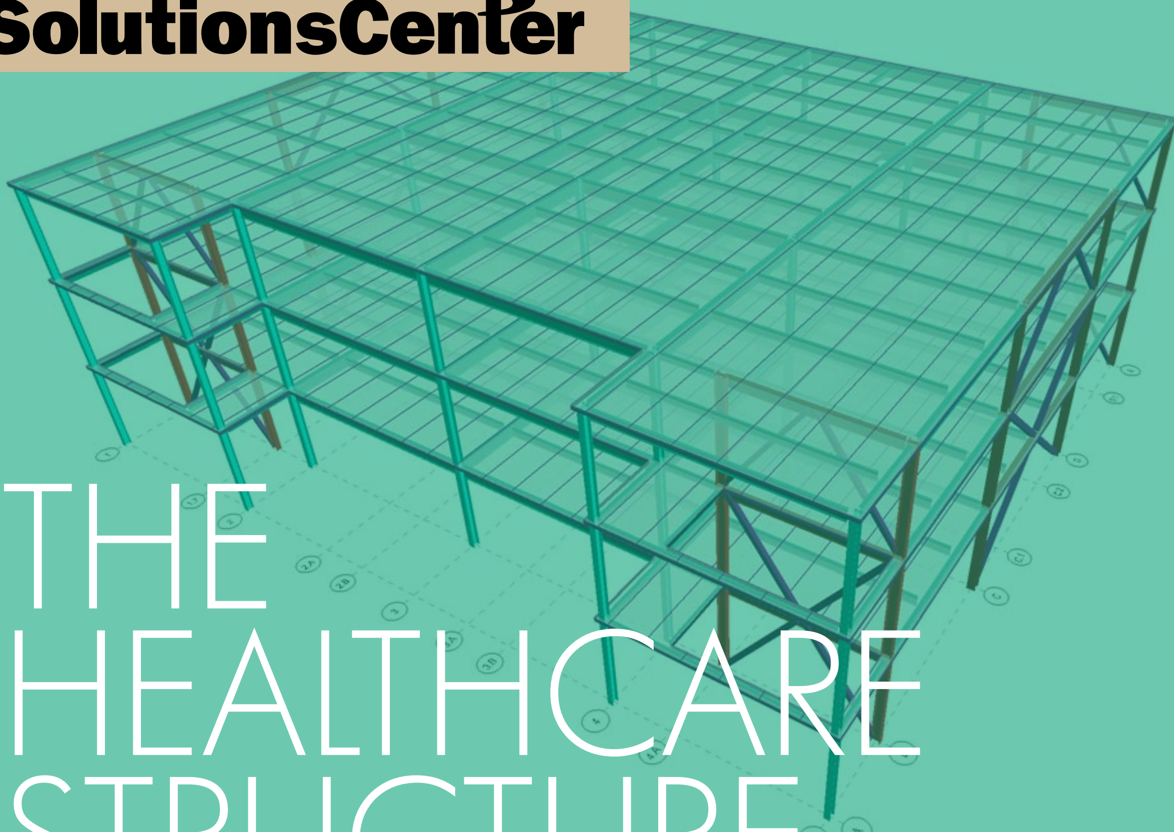
structural
STEEL

Steel SolutionsCenter



THE HEALTHCARE STRUCTURE PROTOTYPE III

Exploring Seismic Load Resisting Systems

USING THE AISC STEEL SOLUTIONS CENTER

What's this?
This package illustrates a representative conceptual solution developed by the AISC Steel Solutions Center (SSC). The information typically received by the SSC and the conceptual solution provided in reply are both presented here. The conceptual solution also comes with continued support throughout the life of the project from the SSC and more directly, AISC's Regional Engineers.

Project Inquiries
Projects find their way to the SSC in a number of ways. Common scenarios include:

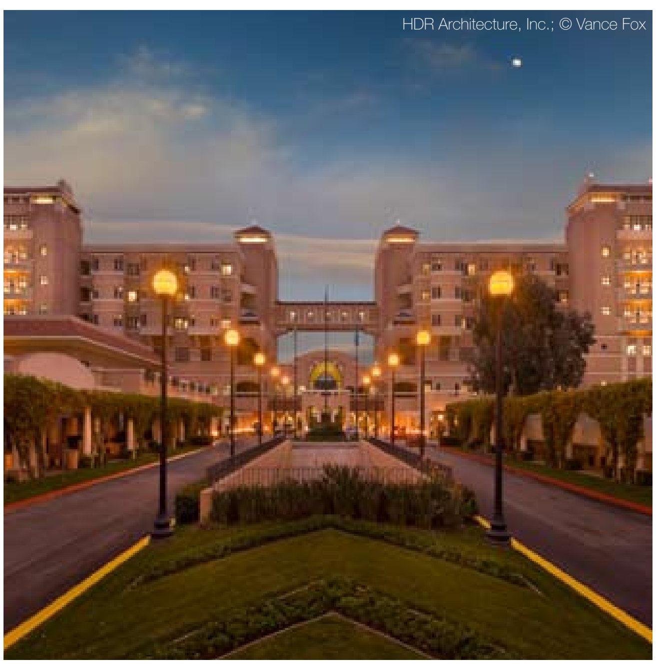
- An owner or architect is developing concepts for a new project. Interested in exploring the advantages of a structural steel framing system, they contact the SSC.
- Project bids are over-budget in another material such as concrete or wood, and a steel alternative is suggested. The architect, engineer, general contractor, or owner contacts a local steel fabricator for assistance who in turn contacts either the SSC or an AISC Regional Engineer for assistance.
- A fabricator learns about a new project in the early stages of development. They contact the owner or project architect to discuss similar steel projects and to highlight the advantages of various steel framed solutions for the project.

Developing a Solution
The AISC team and the client work together—often via conference call—to determine what can be done to move the project forward in steel. Depending on the time frame, the SSC can provide a wide range of solutions from a simple bay framing study to a full conceptual solution. All SSC services are FREE to our clients; however, a level of commitment from the project decision maker to seriously consider the steel alternative is expected.

What do I have here?
This prototype is one example of a conceptual solution that the SSC can provide. Because it is representative of many similar structures, SSC clients often use this prototype as the first step in moving the project forward in steel.

The SSC has been involved in a broad range of projects since its inception in 2001. SSC staff can help you find innovative economical steel solutions for parking garages, office buildings, multi-story residential buildings, healthcare facilities, educational facilities, industrial structures, bridges, and other projects where structural steel can compete.

Please let us know how we can assist you with your next project.


HDR Architecture, Inc.; © Vance Fox


HDR Architecture, Inc.; © Vance Fox

Huntington Memorial Hospital
Phase III
Pasadena, CA
Constructed 2007

This prototype illustrates a typical scenario of how the AISC Steel Solutions Center (SSC) can help a project decision maker evaluate a steel framed alternative. Below is an example of a healthcare structure challenge.

Healthcare Facility

On a sunny day in California, the design team for an outpatient healthcare facility had just finished another meeting regarding the schematic design for their project. The owner and architect wanted to ensure that the building had column-free open areas to allow for the adaptability of the facility, but also maximize daylighting to allow for an enhanced indoor environment in the in-patient care rooms. The design team was aware that the location of the building (Seismic Design Category D) might create a challenge of "hiding" the seismic load resisting system (SLRS) within the building. The Engineer-Of-Record (EOR) remembered meeting AISC's West Coast Regional Engineer at an engineering conference and decided to reach out to discuss various seismic load resisting systems using steel that may be appropriate for the project.

