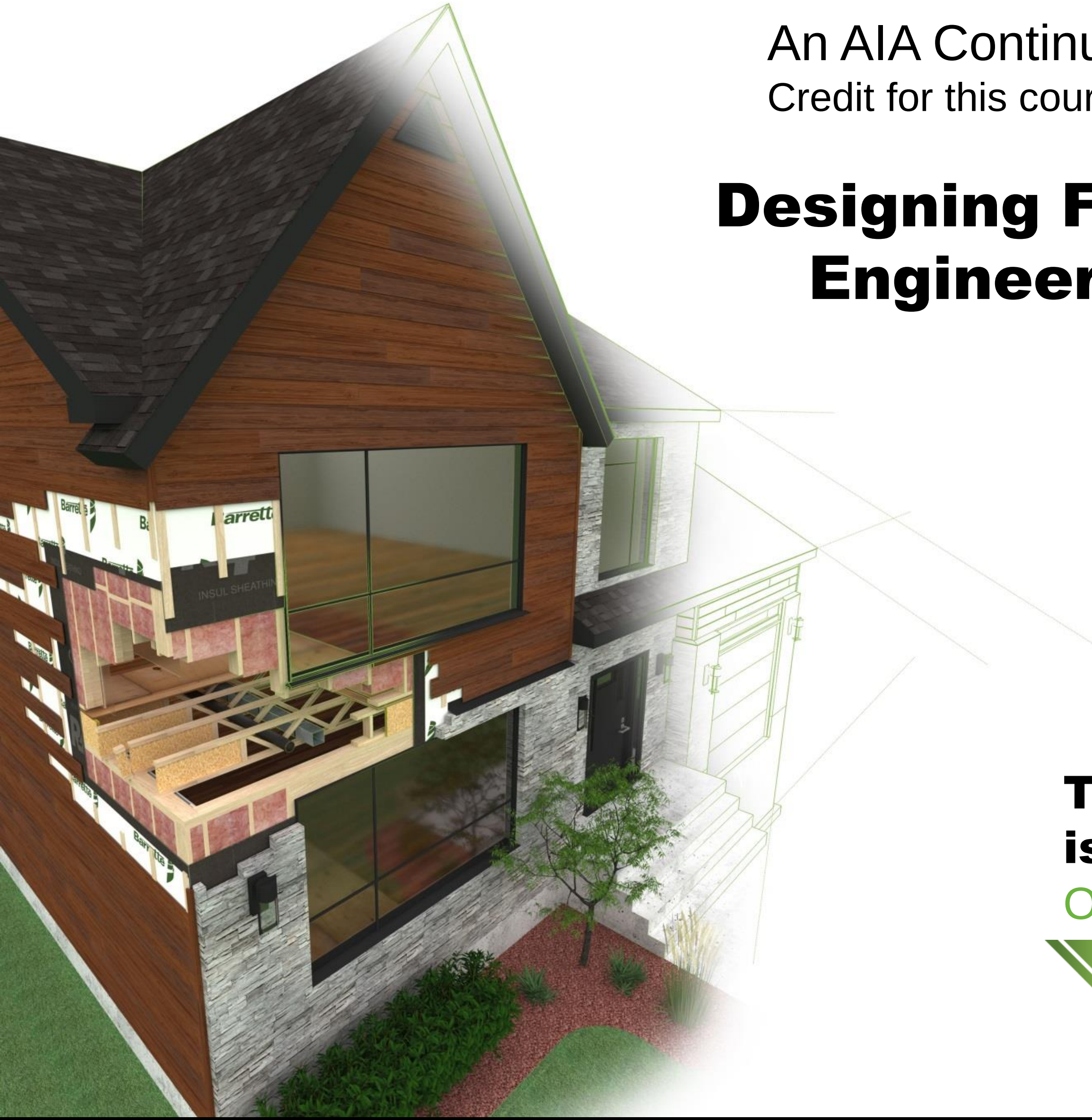

An AIA Continuing Education Program
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Designing Floor Systems with Engineered Wood Joists

CONTINUING EDUCATION AIA

This course
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COURSE OBJECTIVES

Upon completion of this course, you will have a better understanding of the following:

1. Factors for consideration when designing floor systems
2. Appropriate design strategies for code requirements and client satisfaction
3. Types of engineered floor components and their capabilities and limitations
4. Engineering, design and support available from manufacturers

ENGINEERED WOOD FRAMING COMPONENTS HAVE IMPACTED FLOOR SYSTEM AND BUILDING DESIGN

- More efficient use of wood fiber
- “Waste Fiber” now usable
- Greater strength than solid sawn lumber
- “I” shapes and triangulation create strength

- Improved strength offers design flexibility
- Improved strength speeds construction

- Requires new considerations by design professionals:
  - Safety considerations (always)
  - Performance (user comfort) considerations
    - Deflection
    - Vibration
    - Sound Transfer

DESIGNING FLOOR SYSTEMS WITH ENGINEERED WOOD PRODUCTS REQUIRES ATTENTION TO THREE SETS OF CONSIDERATIONS:

Requirements of the applicable model building code with regard to "safety" factors.

