



## DECKING 202: DESIGN METHODOLOGY FOR PENETRATIONS THROUGH COMPOSITE DECK



### LEARNING OBJECTIVES

Upon completing this program, the participant should be able to:

1. Identify the factors influencing composite deck design
2. Understand non-structural considerations for composite deck design
3. Compare the different ways to create openings through composite decks
4. Know the implications of creating penetrations through decks



## AGENDA

### • Introduction

- Structural Considerations for designing Composite Metal Decks
- Non-Structural Considerations for designing Composite Metal Decks
- Creating Openings in Composite Metal Decks
- Conclusion



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## COMPOSITE FLOOR/ROOF DECK IS A PRODUCTIVE AND EFFICIENT WAY TO CONSTRUCT SLAB MEMBERS

**Composite slabs consist of profiled steel decking sheets with an in-situ reinforced concrete topping, creating a composite structural member.**

- The decking acts as permanent form-work to the concrete
- The decking also provides sufficient shear bond with the concrete so that when cured the two materials act together to resist loads in the deck



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## OPENINGS IN THE DECK MUST BE CREATED FOR THE PROPER INSTALLATION OF BUILDING SYSTEMS



Openings in the deck vary in size, location and grouping depending on the building system.

- Water pipes
- Conduits
- Mechanical duct work
- HVAC systems
- Waste systems



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## OPENINGS IN THE DECK TO SUPPORT BUILDING SYSTEMS CREATE DESIGN CHALLENGES THAT MUST BE ADDRESSED

### Structural

- Composite decks are structural members designed to resist loads
- Each opening in the deck creates a potential weak point that needs to be examined by a professional designer
- Determine whether additional reinforcement is needed to strengthen the edge of the opening

### Fire Protection

- Composite decks have a specified fire resistance rating that must be maintained to protect the health and safety of the public
- Each opening in the deck creates a potential access point for smoke and fire
- Proper firestopping measures need to be designed to ensure proper performance of the deck



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## COMPOSITE DECK CONSISTS OF A CONCRETE TOPPING CAST ONTO STEEL DECKING SHEETS

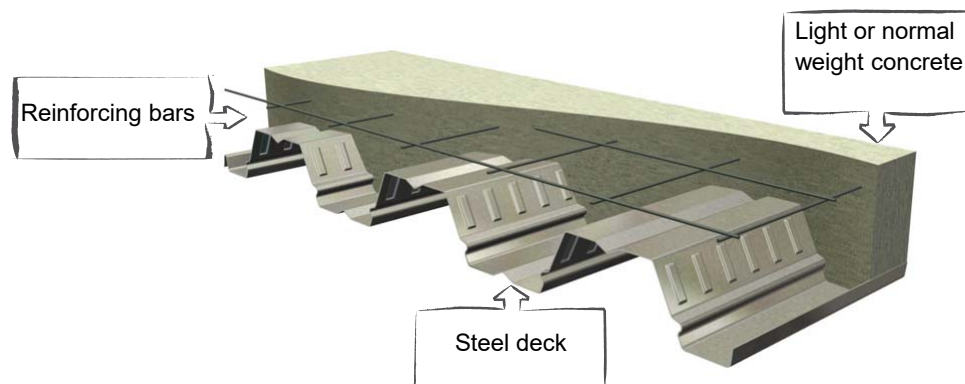


Image from Verco Inc.

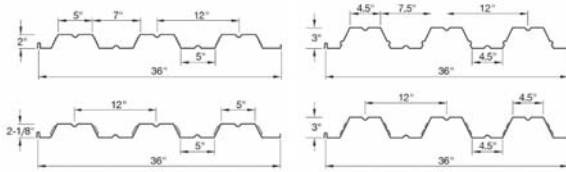


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## STEEL DECK PROFILE, THICKNESS, STIFFNESS AND LOADING ALL PLAY INTO THE DESIGN OF THE DECK

### Common steel deck profiles and thickness



Gauge No.	Design Thickness	
	in.	mm.
22	.0295	0.75
20	.0358	0.91
18	.0474	1.20
16	.0598	1.52

### Steel deck properties

- Manufactured to ASTM A1008/A1008M for uncoated deck
- Manufactured to ASTM A653/A653M for galvanized deck
- Minimum yield strength of 33ksi
- Un-shored spans between 4' to 16' between beams depending on loads
- Thickness normally specified by gauge