KPFF, Inc.

Engaging the Resources

The EOR contacted the AISC Regional Engineer and described all of the project design team's challenges. The Regional Engineer presented a number of ideas, and felt that the design team could benefit from the Steel Solutions Center becoming involved with the project. The schematic drawings were forwarded to a Steel Solutions Center Advisor, and through emails to the EOR, the SSC Advisor provided the following advantages of using structural steel for the project:

- A steel framing system can also be sized to accommodate the project's unique serviceability requirements for vibration.
- Special Concentrically Braced Frames (SCBF) eliminate the need to hide shear walls (concrete or steel) in the walls of the structure, and could be placed at appropriate areas around the perimeter of the project. The use of shear walls for the lateral system also may inhibit future changes and modifications of the systems or usages of areas.
- SCBFs provide not only a sound SLRS, but can also be painted and exposed for architectural details or allow for the placement of windows or doors beneath the braces.

KPFF, Inc.

Mission Hospital Acute Care Tower
Mission Viejo, CA
Constructed 2009

Steel Conceptual Solution

The AISC Regional Engineer also suggested the SSC develop a conceptual solution that would illustrate the placement of the SCBF's along the perimeter of the structure. The SSC Advisor agreed and then compiled all of the information for the project provided by the EOR. A model of the structure was then created using general building design software, and provided a conceptual solution to the EOR. In addition, the SSC advisor also helped to identify AISC publications that aid in the design of SCBF systems.

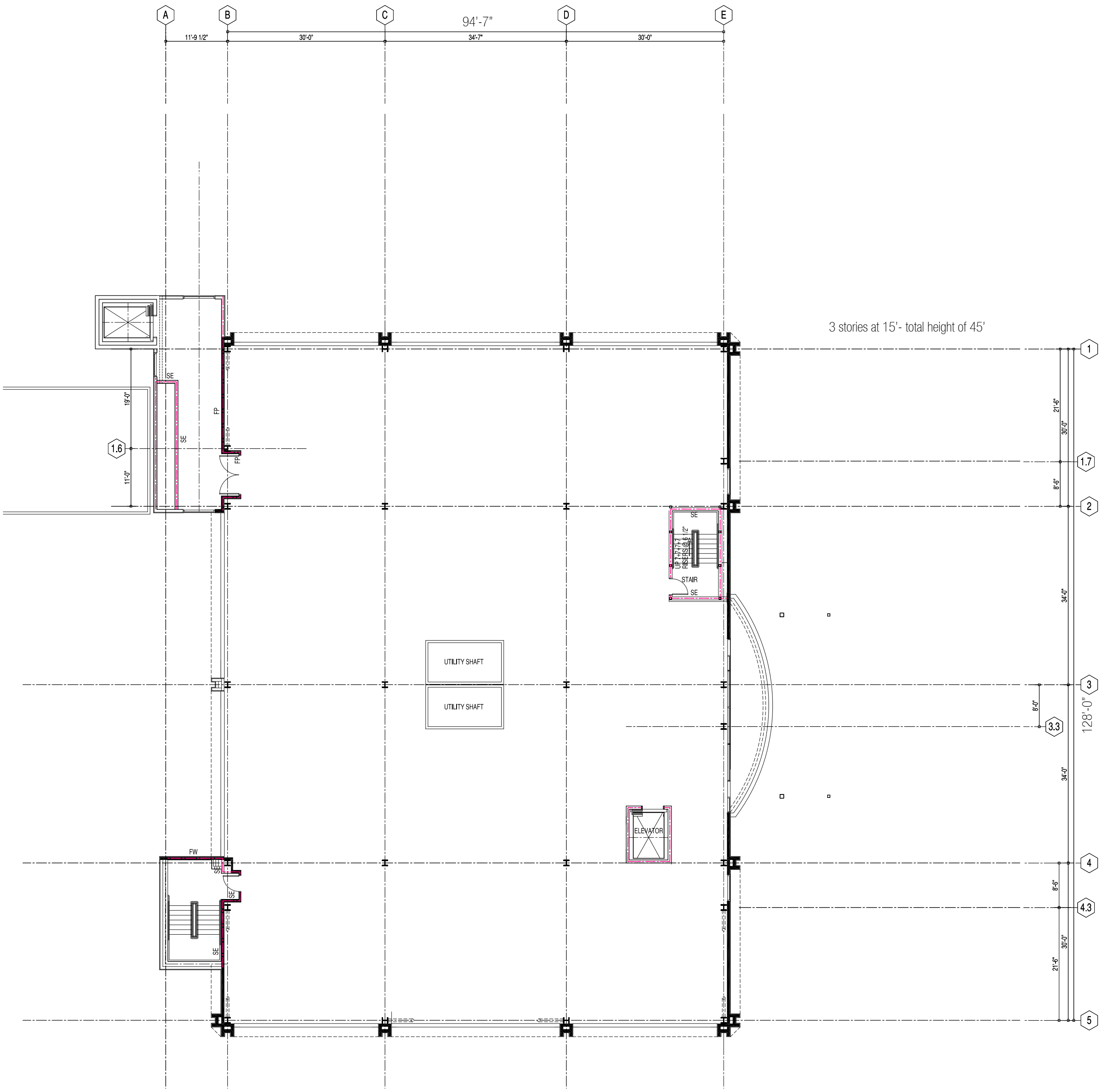
After the conceptual solution was delivered, the Regional Engineer contacted the EOR to further discuss the conceptual solution. The Regional Engineer also highlighted the many advantages a steel solution brings to the project:

- A system that meets the stringent vibration criteria for sensitive equipment and procedures
- Column free areas provide for efficient staff circulation, patient flow, and future modification and renovation options
- A system that easily accommodates the intense medical mechanical and electrical requirements of the healthcare facility
- A system that provides for the adaptability of area usage throughout the life of the structure

The suggested structural steel framing system will meet the healthcare facility's seismic and serviceability needs and will provide cost savings up front and over the life of the project. The conceptual solution created by the SSC tailored to the project's requirements helped to illustrate structural steel's advantages.