Practical considerations including product availability, ease and speed of installation and design flexibility.

"Comfort" factors that may have impact on the physical and psychological well-being of those who will occupy or visit a building.

DESIGN CONSIDERATIONS: BUILDING CODE REQUIREMENTS

Design Safety Factors:

- Length of Span
- Loading Conditions
- Deflection Criteria
- Joist Spacing
- Fire Endurance
- Seismic Performance
- Local Regulations

BUILDING CODE REQUIREMENTS SAFETY FACTOR: LENGTH OF JOIST SPAN

Not specified by building codes but published by product manufacturers and recognized by codes.

Published spans may be used by design professionals within specified loading and spacing parameters.

Span is determined by designer's concept and bearing locations.

Span must be considered in context with loading conditions, deflection characteristics, joist spacing and bearing size.

Manufacturer literature and software can confirm spans.

BUILDING CODE REQUIREMENTS SAFETY FACTOR: LOADING CONDITIONS

Three types of loads may apply to any floor system:

- **Live Loads**
- **Dead Loads**
- **Special Loads (Line, Point, Area)**

Live Loads are *temporary* loads and are defined by the building codes according to the intended use of the structure.

Dead Loads are *permanent* loads and are comprised of the actual weights of materials that make up the floor/ceiling system.

Special Loads are permanent and are actual design loads occurring on confined areas of a floor system.

BUILDING CODE REQUIREMENTS SAFETY FACTOR: DEFLECTION

Deflection is vertical movement of a floor system when subjected to loads.

The Building Code specifies Deflection Limits for floor systems:

L/360 Live Load Deflection and L/240 Total Load Deflection ("L" is joist length in inches)
Example: Joist Length of 20' (L= 240)

240 divided by 360 = .67 inches allowable deflection under full load condition

Deflection limits are based on historical performance and are specified by the codes for user comfort and to prevent cracking of ceiling and flooring materials.

BUILDING CODE REQUIREMENTS SAFETY FACTOR: DEFLECTION

Deflection performance of a floor system is determined by:

- Length of Joist Span (Factor with greatest impact)
- Loading Conditions
- Stiffness of Framing Member (Joist)

- Floor System Deflection can be reduced by:
- Reducing the Joist Span
- Reducing Loading (decreasing on-center joist spacing)
- Increasing the Joist Depth
- Upgrading Joist Makeup
    - Larger flange or chord
    - Better grade of lumber for components
    - Use of engineered materials

BUILDING CODE REQUIREMENTS SAFETY FACTOR: JOIST SPACING

On-Center Joist Spacing is not specified by the building codes. Minimum deflection performance IS specified. Joist spacing, along with loading conditions and length of span, determines deflection performance.

Building codes set only MINIMUM requirements for performance. Joist Spacing is determined by owner/builder preference or “value engineering”.

- Traditional Spacing: 16” o.c.
- Engineered Components Popular Spacing: 19.2” or 24” o.c.

Floor performance can be enhanced by designing for higher deflection limitations. Joist Spacing is the design option most often changed to achieve enhanced deflection performance.

BUILDING CODE REQUIREMENTS SAFETY FACTOR: FIRE RESISTANCE

Building classification and building codes dictate fire resistance requirements for floor systems. Multi-family and institutional residences most often require living unit separations by fire resistant floor/ceiling assemblies.

- Fire endurance requirements are specified to allow adequate time for building occupants to escape and firefighters to extinguish fires. Codes may require durations of 1, 2 or more hours.

Assemblies are tested for fire endurance by independent third-party agencies using ASTM standard test designs and procedures.

- Certified assemblies are published by product manufacturers and by third-party agencies.

BUILDING CODE REQUIREMENTS SAFETY FACTOR: SEISMIC PERFORMANCE

Individual floor joists cannot be rated for a specific seismic zone since they only act as components of a lateral-force-resisting system.

Joists act as “drag struts” or “chords” in lateral-force-resisting systems such as shear walls.

Designers must be aware of the required forces a drag strut must carry and refer to manufacturer data for the product’s drag strut capabilities.

Drag Loads are normally specified by the building designer on construction plans.

BUILDING CODE REQUIREMENTS
LOCAL REGULATIONS

A few local jurisdictions prohibit the use of specific engineered wood framing products.

Some local codes specify more stringent deflection limitations for floor systems than the model building codes permit.

Some municipalities have fire protection regulations requiring the use of sprinkler systems and/or baffling in floor systems. Fire endurance requirements may also vary by jurisdiction.

Design professionals must be aware of these local regulations when designing engineered wood floor systems.