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## STEEL DECKING FIRST SERVES AS FORMWORK AND THEN ACTS COMPOSITELY WITH THE CONCRETE AS A SLAB

### Formwork

- Design of the steel deck as a form to support construction loads



### Structural Member

- Design as a composite slab for superimposed loads after concrete has cured



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## DESIGN OF THE STEEL DECK AS FORMWORK TYPICALLY CONTROLS SO THAT NO ADDITIONAL SHORING IS NEEDED

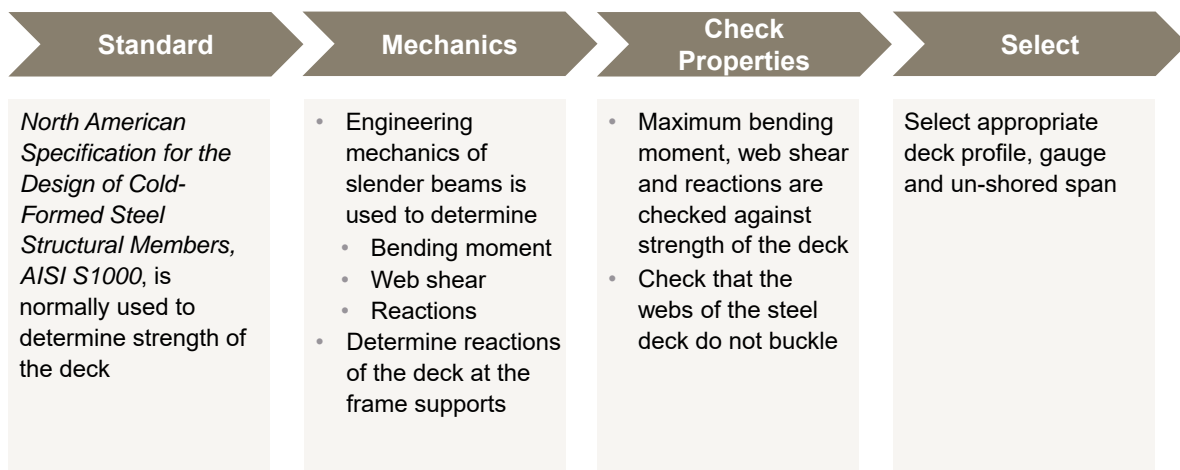
Steel deck designed as formwork must meet the minimum design loads specified by the *Steel Deck Institute's C-2011 Standard for Composite Steel Floor Deck-Slabs*.

- Two load combinations are evaluated and the deck is designed for the worst case scenario
  - Load combination 1: dead weight of concrete plus 20 psf uniform construction live load
  - Load combination 2: dead weight of concrete plus 150 lbs concentrate load per foot width of deck



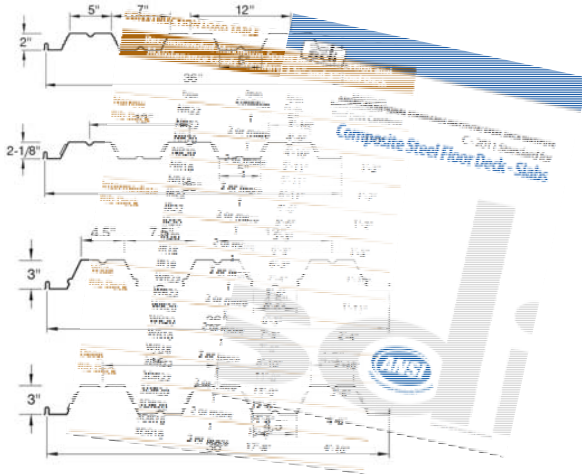
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## THE STEEL DECK ACTS LIKE A COLD-FORMED STEEL BEAM SPANNING BETWEEN THE SUPPORT FRAMING



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## TEMPORARY SHORING IS TO BE AVOIDED SINCE THIS NEGATIVELY EFFECTS THE PROJECT SCHEDULE & BUDGET



The maximum un-shored span of the steel deck is typically provided by the deck manufacturer for each deck type but the design should check deflection of the deck.