Providence Portland Medical Center
Portland, OR
Constructed 2006

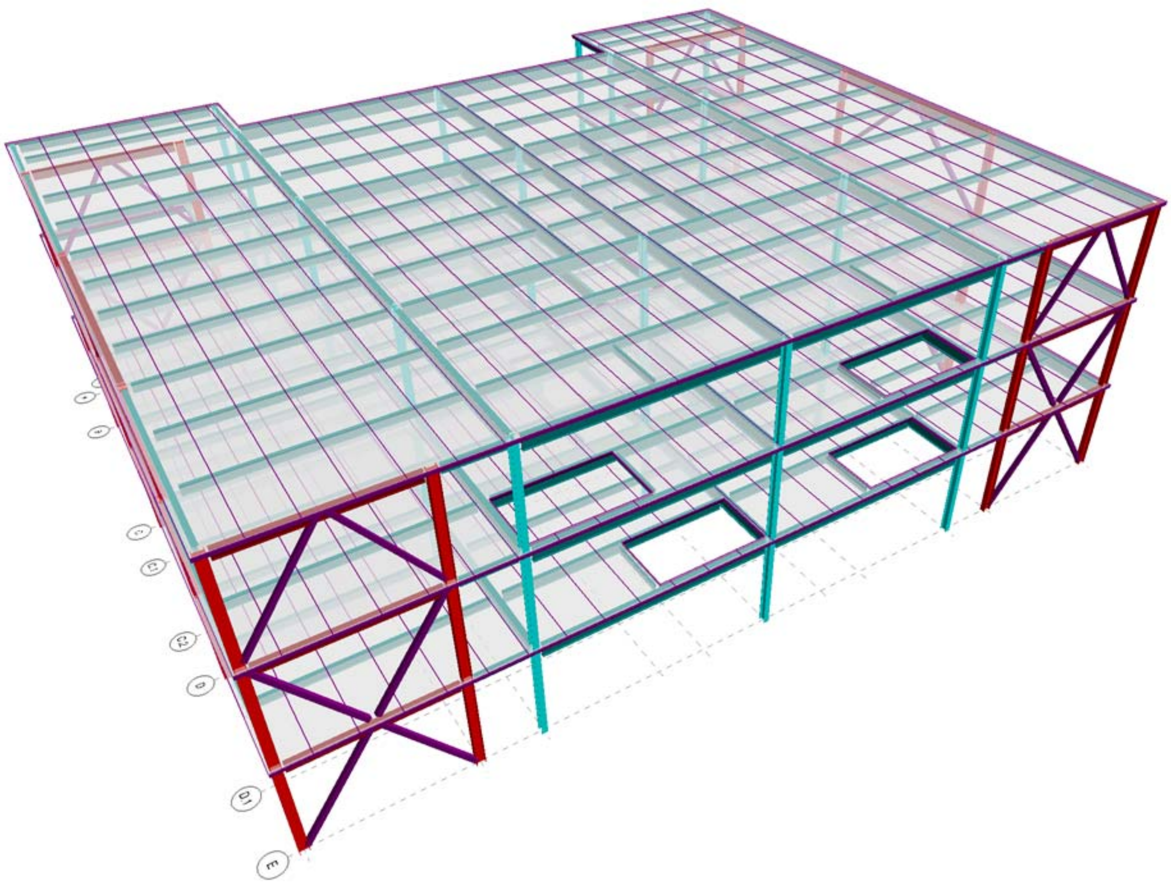
Information Provided to the SSC by the Engineer-Of-Record



Typical Plan

SEISMIC OUTPATIENT FACILITY

Basic SSC Conceptual Framing Model



This Package includes:

- Comments on the Provided Solution
- Steel Quantity Takeoff
- Design Loads and Parameters
- Typical Framing Plans
- Gravity Column Layout
- Gravity Column Schedule
- Special Concentrically Braced Frame Elevations
- Seismic Load Resisting Systems
- Comments on Building Information Modeling
- Comments on Sustainability in Structural Steel Construction

COMMENTS ON PROVIDED SOLUTION

Project Location: San Jose, CA
Prepared for: Engineer-Of-Record

Prepared by: SSC Advisor
Regional Engineer: West Coast Regional Engineer

The information contained in this document is not intended as a basis for structural design for this or any project. Rather, it is a conceptual approach to the project that demonstrates the viability of the steel system for project requirements, budget, and schedule.

1) The design criteria per the *International Building Code* 2006 (IBC 2006) is summarized and included in the Building Code Criteria page.
2) A traditional composite floor framing system was selected for this project. This system provides for long spans and column free spaces as well as the opportunity for future structural modifications.
3) In a traditional floor framing system the fabricated steel framing supports a stay-in-place metal form deck with concrete slab or topping. A 3 in. metal deck with a 4½ in. normal weight concrete topping (total depth of 7½ in.) was used for each level of the model.
4) A mechanical load was placed upon the roof to estimate the effect of possible mechanical systems on the roof. The location of this mechanical area is illustrated on the roof framing plan.
5) The steel quantities and geometry of this investigation are provided on the Floor Framing Plans, the Column Layout Plan, the Column Schedule, and the Frame Elevations on the following pages.
6) Special concentrically braced frames were used to estimate the lateral framing quantities of the building. AISC Seismic Provisions were considered for this study. The estimated lateral frame member sizes are shown in the Frame Elevations page.
7) The floor framing system was optimized for general walking vibration criteria for computer systems/operating rooms (vibration criteria can be found in AISC Steel Design Guide Series, Design Guide Number 11, *Floor Vibrations Due to Human Activity*).
8) Sustainable design principles are being considered. Contributions for the structural steel systems for recycled content have been addressed in this packet. Further information on steel sustainability can be found at www.aisc.org/sustainability.

QUANTITY TAKEOFF SHEET

Project Location: San Jose, CA
Prepared for: Engineer-Of-Record

Prepared by: SSC Advisor
Regional Engineer: West Coast Regional Engineer

Suspended Floor Areas:

39,884 ft^2 (~ 13,295 ft^2 Typical Floor)

Estimated Steel Quantities:

Gravity Columns				
	W12's	26 tons	1.30 psf	32 pieces
Gravity Beams				
	Wide Flange	125 tons	6.27 psf	221 pieces
		19,912 studs		
Lateral Frames				
	Columns	24 tons	1.20 psf	24 pieces
	Beams	14 tons	0.70 psf	18 pieces
	Braces (HSS)	23 tons	1.15 psf	36 pieces
Miscellaneous 5%		11 tons	0.53 psf	
		223 tons	**11.2 psf**	**331 pieces**

– The quantities are based on centerline dimensions.
– Steel not indicated in sketches accounts for framing not included in the estimate such as framing for openings or various members eliminated for simplification. It does not include connection material, slab edge material or façade attachments.

Material Specification

Wide flange shapes are A992, Gr. 50
Rectangular hollow structural sections are A500 Gr. B

DESIGN PARAMETERS: INTERNATIONAL BUILDING CODE 2006

Project Location: San Jose, CA
Prepared for: Engineer-Of-Record

Prepared by: SSC Advisor
Regional Engineer: West Coast Regional Engineer

This investigation is based on the following criteria. The Steel Solutions Center does not assert that these are the criteria that apply to this project. The criteria are chosen based on the project location and the widely adopted model building code, IBC 2006. Requirements by local and state jurisdictions have not been considered. If actual project criteria differ significantly from those listed, the results presented may no longer be valid.