DESIGN CONSIDERATIONS: LOGISTICAL FACTORS

Several elements of practicality must be considered when choosing the type of framing product to be used in an engineered wood floor system, including:

- Installation of Mechanical Systems
- Construction Timetable
- Product Access
- Cost

DESIGN CONSIDERATIONS: COMFORT AND PERFORMANCE

Two factors have significant physical and psychological impact on individuals who inhabit or use a building. They are:

- Sound Transmission
- Floor Vibration

While these factors may, in fact, be measured quantitatively, reactions to them by humans are purely subjective.

Design professionals should be aware of human preferences for performance with regard to these factors.

DESIGN CONSIDERATIONS: COMFORT AND PERFORMANCE

Sound transmission refers to how easily sound is transferred through an elevated floor system.

Some code bodies set minimum standards for Sound Transmission Class (STC) and Impact Insulation Class (IIC).

STC and IIC ratings are secured through testing and certification of floor/ceiling assemblies by independent third-party agencies.

Minimum ratings are specified in order to satisfy the majority of people who occupy or use a structure. Human reactions to sound are subjective.

DESIGN CONSIDERATIONS: COMFORT AND PERFORMANCE

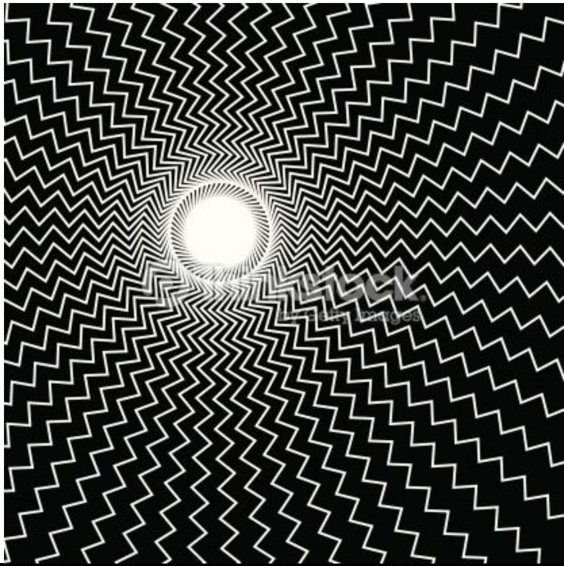
Floor System Vibration

Vibration is oscillatory movement of the floor system when subjected to an impact load such as a footstep, a dropped item or machine vibration.

Floor vibration performance is the least quantitative and most subjective characteristic of a floor system.

Floor system vibration can make occupants uncomfortable and even cause them to fear floor system failure.

Auditory effects (i.e. rattling china closets) heighten human discomfort with vibration.



DESIGN CONSIDERATIONS: COMFORT AND PERFORMANCE

Floor System Vibration

Three factors influence human response to floor system vibration:

- The Frequency Content of the vibration.
- The Amplitude of the vibration.
- The effects of vibration Damping.

DESIGN CONSIDERATIONS: COMFORT AND PERFORMANCE

Floor System Vibration

Frequency Content is the cycle time of the vibration, measured in cycles per second or hertz, Hz.

Humans feel more comfort with higher frequency vibrations than lower Hz cycles.

Shorter lengths of span have higher frequencies than long lengths of span.

DESIGN CONSIDERATIONS: COMFORT AND PERFORMANCE

Floor System Vibration

Amplitude is the magnitude of floor vibration and is directly related to floor stiffness (deflection).

High amplitude vibrations are more annoying than low amplitude.

Amplitude can be reduced by two methods:

- Specifying deeper framing members (joists)
- Using bridging between joists

Continuous bridging perpendicular to the bottom flange of the joist is most effective.

DESIGN CONSIDERATIONS: COMFORT AND PERFORMANCE

Floor System Vibration

Damping of vibration reduces amplitude and shortens the duration of vibrations.

Damping is provided by existing loads and frictions within the floor system.

Damping is achieved with bridging and through the presence of interior partition walls.

DESIGN STRATEGIES

To determine the proper design strategy for a project, the design professional must consider building classification, safety factors, comfort factors and cost.

These considerations will lead to one of two basic design strategies:

- Code Minimum Strategy
- Client Satisfaction Strategy

DESIGN STRATEGIES

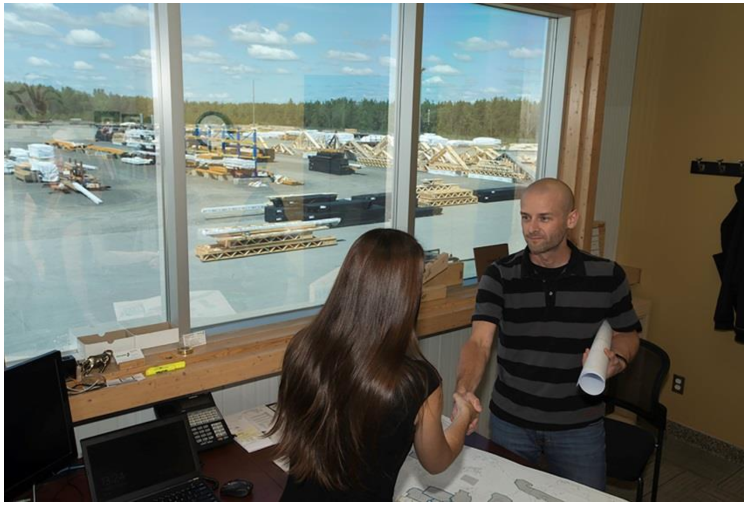
Code Minimum Strategy:

Most often, this strategy is identified as the “Value Engineering” approach. In this design strategy:

On-center joist spacing is maximized and long spans are accommodated.

