

Economical Structural Steel Framing Systems for Multi-Story Residential Buildings



Learning Objectives

- Understand the major structural issues to consider when designing for multi-story residential projects.
- Learn the concepts and advantages of the staggered truss and Girder-Slab structural steel framing systems.
- Understand how innovative structural steel framing systems provide economical and innovative solutions to multi-family residential building design.

Introduction

When designing a structure in today's market, speed of construction, design flexibility, material costs, aesthetics, and availability of materials are just some of the many issues that must be addressed when making the initial decision as to what is the best way to frame out a proposed structure. Considering the optimal material to accommodate all of these issues is essential.

For the multi-story residential market, structural steel has become more of a viable and popular option in recent years. A number of competitive steel systems offer the advantages of competing systems, but also have the ability to meet tighter schedule requirements and increase design flexibility in the process. This article will address two methods of steel-framed construction: Staggered Truss and Girder-Slab.



A common ground level view of column-free first floor of staggered truss project.

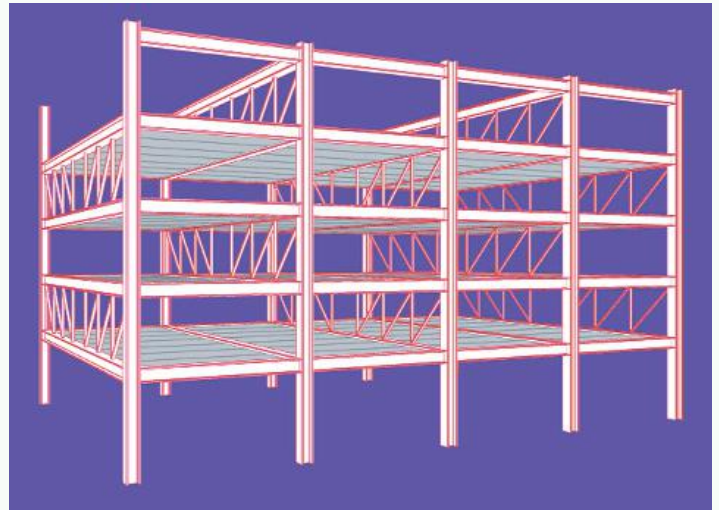
The Staggered Truss

The staggered truss framing system was developed by a team of architects and engineers from the departments of architecture and civil engineering at MIT in the late 1960s. While not new in concept, the system is experiencing a renaissance in today's multi-story residential market place.

Staggered truss is a competitive alternative to flat plate concrete framing for achieving the low floor-to-floor heights often desired for apartments, condominiums, dormitories, hotels and senior residences.

Designers and developers have become increasingly intrigued with its potential because of the inherent efficiencies in cost and schedule savings that give the system substantial economic advantages over other framing systems.

The truss frame provides an efficient method to resist lateral and gravity loads and provides versatility of floor layout with large column-free areas. Comprised of story-high identical trusses throughout the structure, which are buried in the demising walls, the staggered trusses span the entire



Rendering of Chicago Staybridge Suites hotel staggered truss project scheduled for completion in 2009, left. Typical 3-D model of standard staggered trusses supporting hollow core slabs. Rendering: Valerio Dewalt Train



width of the building. The trusses alternate from floor-to-floor so that the bottom chord of one truss aligns with the top chord of the next. This yields column-free areas extending two column bays by the full width of the building, providing exceptional design flexibility. Columns are located along the exterior walls only, resulting in a completely column-free ground level.

The most common floor system used with staggered truss is precast hollow-core slab, or plank, which is grouted in the seams but left untopped. The hollow-core slab is a very cost-effective, dry, all-weather system that provides semi-finished floors and ceilings. Although other floor systems are feasible, hollow-core slab is used most often to keep floor-to-floor heights to a minimum. For a typical residential loading of 40 PSF plus 20 PSF partition load and a span of 30 feet, an 8-in. hollow-core slab is usually adequate. The lightweight steel and hollow-core slab system results in reduced foundation loads which, in turn, results in reduced foundation costs. During construction, erection of the frame proceeds rapidly due to the quick placement of trusses and slab.

Because the story-high trusses typically span the entire width of the building, the truss diagonal is omitted from the center panel of the truss to allow for corridors in the building. This open center panel is often referred to as a Vierendeel opening or

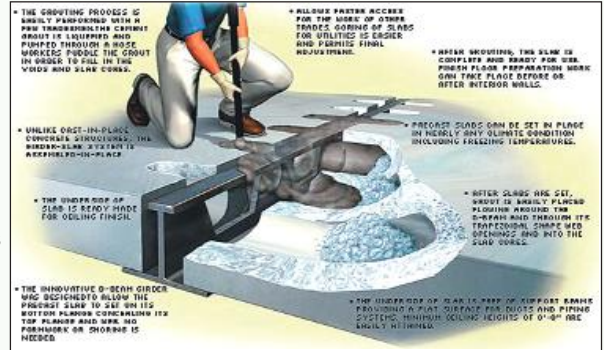
panel. Trusses are typically fabricated with W10 top and bottom chords and 6-in. hollow structural shape (HSS) web members. To help speed slab erection, a minimum chord width of 8-in. is recommended. At the top and second stories, where it is not feasible to place a truss in the staggered arrangement, posts and hangers are used to support the roof and second floor.