Gravity Loads

Dead Loads	Composite Deck=75 psf [3 in. metal deck with 4½ in. concrete slab]
Live Loads	Medical Mechanical= 125 psf [Second Floor]
	Medical=100 psf [Third Floor]
	Roof=20 psf [Portion Roof]
	Mechanical Roof=125 psf [Portion Roof]
Superimposed Dead Loads	All Occupancy or Uses= 20 psf [Partitions, CMEP, etc.]
Cladding Loads	Façade=400 plf [Glazing]

Wind Load Parameters

Basic Wind Speed	85 mph
Wind Importance Factor, I_w	1.15
Exposure Category	B
Topographical Factor	1.00
Drift Limit	H/500

Basic Seismic-Force-Resisting System

Special Concentrically Braced Frames

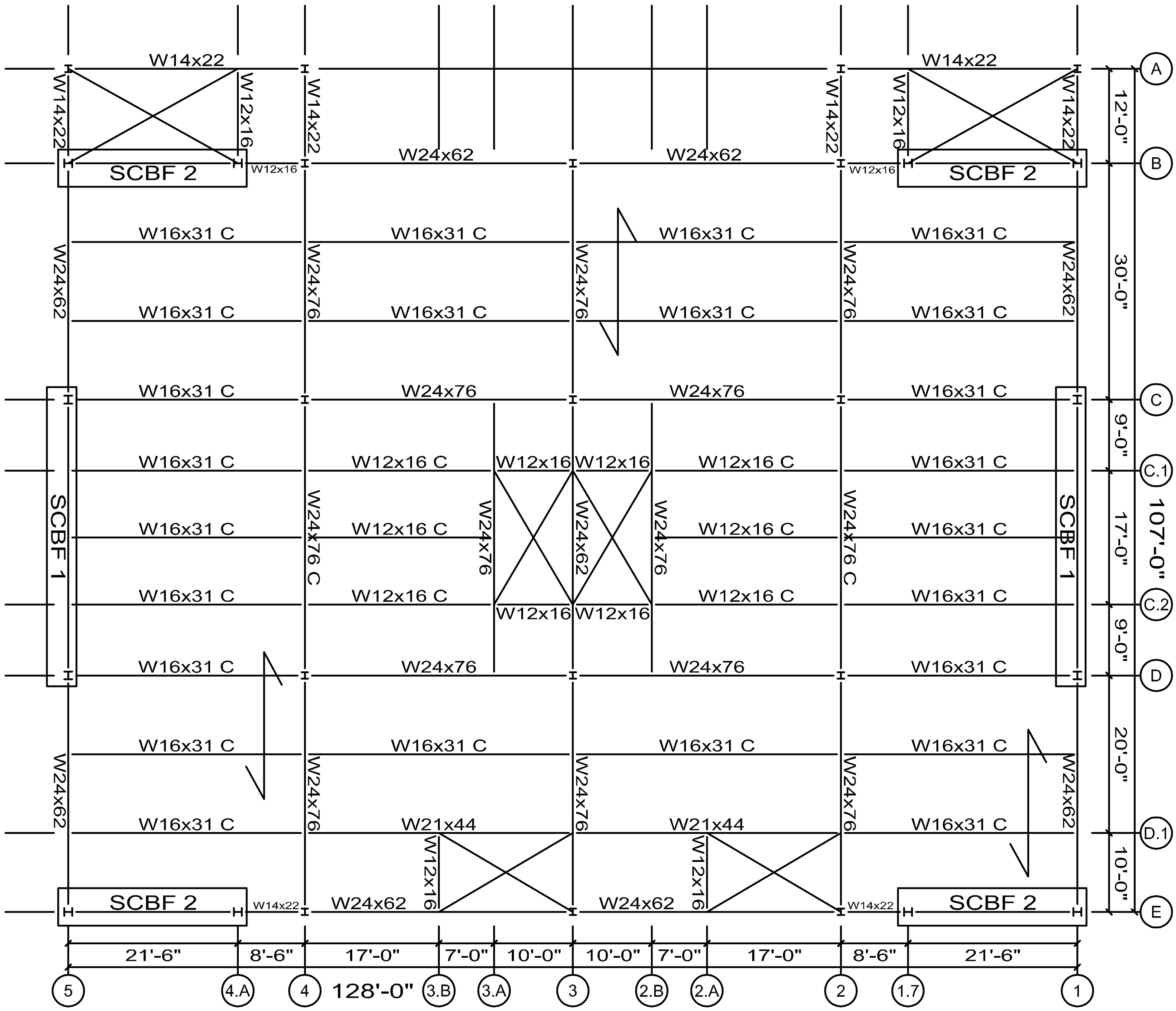
Seismic Design Parameters

Site Class	D
Seismic Importance Factor, I_E	1.50
Seismic Design Category	D
Spectral Response Acceleration at Short Periods (0.2s), S_S	1.639 g
Spectral Response Acceleration at One Second Period (1.0), S_1	0.683 g

	X-axis	Y-axis
Building Period Coefficient, C_T	0.020	0.020
Response Modification Coefficient, R	6.0	6.0
System Overstrength Factor Ω_O	2.0	2.0
Deflection Amplification Factor, C_d	5.0	5.0

Note: The requirements of the AISC *Seismic Provisions* WERE used in determining the quantity estimate for this project. Whether or not the special seismic requirements must be taken into account in the design is based on the applicable building code and local requirements.

SECOND FLOOR FRAMING PLAN



NOTES:

1) Each member is marked with the estimated wide-flange member size and the designation for camber.
   If present, the designation "C" indicates an assumed camber from ½ in. to 2½ in.
2) ▭ Boxes and the designation "SCBF" indicates the locations of the special concentrically braced frames.
3) ⟷ indicates the direction of the metal deck for the floor system.
4) The estimated flooring system consists of 3 in. metal deck with 4½ in. normal weight concrete topping (7½ in. total depth).

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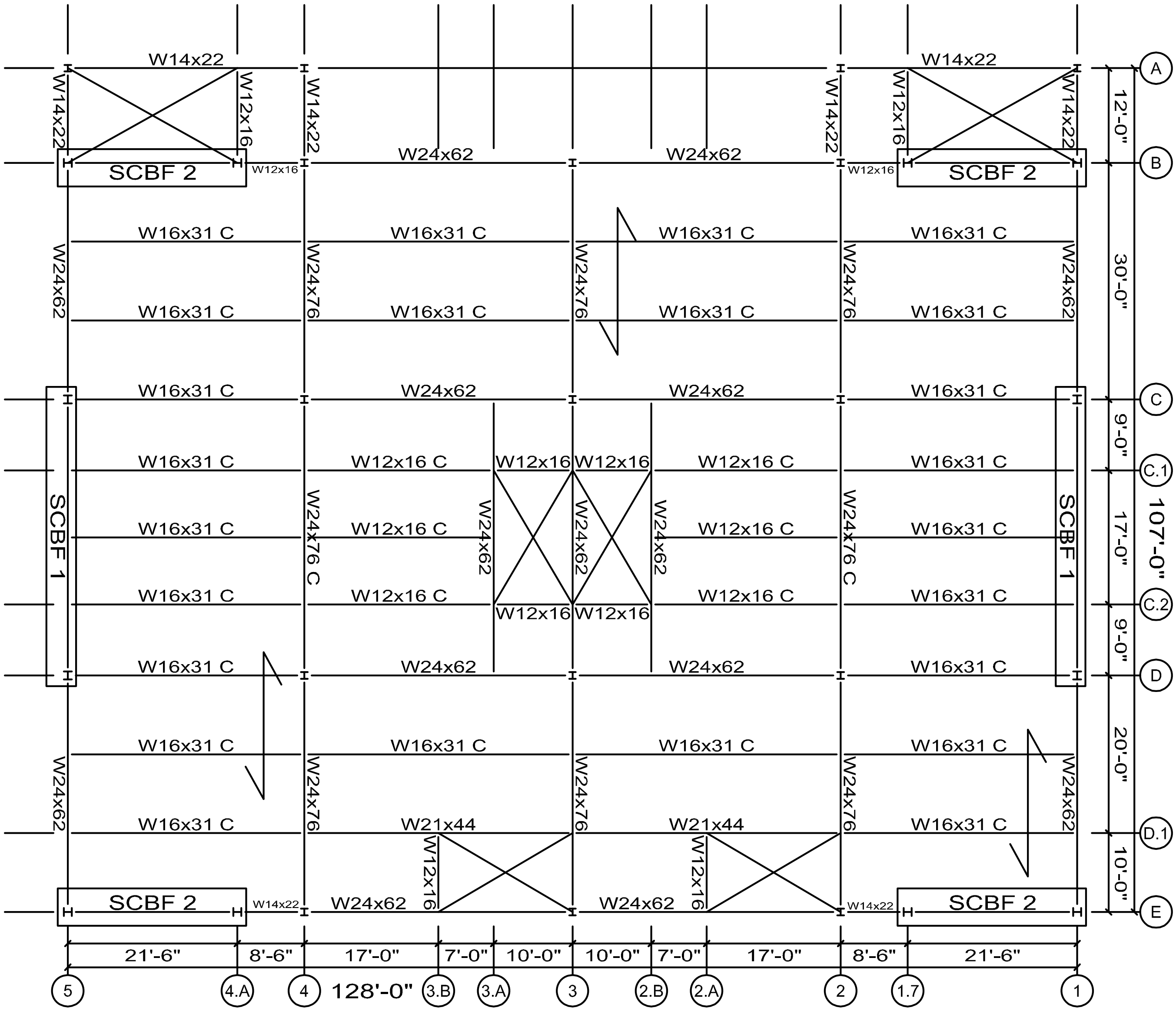
THIRD FLOOR FRAMING PLAN