- Deck deflection limits are specified in *SDI C-2011*
  - Deflection of the deck can lead to ponding which results in increased dead load on the structure
  - Calculated deflection of deck is based on the weight of the wet concrete and the self weight of the steel deck uniformly loaded on all spans
  - The deflections is limited to the lesser of  $1/180$  of the clear span or  $3/4$ "



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## AFTER CONCRETE CURING THE COMPOSITE DECK CAN BE DESIGNED AS A REINFORCED CONCRETE BEAM

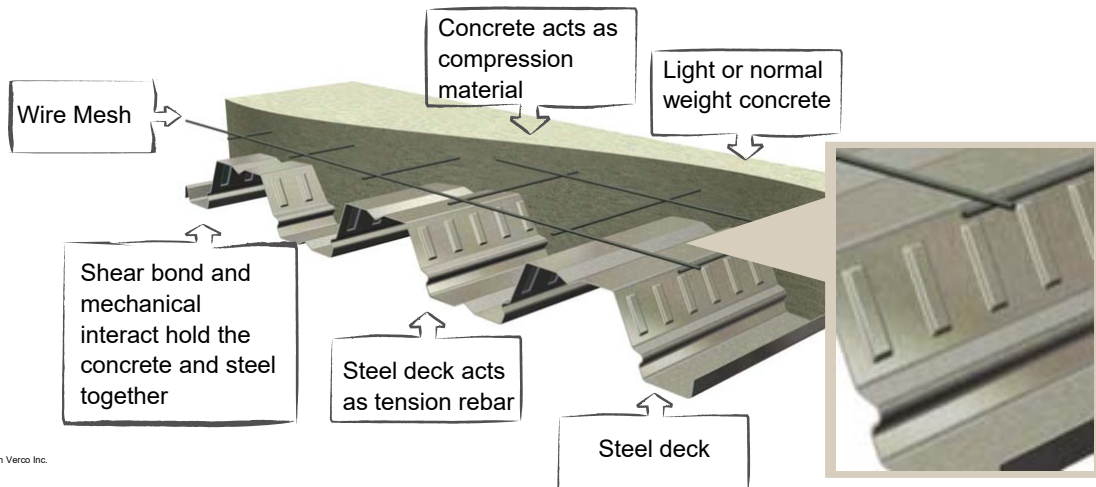


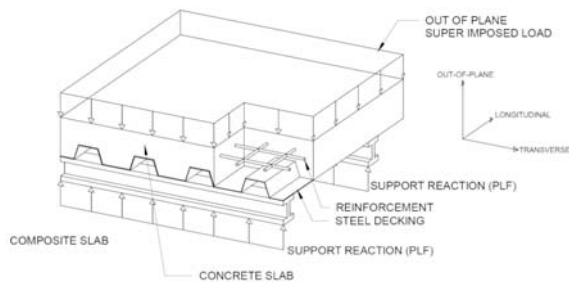
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## THE BENDING CAPACITY OF THE COMPOSITE DECK MUST BE SUFFICIENT TO RESIST OUT OF PLANE GRAVITY LOADS



**The composite deck must resist superimposed dead and live loads plus the self-weight of the deck and concrete.**

- *ANSI/SDI C-2011* lists various methods to determine the strength of the composite deck slab such as:
  - Prequalified section method
  - Shear bond method
  - Full scale performance testing
- Deflection must also be checked
  - Not to exceed  $L/360$  during service live according to building codes
  - Deflection seldom controls the design

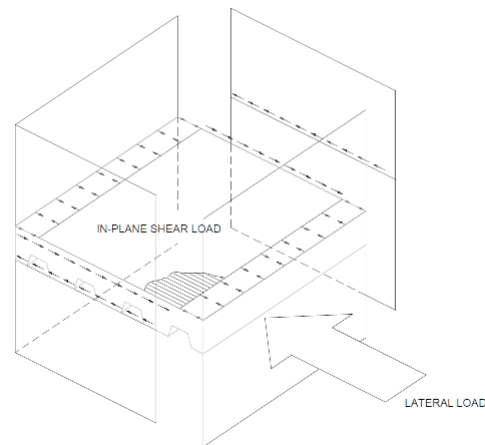


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## THE COMPOSITE DECK ALSO RESISTS IN-PLANE SHEAR LOADS AND TRANSFER THEM TO THE BUILDING FRAME

**To use the composite deck as a horizontal shear diaphragm the deck is modeled as a horizontal beam with interconnected floor deck units that act as the beam web.**

- Joists or beams function as web stiffeners
- Perimeter beams act as beam flanges
- *Steel Deck Institute Diaphragm Design Manual, SDI-DDM*, provides detailed design instructions



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## DECK MANUFACTURERS PROVIDE DESIGN TOOLS TO SIMPLIFY THE DESIGN PROCESS FOR ENGINEERS

### Deck manufacture summary tables

These tables summarize design parameters and permissible loads such as section properties, maximum un-shored span, superimposed loads and diaphragm shear load to ease the design process.