The staggered truss system lends itself to production economies in terms of mass-producing standard pieces with slight variations in member sizes. Jigs and fixtures may be built to accommodate the truss geometry and the slight variations in member sizes. Today's fabrication shops are highly automated, efficient operations where trusses are produced to precise tolerances in a controlled environment.

Recently a hotel project in Chicago, a Staybridge Suites under construction downtown, became the first in the area to utilize the staggered truss system. Financed by local developer the Miglin Properties and designed by Valerio Dewalt Train Architects, Chicago, the project team has leveraged the inherent benefits of the staggered truss system to the benefit of the project, while also using unique cantilevered areas to make the hotel a signature structure. More information on the Staybridge Suites project can be found at www.aisc.org/staybridge.

The Girder-Slab® System

Girder-Slab is an alternative to cast-in-place concrete or masonry bearing systems. The non-proprietary system has been used in over 3 million square feet of construction. Key attributes with the system are that low floor-to-floor heights are easily achieved – to a minimum of 8 feet,



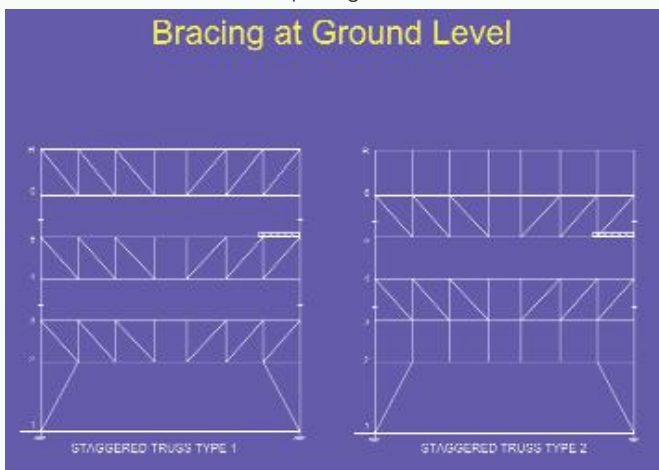
Typical Girder-Slab system installation. Image courtesy of Girder-Slab®

8 inches - and no shoring is required. A lighter frame often results in foundation savings and installation can be performed in cold weather without delay.

Girder-Slab is a patented system, available through all structural steel fabricators, that uses dissymmetric beams (D-Beams) that carry precast hollow-core slabs on their bottom flanges. The D-Beams come in 8-in. or 9-in. depths. The sections are produced from "parent" sections (W10s, W12s or W14s) that are sliced in half through the web in a hexagonal pattern to form two equal T-sections. A 3-in.-wide bar is used to form the top flange.

Traditionally, 9-in.-deep D-beams are best for hollow-core slab systems that require a structural topping. Eight-inch D-beams are usually sufficient for hollow-core slab systems that only require a nominal skim coat topping or no topping at all. By resting the hollow-core slabs on the beams' bottom flanges, nearly the entire structural depth is incorporated into D-Beam depth. The beams are designed to develop composite action between the slabs and grouted cells. Once the slabs are erected on the beams, they are grouted into place. Grout flows through the openings in the web of the beam and into the hollow cores of the slab before it solidifies.

The precast slab can span either parallel or perpendicular to the perimeter of the building, with each direction having its own advantages. When the hollow-core slab spans parallel to the perimeter, D-Beams run in demising walls between residential units. Spandrel beams can often be removed after



As shown in Staggered Truss Type 2, posts and hangers are used to support the roof and second floor at the top and second stories, where it is not feasible to place a truss in the staggered arrangement.

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Showing off its curves, the Aqua condominium project under construction in Long Island Beach, N.Y., is employing the Girder-Slab framing system. Rendering: Robert M. Swedroe Architects & Planners; Photo: Canatal Industries Inc.

they are used for erection purposes. Because of this, true floor-to-ceiling windows can be achieved if this is a priority for a project. When the slabs span perpendicular to the perimeter (spandrel beam carries plank load), beams will run along the perimeter and corridor walls. This provides open space between units and is helpful if the units in a building are not laid out regularly.

The system is UL certified (Design K912) for fire with spray-on or board assemblies. A typical D-Beam spans 16 ft to 20 ft and can be increased to 24 ft with the use of tree columns. With precast slabs spanning an average of 28 ft to 30 ft, bay sizes of about 20 ft by 30 ft are usually efficient. This system reduces and sometimes eliminates soffits, which is optimum in application for condominiums, hotels or dormitory structures.