NOTES:

1) Each member is marked with the estimated wide-flange member size and the designation for camber. If present, the designation “C” indicates an assumed camber from ½ in. to 2½ in.
2) ▭ Boxes and the designation “SCBF” indicates the locations of the special concentrically braced frames.
3) ⟷ indicates the direction of the metal deck for the floor system.
4) The estimated flooring system consists of 3 in. metal deck with 4½ in. normal weight concrete topping (7½ in. total depth).

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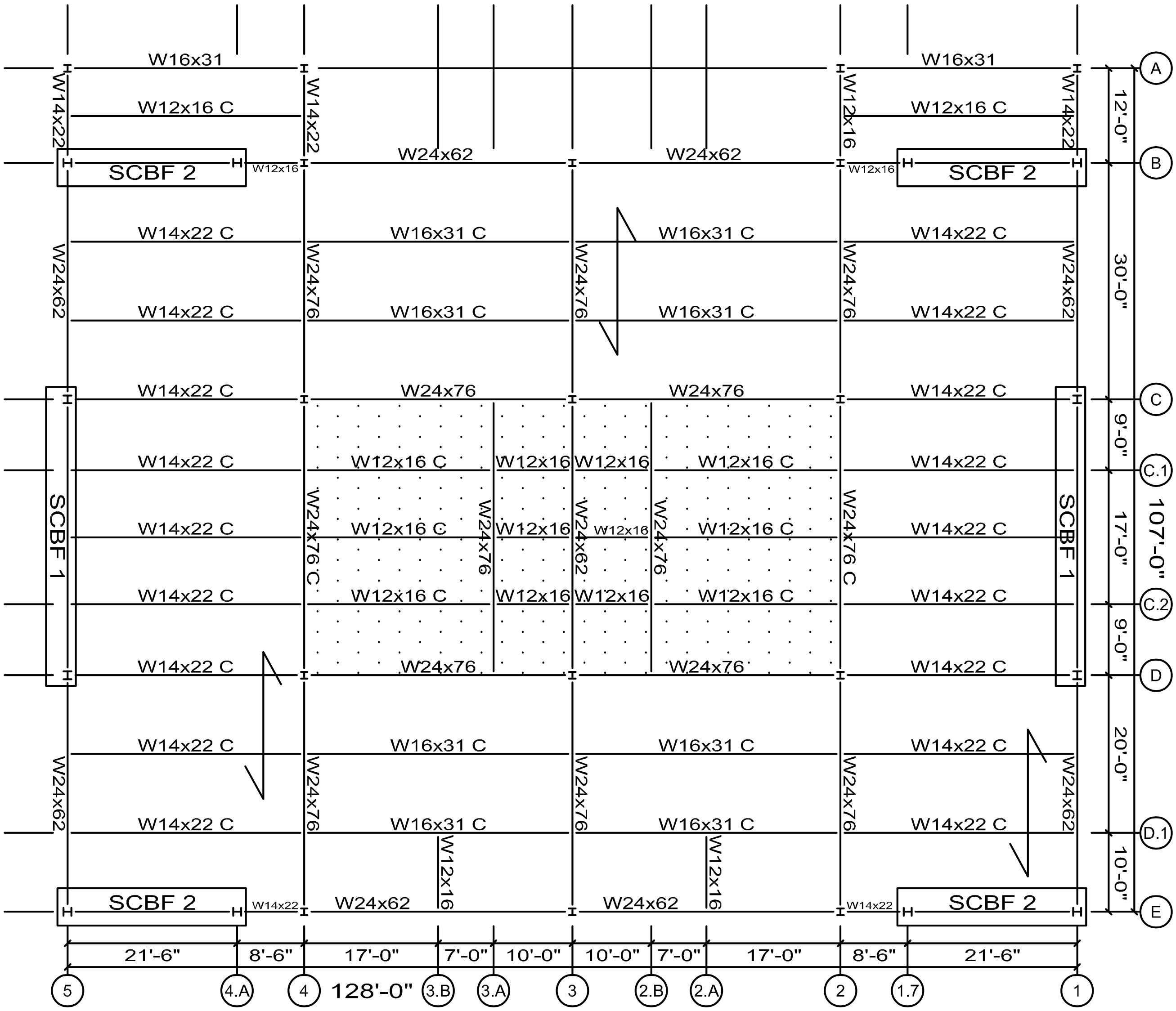
ROOF FRAMING PLAN



NOTES:

1) Each member is marked with the estimated wide-flange member size and the designation for camber.
   If present, the designation "C" indicates an assumed camber from ½ in. to 2½ in.
2) Boxes and the designation "SCBF" indicates the locations of the special concentrically braced frames.
3) indicates the direction of the metal deck for the roof system.
4) The estimated roof system consists of 3 in. metal deck with 4½ in. normal weight concrete topping (7½ in. total depth).
5) indicates the area of the proposed mechanical area for the roof. A theoretical mechanical live load was placed in this area.