### These table do NOT consider opening in the deck

The deck manufacture summary table assume the composite deck is a solid uniform platform with no openings or penetrations.

### The engineer must evaluate openings in the deck

Openings in the deck can negatively effect performance, the engineer must independently examine the opens and their effects ont he deflection, bending and shear strength of the deck to determine if additional reinforcement is required.



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## EACH OPENING IN THE DECK NEEDS TO BE EVALUATED TO DETERMINE IF ADDITIONAL REINFORCEMENT IS NEEDED

Opening	Size	SDI Recommendation
<b>Small</b>	Up to 12"	Single openings up to 6" do not generally need any reinforcement
<b>Medium</b>	1' – 4'	Normally require additional rebar reinforcement placed in the slab
<b>Large</b>	Greater than 4'	Rebar reinforcement placed in the slab and additional steel framing may need to be designed

### The need for additional reinforcement in the slab depends on various parameters.

- Opening size
- Location within the span
- Orientation of opening
- Steel deck type
- Deck gauge
- Concrete thickness
- Loading



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## CONTRACTORS USUALLY CUT OPENINGS IN THE DECK BEFORE THE CONCRETE IS POURED



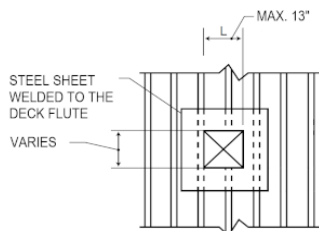
**Cutting openings in the deck before concrete is poured allows for easier installation but it can also negatively effect deck performance.**

- Reduces the flexural capacity of the deck
- Induce excessive deflection
  - Leading to concrete ponding which increases dead load
- Reduces the deck vertical shear capacity around opening
  - May result in deck web crippling under concentrated loads during construction



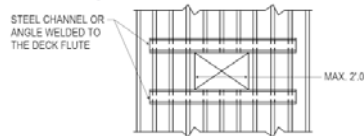
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## SDI'S PAPER 'DECK DAMAGE AND PENETRATIONS' PROVIDE SOME OPENING REINFORCEMENT SUGGESTIONS



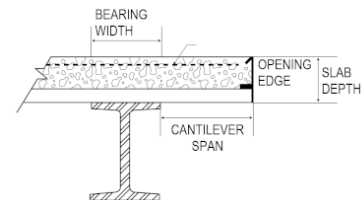
### Openings 8" – 13" spaced more than 4' apart

- Weld steel sheets to the deck



### Openings 13" – 24" perpendicular to deck

- Weld steel frames to the deck



### Openings larger than 2'

- Analyze the deck panel as a cantilever slab

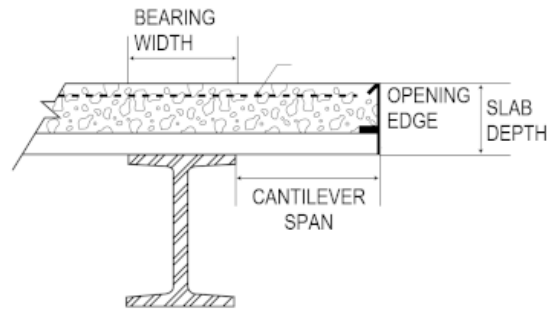


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## SDI PROVIDES DESIGN REQUIREMENTS FOR ANALYZING THE DECK AS A CANTILEVER SPAN

### SDI's requirements for steel deck design as a cantilever span

- Allowable bending stress of the steel deck shall not exceed  $0.6F_y$  with loading of concrete weight + deck weight + the larger of 20 psf or 150 lb. concentrated load
- Allowable deflection of free edge shall not exceed  $1/120 L$  under loading of concrete + deck
- Web crippling shall be checked with loading of concrete weight + deck weight + 20 psf over cantilever and adjacent span



