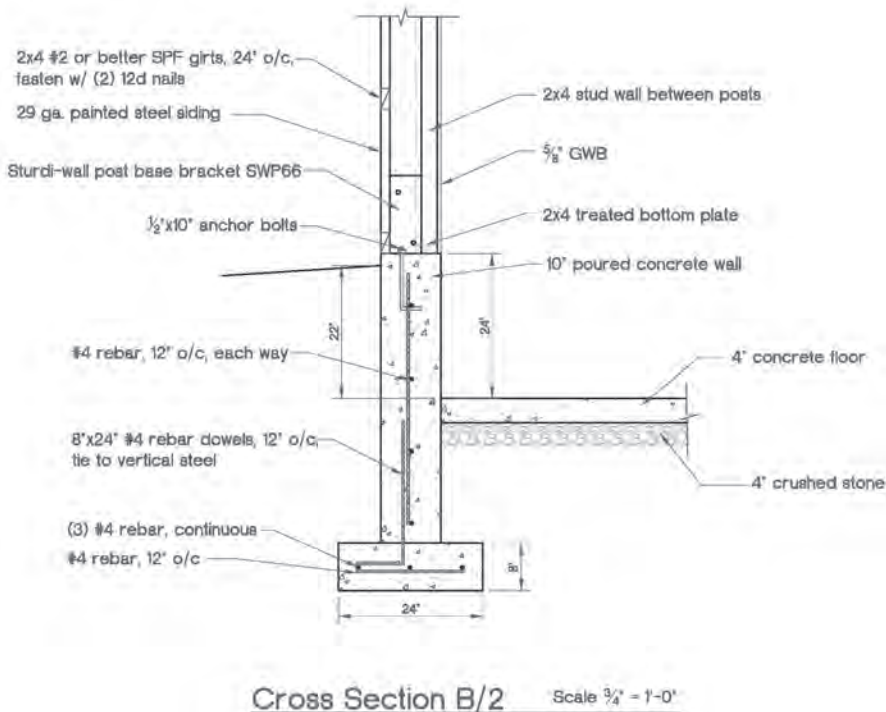


FIGURE 9. Example 1: Foundation detail

foundations were designed according to ASABE EP 486 Shallow-Post Foundation Design. The connections of the posts to the top of the retaining walls were based on methods described in the NDS. A unique feature of this gym was the scissors truss roof system that provided a ceiling 20 feet high at the sidewalls and 25 feet high at the center of the gym floor. As previously mentioned, walls and ceilings with 1-hour fire-resistance ratings are required for type VA construction. This was accomplished by applying 5/8-inch-thick type X gypsum to the inside face of the walls (in accordance with Underwriters Laboratory [UL] design U528) and to the underside of the truss bottom chord (in accordance with a fire resistance calculated per IBC Section 721.6). Diaphragm action was used to provide lateral and longitudinal stability. Diaphragm design was performed in accordance with ASABE EP484 Diaphragm Design of Metal-Clad, Wood-Frame Rectangular Buildings.

EXAMPLE 2: MULTIPURPOSE RECREATIONAL BUILDING FOR A CAMP/RETREAT CENTER

Example 2 (see **Figures 10–12**) features an 80- by 120- by 20-foot post-frame building designed in accordance with the 2006 IBC and constructed on top of a cast-in-place concrete foundation wall in 2007. Main characteristics include an open floor plan (except for the restroom and mechanical room in one corner of the building) and a cast-in-place rear concrete wall that functions as a retaining wall. This camp/retreat center was designed for an A-3 occupancy and type VB construction. Per IBC Table 503, the maximum allowable area for an A-3 building of VB construction is 6,000 square feet. Because this was less than the actual designed building size of 9,600 square feet, an allowable increase for fire-fighting access (calculated in accordance with the IBC Section 506.2 open-perimeter formula) was used. The occupant load for this building using 5 square feet per person for the open floor plan would have resulted