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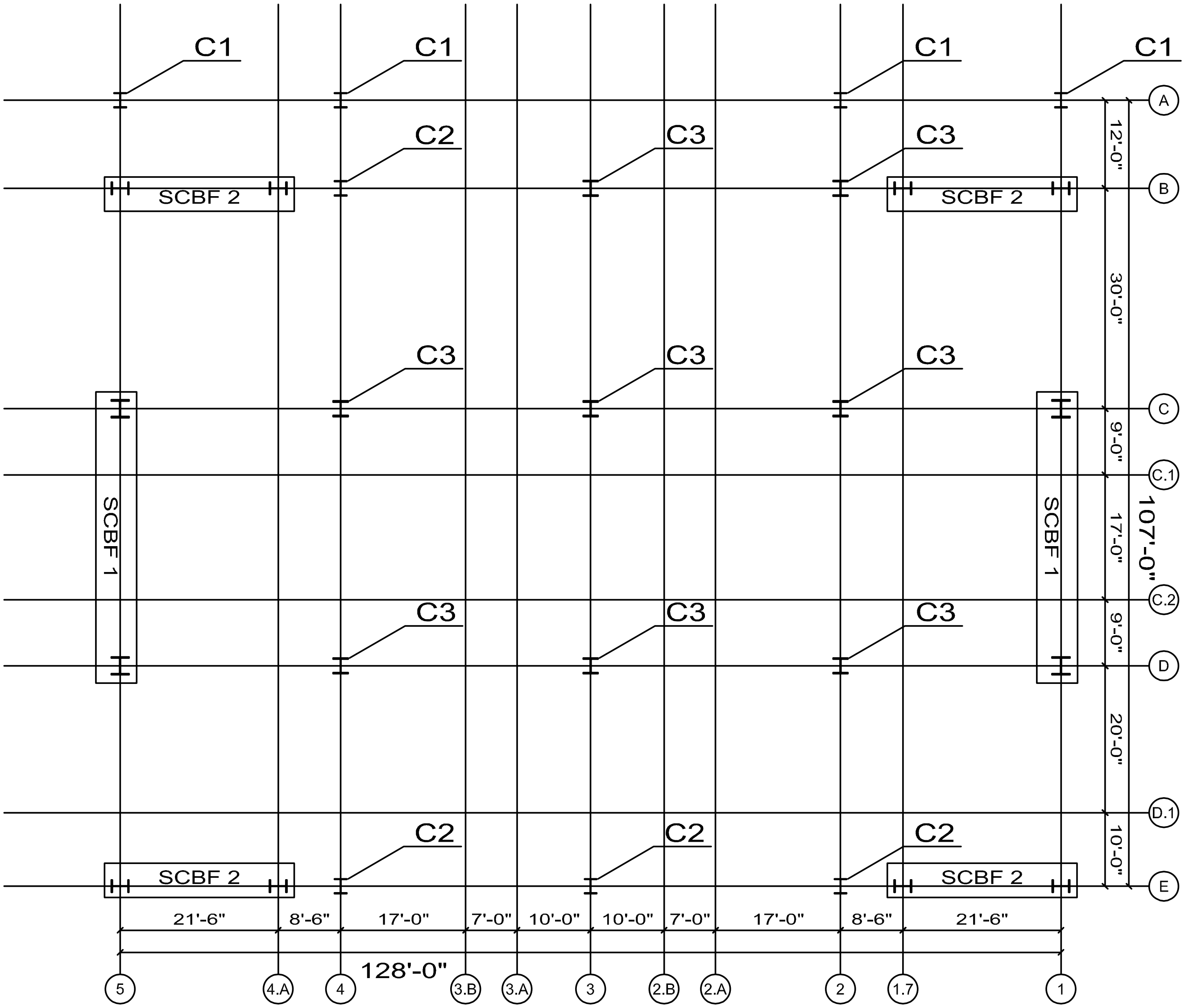
COLUMN LAYOUT



NOTES:
1) The columns located within the boxes are columns for the lateral system frames.

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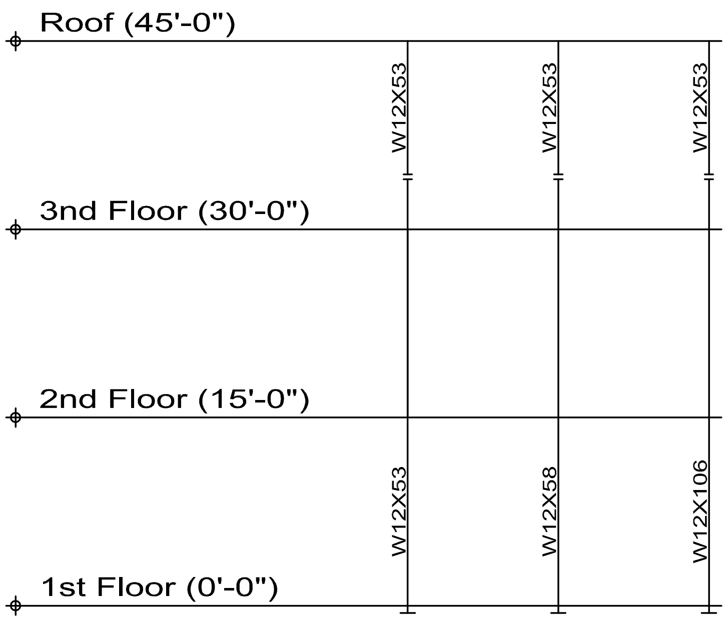
COLUMN SCHEDULE



COLUMN MARK	C1	C2	C3

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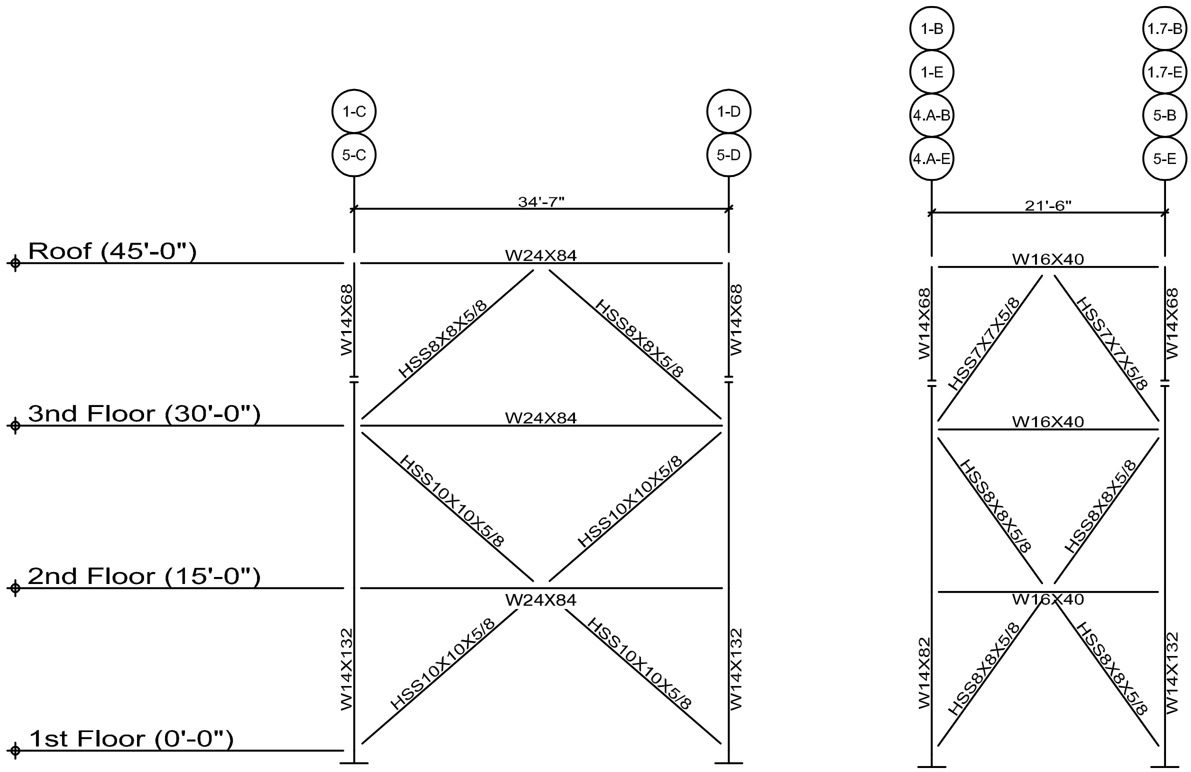

SCBF 1

SCBF 2

NOTES:
1) The designation “SCBF” indicates a special concentrically braced frame.