The curvaceous Aqua condominium project under construction in Long Beach Island, N.Y., is demonstrating that flat walls and 'typical' bays no longer have to be standard in a steel-framed

building. Designed by Robert M. Swedroe Architects & Planners, Miami Beach, Fla., and utilizing the Girder-Slab system, the project's curved façade challenges were easily achieved with the structural steel and hollow-core slab system. The system provided the design team with flexibility and enabled them to develop cost-saving measures for the project.

The multi-story residential market is fraught with opportunity for designers and building teams to evoke imaginative solutions to the needs of modern multi-family residential living. The staggered truss and Girder-Slab are two structural steel framing systems designers are adding to their pallets to bring lightweight, efficient, open, economical and aesthetically pleasing solutions to market. ■

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*For additional information on staggered
truss or Girder-Slab framing solutions, or
to schedule a CEU program, please
contact the American Institute of Steel
Construction's Steel Solutions Center at
866.ASK.AISC or solutions@aisc.org.*

BENEFITS OF THE STAGGERED TRUSS FRAMING SYSTEM

Advantages of the staggered truss

The staggered truss system has many advantages over conventional flat plate concrete framing systems for multi-story residential construction.

These include:

- The building has a column-free interior throughout the entire ground level providing greater architectural design flexibility.
- The lightweight steel and plank system can reduce foundation loads by 20% or more, resulting in a significant reduction in foundation construction and cost. In addition, the majority of interior foundations will be eliminated.
- The 8-in. thick floor system provides the lowest floor to floor heights achievable provides one of the lowest floor to floor heights achievable in the industry.
- The staggered arrangement of the trusses allows clear open spaces of 60 feet or more by the full width of the building at every bay, on every floor.
- The floor and frame components are plant fabricated in a controlled environment, resulting in increased quality and reduced chance of errors.
- Field labor is kept to a minimum, with fewer pieces to erect, resulting in faster construction, and faster building completion.

BENEFITS OF THE GIRDER-SLAB FRAMING SYSTEM

- Flexible floor-to-floor heights (a minimum of 8 feet, 8 inches) to ensure maximize building height.
- Super-fast structure and building completion.
- Reduced building structure weight.
- Floor plan design flexibility.
- Limited weather impact (including cold climates).
- Structure assembly is one process, one source.
- Integrates well with mixed use spaces below.
- Meets fire code ratings using UL K912.
- Meets required sound (STC) ratings.
- Limited on-site labor.
- Reduced on-site overhead costs.
- Eliminates/reduces soffits.
- Factory made quality components.



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**ALA Continuing Education Questionnaire -
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Program Title:

Economical Structural Steel Framing Systems for Multi-Story Residential Buildings

ALA/CEP Credit: This article qualifies for 1.0 LU's (health, safety, and welfare) of State Required Learning Units and may qualify for other LU requirements. (Valid through Feb.2009.)

Instructions:

- Read the article using the learning objectives provided.
- Answer the questions.
- Fill in your contact information.
- Check whether logging of ALA/CEP credit (ALA members with logging privileges only) or certificate of completion is desired.
- Sign the certification.
- Submit questions with answers, contact information and payment to ALA by mail or fax to receive credit.
- Article and tests are also available online: www.licensedarchitect.org

QUIZ QUESTIONS

1. The staggered truss framing system is a competitive alternative to flat plate concrete framing for achieving:
 - a. Low floor-to-floor heights
 - b. Long-span column-free spaces
 - c. Versatility of floor layout
 - d. All of the above

2. Inherent efficiencies in cost and schedule are not reasons why designers and developers are looking more closely at staggered truss as an option for multi-family residential construction.
 T F
3. The staggered truss system was developed in the:
 - a. 1960s
 - b. 1970s
 - c. 1980s
 - d. 2003
4. With the staggered truss system, the trusses alternate from floor to floor so that the bottom chord of one truss:
 - a. aligns with the top chord of the next truss
 - b. aligns with the front of the building
 - c. aligns with the bottom chord of the next truss
5. In the staggered truss system, columns are located:
 - a. throughout the building
 - b. only along the exterior of the building
 - c. at typical bay spacings
6. The open center panel of the staggered truss is referred to as a:
 - a. Vierendeel opening or panel
 - b. Unbraced opening

- c. Box truss opening
 - d. None of the above
7. Girder-Slab is a patented system, available through all structural steel fabricators, that uses dissymmetric beams (D-Beams) that carry precast hollow-core slabs on their bottom flanges.
 T F
 8. What minimum floor-to-floor height is easily achieved with the Girder-Slab system:
 - a. 8'8"
 - b. 9'3"
 - c. 9'-8"
 - d. 10'-2"
 9. With the Girder-Slab system, spandrel beams can often be removed after they are used for erection purposes. Because of this, true floor-to-ceiling windows can be achieved for multi-family residential buildings.
 T F
 10. Innovative structural steel systems such as Girder Slab no longer make flat walls and 'typical' bays a standard requirement in a steel-framed building, curves and shapes are now attainable.
 T F

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