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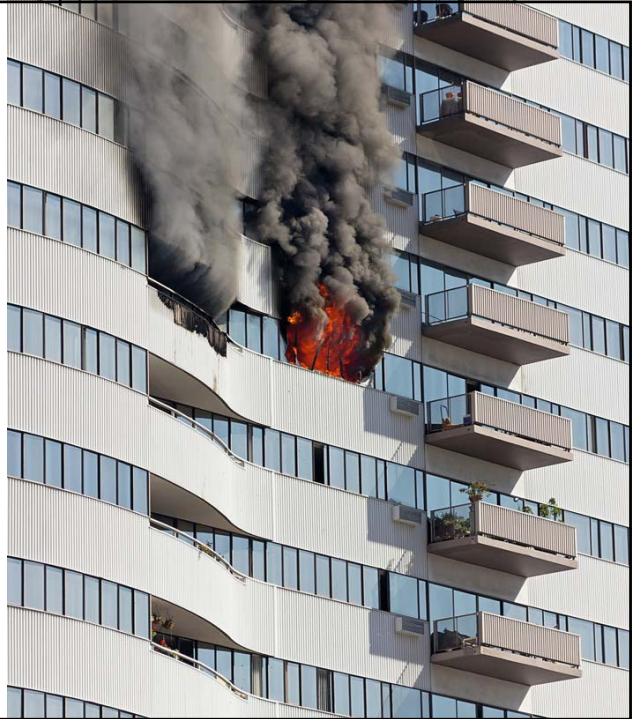


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## PUBLIC SAFETY IS THE FOCUS OF BUILDING CODES

**Passive fire protection is required by building codes to minimize the spread of fire and smoke during a fire event.**

- The building is divided into compartments designed to contain hot gases and smoke allowing more time to safely exit the building
- Design team uses the size, type of occupancy or use of the building to determine which passive firestop systems are needed
  - Openings, joints and penetrations must be fire protected with fire-resistant rated assemblies



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## THROUGH-PENETRATION FIRESTOP SYSTEMS ARE TESTED TO ASTM AND UL FIRESTOPPING TEST STANDARDS

**Designing for passive fire protection consists of several elements, that together form the basis for a firestop system**

- The system comprises 3 elements:
  - Fire-resistant rated assembly
    - Wall or floor
  - Penetrating item
    - Pipe, cable, duct, etc.
  - Firestop component



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## CERTIFIED TESTING AGENCIES TEST EACH FIRESTOP SYSTEM TO EVALUATE FUNCTIONALITY AND QUALITY



The performance of the firestop system is dependent upon the specific assembly of materials tested.

- Number of penetrations
- Type of penetrations
- Size of penetrations
- Wall or floor materials

Firestop systems must be installed exactly per their listing details and manufacture's instruction to perform as design.



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## FIRESTOP IS CRITICAL TO PUBLIC SAFETY THUS REVIEW AND APPROVAL IS REQUIRED BEFORE INSTALLATION



### Authority Having Jurisdiction

- Reviews and approvals firestopping plan before installation



### On-site Inspection

- Ensures firestop system is installed correctly per the submitted and approved firestopping plan



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## THERE ARE MANY SOLUTIONS TO FIRESTOPPING FLOOR PENETRATIONS

There are many different kinds of firestopping solutions for floor penetrations with the industry moving towards preformed devices.

- Foam
- Sealants
- Wraps
- Collars
- Preformed devices



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## THERE ARE THREE MAIN METHODS FOR CREATING OPENINGS IN THE COMPOSITE DECK



### Core-drilling

- Drill opening in deck after concrete is cured
- Deck cut during drilling
- Firestop opening after drilling



### Sleeving or Boxing-out

- Frame out opening before concrete is poured
- Deck can be cut before or after concrete is poured
- Firestop installed after pour



### Preformed devices

- Installed before concrete is poured
- Deck cut after concrete is cured
- Firestopping is integrated into device



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## CORE DRILLING AFTER THE CONCRETE HAS CURED CREATES A SMOOTH CLEAN OPENING IN THE DECK

### Advantages



- Does not disturb the mechanical interlock of the concrete and deck
- No additional reinforcement installed prior to concrete pour
- No additional deck framing required