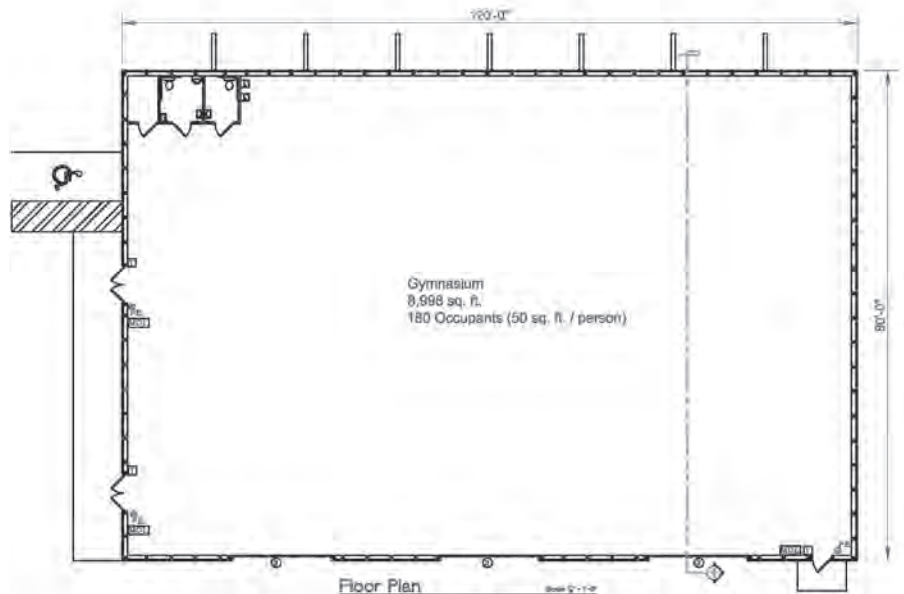


FIGURE 10. Example 2: Floor plan

in an occupant load greater than 299, which would have required installation of an automatic sprinkler system. The owners met with their building official, and the building official accepted an occupant-load calculation based on 50 square feet per person, similar to that of an exercise room. This resulted in a much more reasonable occupant load. The maximum occupant load of 180 people was required to be posted on signs next to all the entrance and exit doors.

As previously stated, this design used post-frame construction on top of cast-in-place concrete foundation and retaining walls. Posts were spaced 4 foot on center at the request of the owner. A design featuring embedded posts spaced 8 foot on center might have been more cost effective. Note that all gable columns extend to the roof line, a detail that we would suggest for most post-frame building designs. A scissors truss roof system was used to create a 25-foot-high ceiling at the center of the building. Individual trusses were spaced 2 foot on center so that plywood roof sheathing and metal ceiling panels could be installed directly onto the trusses. This eliminated the need for purlins.