Quantities of framing materials are minimized and installation time is reduced.

The installed cost of the floor system is minimized.

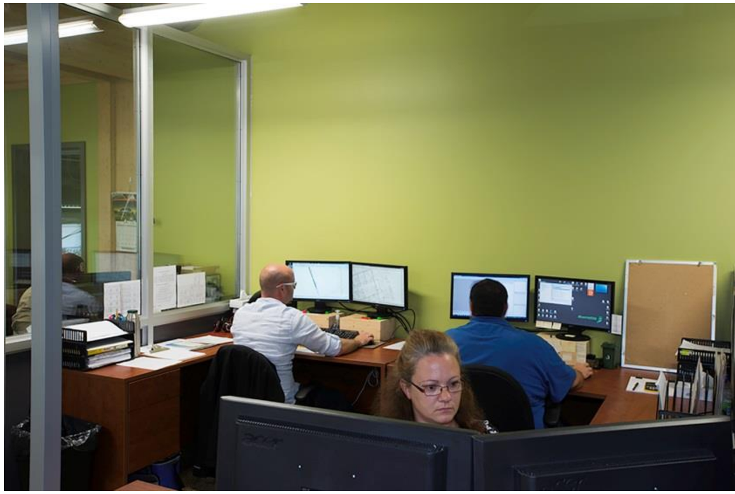


DESIGN STRATEGIES

Client Satisfaction Strategy:

The classification of a building normally dictates the application of this strategy. Custom residences and other privately commissioned projects naturally demand a client satisfaction design strategy.

This strategy gives high priority to comfort and performance factors when designing floor systems and usually specifies structural performance in excess of that required by the building codes.



In this strategy, cost is usually not of primary concern

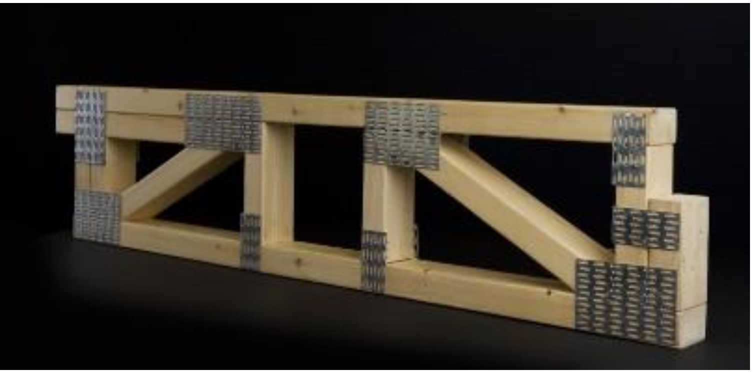
ENGINEERED WOOD
FLOOR FRAMING COMPONENTS

Floor Joists
Beams and Girders
Rim / Band Board
Hangers / Connectors

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Floor Joists:

Wood I-Joists



Steel-Plate-Connected
Parallel Chord
Floor Trusses

All-Wood Parallel Chord
Floor Trusses

ENGINEERED WOOD
FLOOR FRAMING COMPONENTS

Wood I-Joists

- Invented 1969 by Trus Joist Corporation
- “I” cross section
- Solid sawn flanges and plywood web (switched to OSB webs)
- APA-The Engineered Wood Association published standards for I-Joists
- Flanges resist bending, web resists shear
- Efficient use of wood fiber
- Consistent quality
- Lighter than dimension lumber

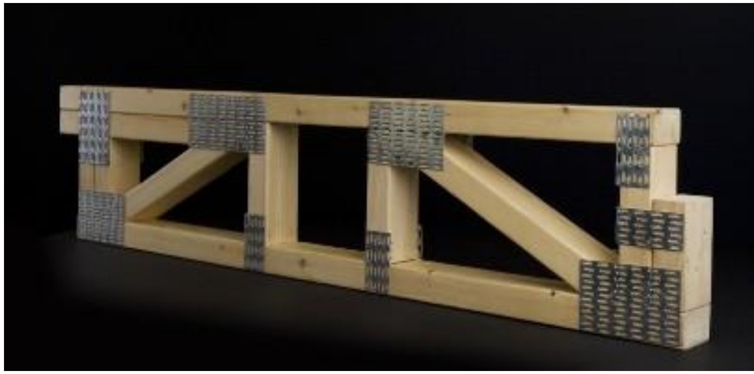
ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Wood I-Joists