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Designing for Seismic Forces

Special concentrically braced frames were selected as the seismic load resisting system (SLRS) for this prototype based on the fictional client's needs. The choice was based on the allowance of space and natural lighting between the braces, and the need for the SLRS to be on the perimeter of the building. However, for other healthcare facilities geometry, work flow, or other factors could make a different SLRS system more practical. There are a number of structural steel SLRS that may be more suitable for your healthcare facilities needs. These include:

- Braced Frames (concentrically, eccentrically, or buckling-restrained-braces)
- Moment Frames (ordinary, intermediate, or special)
- Special Steel Plate Shear Walls
- Special Truss Moment Frames

These systems are illustrated on the following page, and have been utilized in numerous structures in areas of Seismic Design Categories D, E, and F.

AISC has developed numerous resources to aid in the design of structural steel seismic load resisting systems. The AISC Seismic Provisions for Structural Steel Buildings (AISC 341), Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications (AISC 358), Seismic Design Manual, Facts for Steel Buildings- Number 3 Seismic, and design guides provide the information necessary to design a structure for "life safety".

Healthcare structures are designated as essential facilities by building codes and need to stay open and operable after a seismic event. Therefore, prescriptive "life safety" requirements may not be adequate for the structural steel SLRS, and alternate design approaches may be necessary. Many engineers are now turning to performance based design rather than prescriptive design. Engineers who are leaders in performance based design have worked with the steel industry to help better predict the performance of structural steel during a seismic event and to advance the technology used to predict the behavior of structural steel.

Construction of the Seismic Load Resisting System

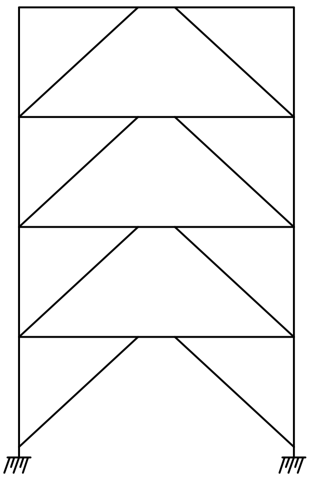
The construction of the SLRS is as important as the design of the system. Special inspections are often required to ensure that the SLRS is being constructed properly. Structural steel SLRS are unobstructed with all elements and connections exposed in the fabrication shop and in the field. Inspections of the structural steel SLRS are easier because of the exposure of those critical elements.

Fabricators and erectors of structural steel buildings are recognized as being skilled and safe workers. In addition, the AISC Certified Fabricator and Erector programs are recognized by many jurisdictions across the United States.

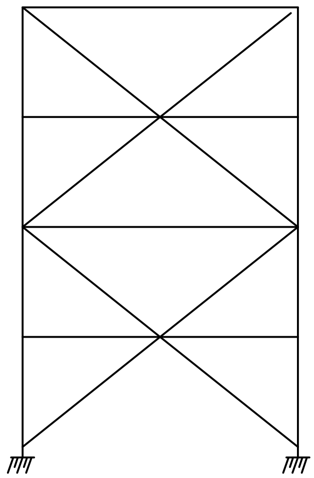
Special Steel Plate Shear Walls

Providence Portland Medical Center
Portland, OR
Constructed 2006

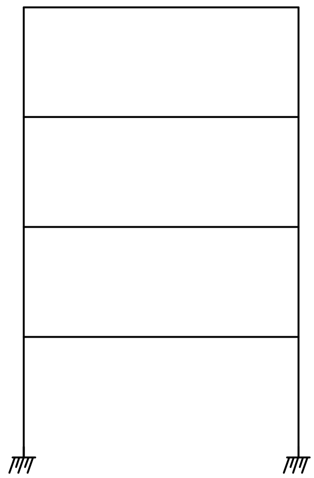
SEISMIC LOAD RESISTING SYSTEMS



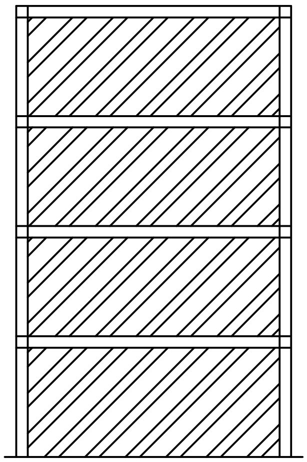
Eccentrically Braced Frame



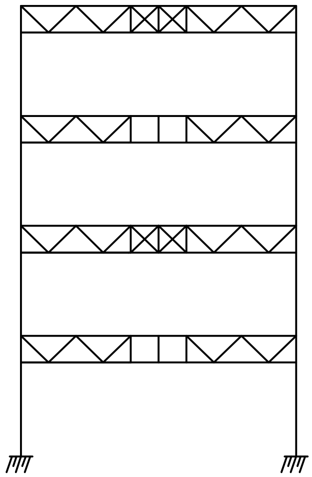
Special Concentrically Braced Frame



Moment Frame



Special Steel Plate Shear Wall



Special Truss Moment Frames

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Building Information Modeling

Building Information Modeling (BIM) is the process of generating and managing a building database in a graphic, multi-dimensional building information model (also abbreviated BIM). The BIM can be used for the entire life cycle of a building project and can contain items that include building geometry, spatial relationships, geographic information, sizes and quantities of building components, and energy system information.

The BIM process requires a great deal of advanced planning and early involvement prior to construction, which in turn helps to eliminate time-consuming design and field issues, materials savings, earlier occupation, and lower up-front costs. The BIM process and model can be advantageous in a variety of ways for almost all parties involved in the construction process:

Owner

BIM allows an owner to capture facilities lifecycle data, reducing maintenance cost over the lifecycle of the building.

Architect/Engineer/Detailer

The Building Information Model can provide for a more accurate steel tonnage, resulting in foundation savings. The BIM model allows design teams to view complicated configurations and connections in 3D. The BIM process also reduces requests-for-information (RFIs) and change orders by identifying collisions and interferences virtually on the model before they ever become issues in the field.

Fabricator

BIM can streamline the entire structural steel fabrication process. Today's high-tech fabrication shops can upload electronic information directly into fabrication equipment without having to convert 2D drawings into different formats. The BIM model can provide for a more accurate steel tonnage, resulting in more accurate estimating/bidding and material savings.

Erector

Erection considerations can be handled before the foundation has been poured. Representations of construction equipment can be placed on the model to allow the erection team to evaluate site conditions and site scheduling. And with collisions and interferences evaluated on the model, time-consuming field modifications and repairs are almost eliminated. Therefore, using the BIM process results in a compressed schedule and faster erection time.