### Disadvantages



- Risk of cutting existing reinforcement
  - Existing reinforcement must be located prior to drilling
  - Scanning devices used to locate reinforcement
- Drilling process requires water
- Firestop system is installed after drilling
- Influenced by skill of installer



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## SLEEVING OR BOXING-OUT GIVES THE CONTRACTOR A CLEAN AREA TO WORK AFTER CONCRETE POURING



### Advantages

- Can cut the deck after concrete is poured
- No risk to reinforcement



### Disadvantages

- Welding machines needed to attach sleeves/boxes to deck
- Plasma cutters or torches are used to cut the deck
  - Sparks from the cutting process create a fire hazard
  - Special permits are often required to use these tools
- If cutting deck before concrete curing additional reinforcement or deck framing may be required
- Firestop installed after concrete is poured



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## PREFORMED DEVICES INCORPORATE THE FIRESTOPPING ELEMENTS INTO THE DEVICE SIMPLIFYING INSTALLATION



### Advantages

- Deck is cut after concrete is cured
- Does not disturb the mechanical interlock of the concrete and deck
- No risk to reinforcement
- Firestop incorporated into device
- Not influenced by skill of installer



### Disadvantages

- Additional reinforcement may be required if many devices are installed together creating a void



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## CONCLUSION

### Structural

- Structural member to carry live and dead loads
- Structural member to transfer loads to the building frame
- Formwork to support construction loads
- Take into consideration that openings will be made in the deck to accommodate the building systems

### Firestop

- Openings in the deck must be firestopped to protect the public from fire and smoke during a fire event
- Firestop systems must be submitted and approved
- Firestop system must be installed exactly as tested and listed

### Constructability

- Contractors have several options when creating penetrations in composite metal decks
- In addition to the creation of the opening, care should be taken to properly firestop the penetration to ensure the continuity of the firestop performance.



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## HILTI FIRESTOP CAST-IN DEVICE PORTFOLIO



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## HILTI CFS-CID MD FIRESTOP SYSTEM IS SPECIFICALLY DESIGNED FOR USE IN COMPOSITE DECKS

- System Components
  - Hilti Services Portfolio
  - Robotic Total Station
  - TE 60-A36 Combihammer
  - Platform
  - Cast-in Device
  - Guide Sleeve
  - Hole Saw



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## INSTALL THE PLATFORM, CFS CID MD PLT, TO CREATE A FLAT SURFACE AND KEEP OUT CONCRETE

### Step 1

- Prior to pouring the concrete
- Locate the position and attach the platform
- Platforms may be paired up for multiple penetrations



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## LOCATE AND INSTALL THE FIRESTOP DEVICE, CFS-CID MD



### Step 2

- Locate and attach the Cast-in Device
- Location may utilize the BIM model and a robotic Total Station, to pinpoint the exact location
- Run additional reinforcement
- Concrete can now be poured and cured



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## AFTER CONCRETE IS POURED AND CURED REMOVE THE END CAPS



### Step 3

- After curing the opening can be located using the devices whiskers.
- The caps can be removed to expose the opening



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## INSTALL THE PROTECTIVE SLEEVE, CFS-CID MD HS GUI, AND DRILL OUT THE DECK WITH THE CFS-CID MD HS



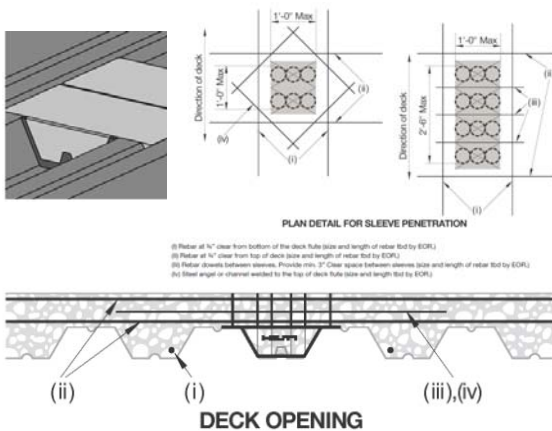
### Step 4

- Insert the guide sleeve to protect the integrated gasket
- Use the hole saw to cut the deck
- Insert the pipe
- Penetration is now Firestopped!



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## HILTI WHITE PAPER - OPENINGS IN COMPOSITE FLOOR DECKS ON ASK.HILTI



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THANK YOU

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