- Depths of 9-1/2”, 11-7/8”, 14”, 16”, 18”
- Flanges of solid sawn SPF, LVL, LSL
- Multiple span applications with proper blocking
- Installation requires accessory reinforcement pieces: web fillers, web stiffeners, squash block
- Can accommodate some special loads with proper reinforcement
- Penetrations through web limited
- Structural rim board required at ends of joists
- Engineered repair details required

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Steel-Plate-Connected Floor Trusses



- Invented in 1952 by A. Carroll Sanford
- Open web configuration
- Made possible by the innovation of the steel truss plate
- Truss engineering software designs trusses for specific job conditions
- Must be fabricated to exact jobsite dimensions
- May be designed to accommodate duct chases
- Constructed of SYP, Doug Fir or SPF lumber
- Flanges of 4X2 most common

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Steel-Plate-Connected Floor Trusses

- Structural rim board not required at end of trusses
- Can be designed to handle special loads
- Common depths of 12”, 14”, 16”, 18”, 20”, 22”, 24”
- May be damaged by excessive construction materials loads
- Engineered repair details required
- Local production only…no national brands

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Proprietary Steel Plated Floor Trusses

- Open web configuration
- Wood or steel webs
- Stock lengths with trim-able “I” ends
- SpaceJoist TE, Trim Joist, Gator Joist
- Depths of 9-1/4”, 11-1/4”, 14”, 16”, 18”
- Flanges of 4X2 or 3X2
- Structural rim board required

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

All Wood Parallel Chord Trusses

OPEN JOIST

- Invented in Canada in 1989
- First trim-able open-web floor joist
- Stock lengths in two-foot increments
- Combination of “I” and truss engineering
- Values from actual testing
- Assembled with precision finger joinery and structural adhesive
- Spruce-Pine-Fir webs and flanges (4X2 & 3X2)

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

All Wood Parallel Chord Trusses

- Depths of 9-1/2”, 11-7/8”, 14” 16”
- No metal connectors or fasteners
- Technology allows efficient use of wood fiber
- Trusses are individually tested
- Simple span, bottom chord bearing (1-1/2” bearing)
- Can accommodate special loads with reinforcement
- Standard Repair Details on hand

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Structural Rim Board

Supports vertical loads transferring down through bearing walls.

Available in several technologies:

- LVL (laminated veneer lumber)
- PSL (parallel strand lumber)
- LSL (laminated strand lumber)
- OSB (oriented strand board)
- Glu-Lam (laminated solid sawn lumber)
- Solid sawn lumber

ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Beams and Girders

Beams and girders are manufactured with the same technologies as structural rim board, including:

- LVL (laminated veneer lumber)
- PSL (parallel strand lumber)
- GluLam (laminated solid sawn lumber)
- Steel plated girder trusses

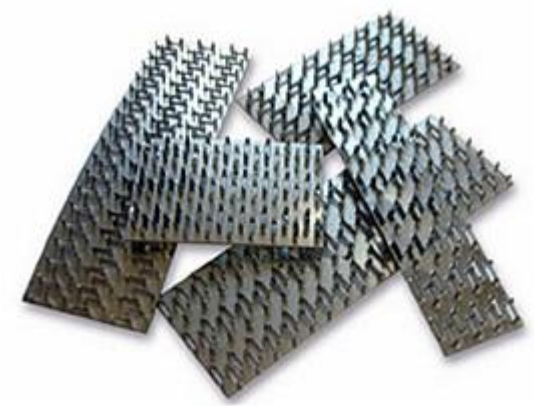
ENGINEERED WOOD FLOOR FRAMING COMPONENTS