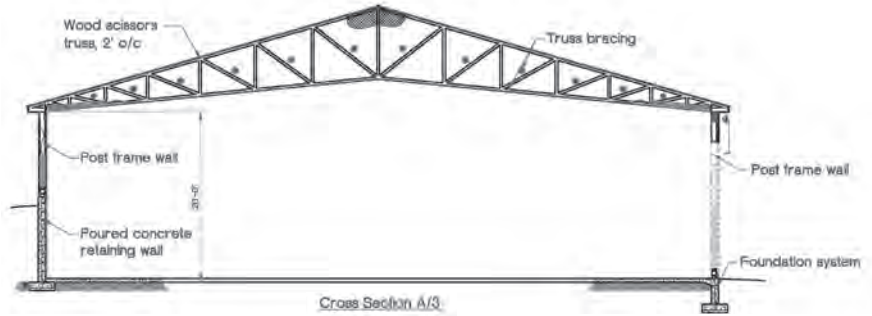


FIGURE 11. Example 2: Cross-section

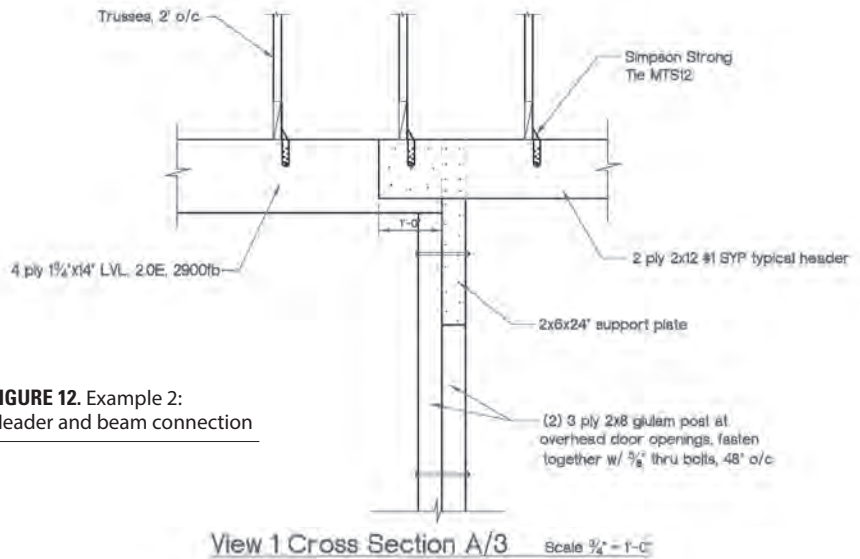


FIGURE 12. Example 2: Header and beam connection

EXAMPLE 3: COMMUNITY CENTER GYMNASIUM

Presented as Example 3 (Figures 13–15) is an 82- by 114- by 24-foot gym that was erected in 2005 and designed in accordance with the 2003 IBC. Gable trusses cover the main gymnasium area, and attached offices, storage space, classrooms, a concession area and restrooms are located alongside the gym in a lean-to area framed with mono-slope trusses.

The project design team included an architect who provided architectural plans that covered the building code review. Our structural design was used, in addition to the architectural plans, to create a complete set of plans for submission to obtain the required permits.

The foundation for the Example 3 building is a grade beam foundation system installed on top of a driven piling system. Columns were fastened directly to the concrete grade beam

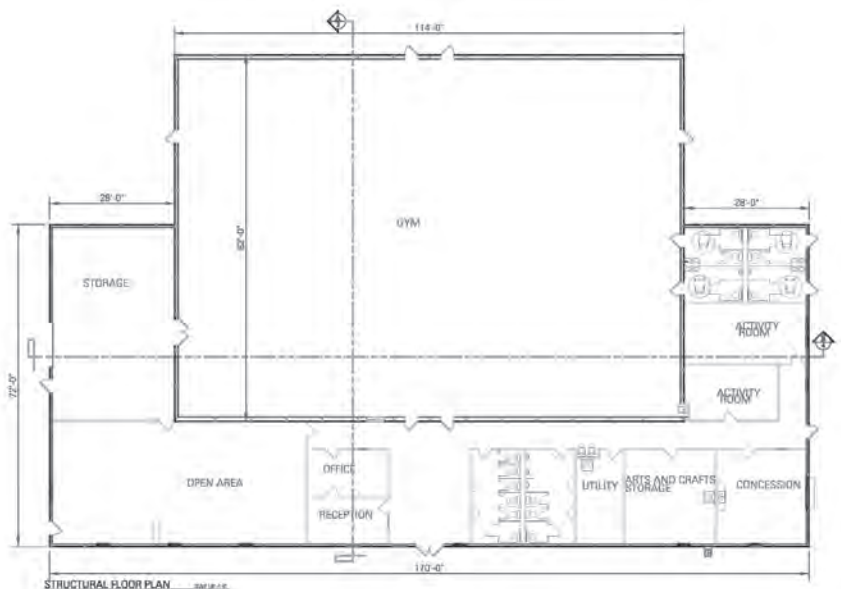


FIGURE 13. Example 3: Floor plan