Specialty Contractor

The BIM process enhances scheduling of all subcontractors on the project. With BIM, the subcontractors will know which phase of their work can begin, and the conditions of the construction site they can expect prior to the start of their work. Also, collisions between systems (MEP, HVAC, specialty equipment, etc.) and the structural steel can be evaluated prior to construction, almost eliminating field re-routes or fixes; resulting in a compressed schedule and faster erection time.

Interoperability

The structural steel industry remains a leader in the use of BIM technology—having been using it since before the term 'BIM' was even introduced. Back in 1998, AISC recognized the advantages in cost and schedule that could be gained if different disciplines using different software tools could readily share and access each other's data. AISC's efforts in this area have led to industry wide adoption and acceptance of this method of collaborative project delivery with various methods of exchanging data between different disciplines available today. To learn more visit www.aisc.org/integration.

Photo courtesy of Magnusson Klemencic Associates

The green buildings movement is increasing at a rapid pace. More and more owners, architects, engineers and contractors are realizing the benefits of sustainable design and construction practices. Selecting structural steel as the framing system is one step toward improving the green or sustainable performance of health-care facilities and other building types. There are multiple credit opportunities for structural steel under the U.S. Green Building Council's Leadership in Environmental and Energy Design (LEED®) for New Construction program. These include MR Credit 1.1: Building Reuse—Maintain Existing Walls, Floors and Roof, MR Credit 2: Construction Waste Management, MR Credit 3: Materials Reuse, MR Credit 4: Recycled Content, MR Credit 5: Regional Materials and ID Credit 1: Innovation in Design. (For more information on these credits, visit www.usgbc.org.) Structural steel also provides sustainability gains and opportunities beyond the LEED system.

Recycled Content

Steel made via the electric arc furnace process (all wide-flange members, channels and angles and some plate and hollow structural sections) has an industry-average recycled content of 93.3%.

Recycling Rate

There is an established market for steel scrap (structural and otherwise), and 98% of all structural steel is recycled at the end of a building's life.

Cradle-to-Cradle

Many materials can be recycled, but most are down-cycled to a different product. For example, concrete from a deconstructed building can be used again as road aggregate, but it can rarely be used again as aggregate for structural concrete. Steel, on the other hand, can be recycled over and over again, or "multi-cycled," without losing any of its strength or properties. This makes steel a true cradle-to-cradle product as opposed to a cradle-to-grave product. And it's not just structural steel. Steel products of all types can become steel products of all other types.

Offsite Fabrication, Onsite Erection

Steel is fabricated in highly automated facilities to strict tolerances, greatly minimizing additional work and the resulting additional labor hours and equipment required on a project site, thus lowering the steel-framed structure's environmental footprint.

Erection Schedule

The erection schedule for a steel-framed health-care structure is about one-third less than that of competing framing systems. This reduced construction schedule not only lowers the steel-framed structure's environmental footprint, it also allows the steel-framed health-care facility to open earlier.

Foundations

Lighter steel-framed health-care structures result in lighter foundation loads, thus decreasing the amount of material needed for the foundation.

Environmental Impact

A study conducted by independent consultants compared the environmental impact of two medical office buildings in Omaha—one framed with structural steel framed and one with concrete framed projects—and concluded that the steel building came out ahead in four of five categories: global warming potential, eutrophication potential, acidification potential and smog potential. The fact that the results in each category, including primary energy demand where steel lagged concrete by 1%, are within 10% of each other indicates that the choice of a structural framing system should not be made on the basis of the environmental impact of the materials alone. It is not just the selection of materials that is important from a sustainable perspective, but also the optimization of those materials in both the design and the actual construction process.

Early Involvement

Adopting a collaborative, integrated project delivery methodology on a steel-framed health-care project means getting the fabricator involved early. An experienced fabricator can help choose more efficient steel assemblies, saving time, materials, and money. Collaborative design combined with a steel framing system and building information modeling (BIM) can result in a project that uses less material, which results in less labor, less cost and less environmental impact.

Flexibility

Steel framing allows for easier reconfiguration or expansion of any type of structure. This is especially important with hospitals and other health-care-related structures where ever-evolving patient needs and equipment requirements mandate regular facility changes.

Deconstruction

Steel-framed health-care facilities can be easily deconstructed, and members can be remanufactured into new members or reused with minimal additional fabrication work. Only 2% of all structural steel from health-care projects ends up in a landfill, with 98% being recycled into new steel products.

Further Support

After the delivery of the conceptual solution, the EOR was able to discuss the steel option with the owner and design team. The design team responded positively to the conceptual solution. Seeing the schematic model allowed them to discuss a number of ideas (exposing some of the steel framing, the locations of the lateral system, placement/modification of mechanical systems, etc.) that were not considered during initial project team meetings. The EOR again contacted the AISC Regional Engineer to discuss some of the additional ideas, as a result of the great response from the entire design team, and the Regional Engineer suggested that the SSC create a second model of the structure that illustrated how the frame could be adapted to address these additional items. The SSC Advisor agreed that a second scheme would be a great idea, and the advisor created the second structural model.

While the SSC Advisor was modifying the conceptual model, the Regional Engineer reached out to an AISC Member Fabricator in the area of the project who was familiar with fabricating steel for a healthcare project. The member fabricator also provided conceptual pricing and schedule estimates of the steel package based on the information provided. The Regional Engineer then was able to facilitate a meeting with the member fabricator and project design team.

Delivering the Message

During the meeting the AISC Member Fabricator was able to address numerous questions from the project team about items such as welding, bolting, inspection, and steel availability. The project team also discussed a number of benefits that a structural steel system could provide, including:

- An erection schedule that accelerated the project schedule, and allowed earlier utilization of the facility
- Lower soft costs and earlier revenue generation due to accelerated erection schedule
- A system that meets the architectural requirements providing enhanced indoor environments for patients and caregivers
- Structural steel seismic systems meet the stringent seismic building code criteria placed on healthcare (Occupancy Level III & IV) structures

After the meeting the AISC Regional Engineer gave the EOR a list of structural steel framed healthcare facilities in the area. After a few follow up meetings between the owner and design team, a structural steel system with special concentrically braced frames was officially selected as framing system for the project. The AISC Member Fabricator was awarded the project and participated as a member of the project team. This allowed for fabrication expertise to be captured during the project's final structural design.

The project team was reassured knowing that the AISC Steel Solutions Center would provide a high level of technical assistance throughout the life of their project. They voice their agreement that "there is always a solution in steel!"

Postscript

This story is being repeated at the Steel Solutions Center on a daily basis. Project decision makers are reaching out to AISC Regional Engineers and the SSC for new ideas to solve their project challenges.

The SSC has resources to help you throughout the life of your project. The SSC works with everyone involved with the construction industry including mills, service centers, fabricators, engineers, architects, general contractors, and code. The SSC can offer solutions that provide reduced foundation weight and cost, increased speed of erection, and help with seismic lateral resisting systems. The SSC provides a win-win outcome for everyone involved, and best of all, it is a free service!

What should you do next?

You've invested the time to examine this prototype—a conceptual solution for the conventional framing system in a healthcare project. Ask yourself if this system might be beneficial for your next project. When you start to approach your next project, contact your local steel fabricator, AISC Regional Engineer, or call/e-mail the Steel Solutions Center directly to discuss what benefits a steel solution can provide to your project.

There's always a solution in steel.

Steel Solutions Center
Your connection to ideas + answers
solutions@aisc.org | 866.ASK.AISC

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