Hangers and Connectors

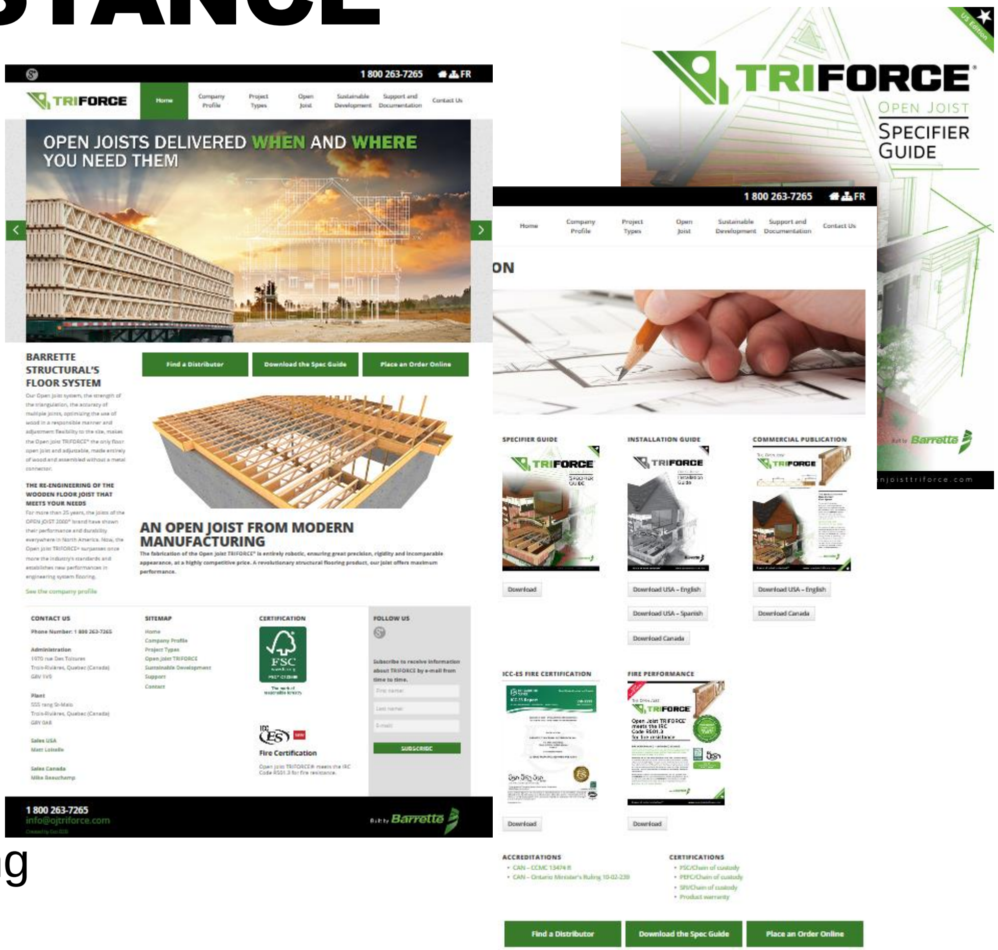
The designer must choose hangers that accommodate the loads and reactions at the ends of joists and beams.

Major manufacturers offer products to fit all engineered wood joist and beam sizes.

Manufacturers provide Design Guides to help designers choose correct products.



DESIGN ASSISTANCE



Manufacturer Literature

- Span charts and load tables
- Installation details
- Fire and sound assemblies
- Product specifications

Manufacturer Web Sites

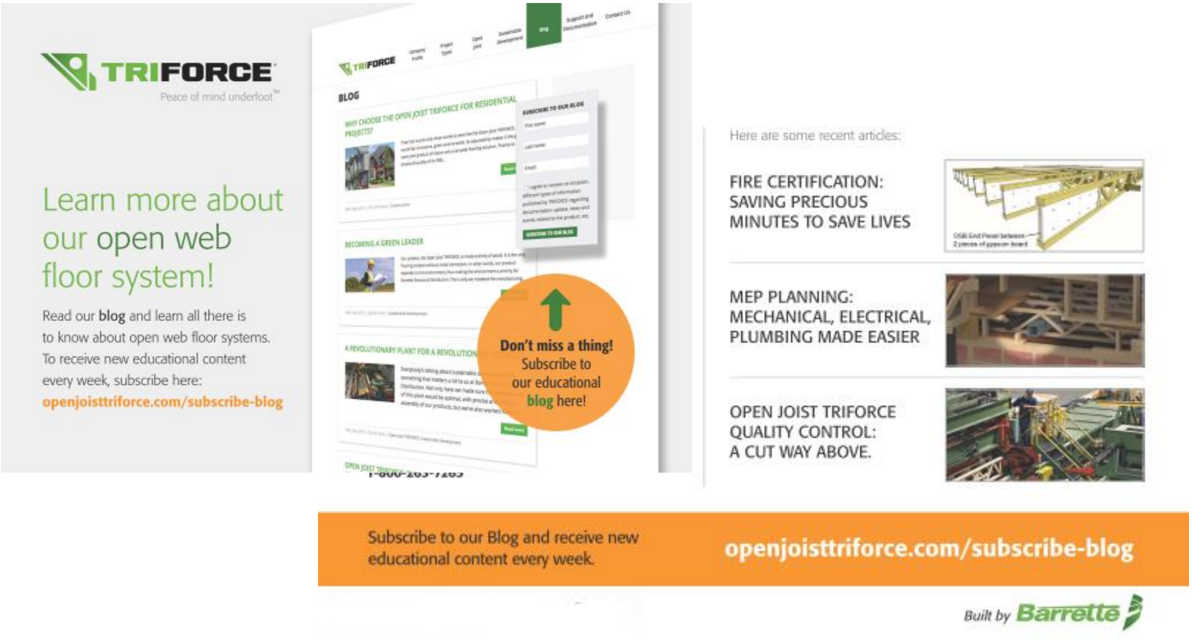
- Repeat of printed information
- Interactive for product sourcing
- Downloadable details and language

DESIGN ASSISTANCE

What is our blog about?

You will find exclusive content about open web floor systems. Our bloggers will share their knowledge and insights about:

- Construction best practices
- Sustainable development
- Technical information
- Educational Content
- And more!



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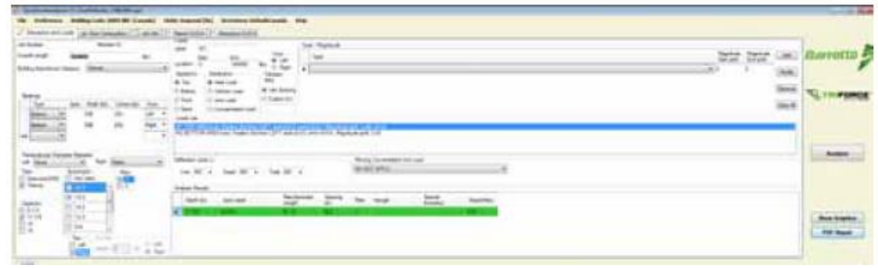
DESIGN ASSISTANCE

Engineering/Design Software

- Free of charge
- Training provided

Design Done by Supplier

- Design floor system to architect's specification
- Final approval by architect and/or engineer
- Sealed shop drawings available

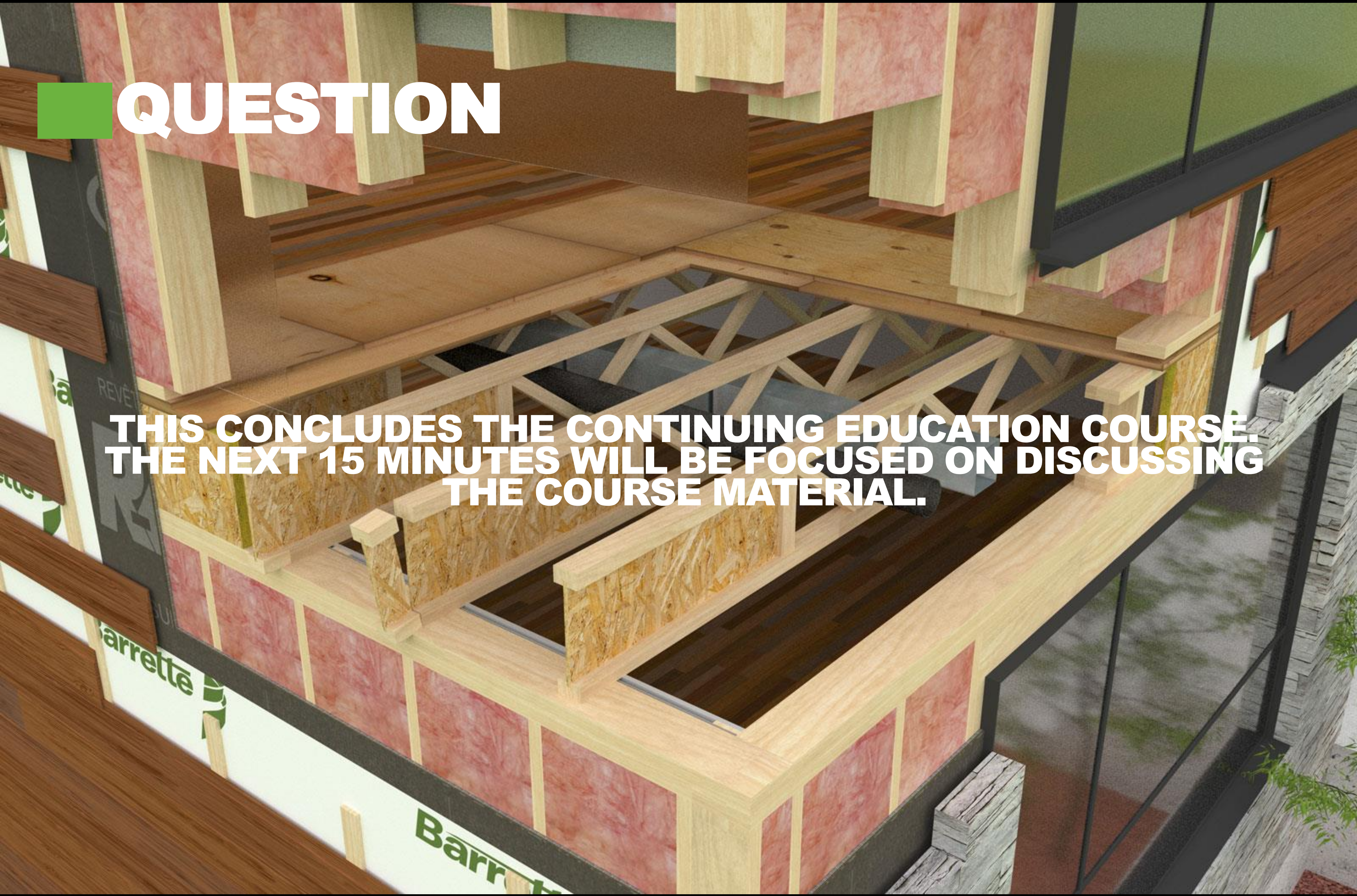


CONCLUSION

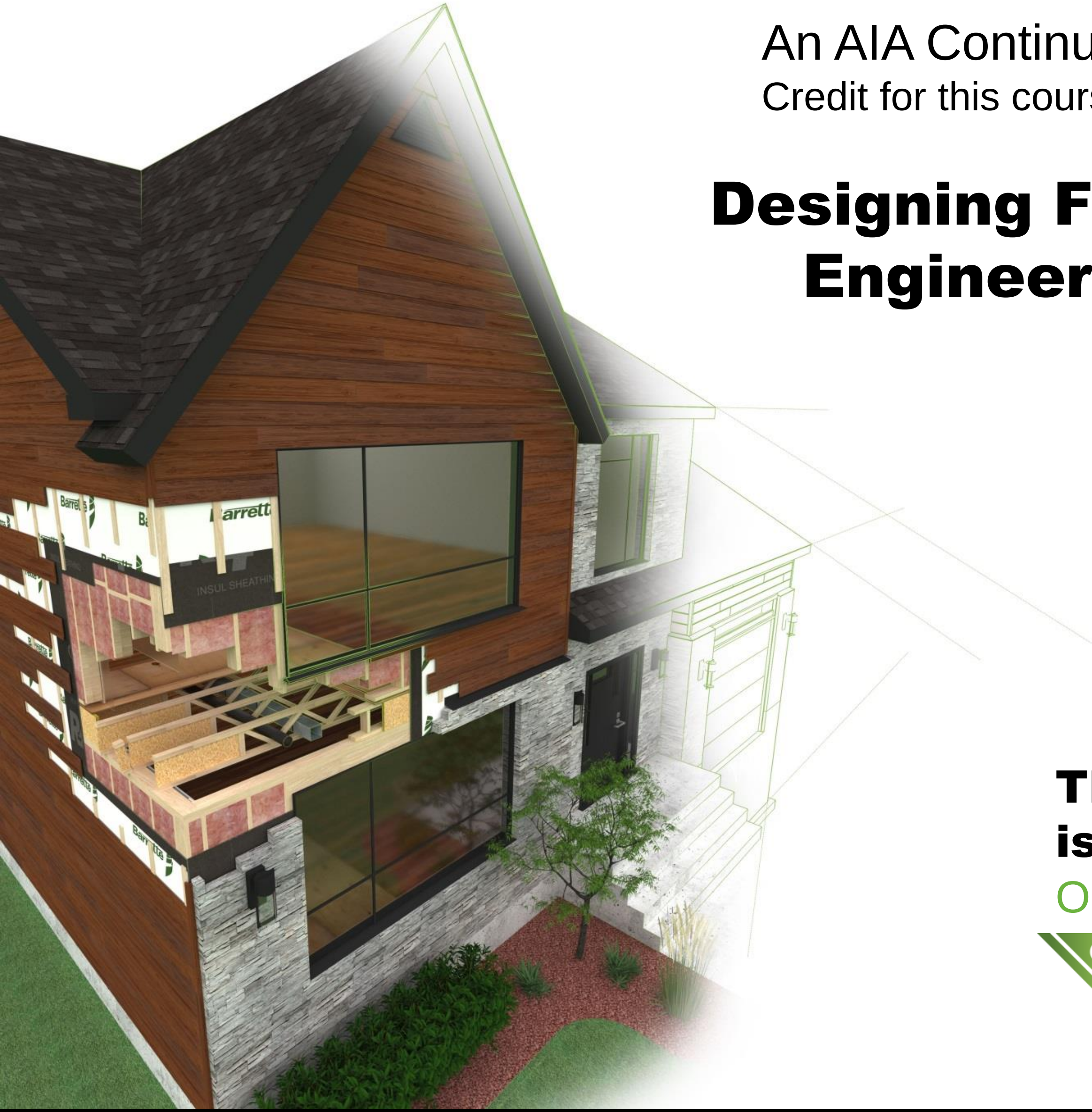
By now, you should have a better understanding of the following:

- The design safety factors that must be considered when designing floor systems
- The comfort and performance factors that should be considered when designing
- floor systems with engineered wood products
- Approaches to designing floor systems for maximum efficiencies and client satisfaction
- Engineered floor framing products available today and their capabilities and requirements
- The assistance available to design professionals from producers of engineered wood framing products

QUESTION



THIS CONCLUDES THE CONTINUING EDUCATION COURSE.
THE NEXT 15 MINUTES WILL BE FOCUSED ON DISCUSSING THE COURSE MATERIAL.



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