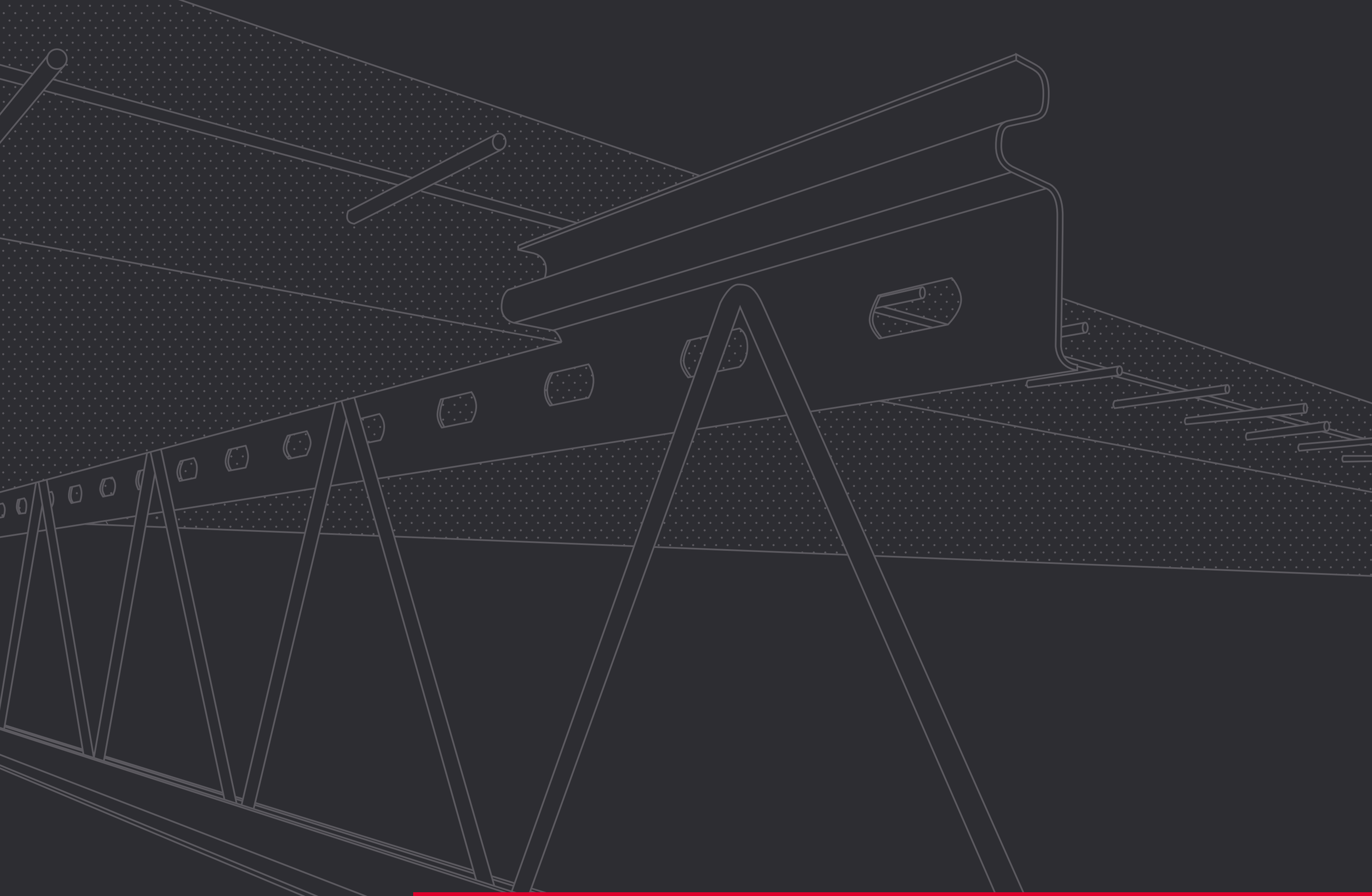

HAMBRO COMPOSITE FLOOR SYSTEM

Technical Manual

CANADA

CANAM
BUILDINGS

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Products, services and solutions

Canam Buildings and Structures Inc. (“Canam”) specializes in the design and fabrication of steel joists and joist girders, steel deck, purlins and girts, welded wide-flange shapes (WWF), load-bearing steel stud walls, as well as the Murox prefabricated building system, Econox relocatable buildings and Hambro composite floor system. It offers value-added engineering and drafting services, architectural flexibility and customized solutions and services.

What is more, Canam has redefined building design and construction by adopting the systematic BuildMaster approach that can reduce installation time of building structures by up to 20%.

Because product quality, site supervision and deadlines are critical aspects for any project, our reliability makes life easier for our customers. Furthermore, a rigorous site management process has been developed to deliver projects on time. Advanced equipment, well-trained staff and quality products are what set us apart. Regardless of the project, Canam will meet your needs, while ensuring that current building code requirements are met.

Our exceptional service also means just-in-time delivery at a time that works for you. To make sure we eliminate delays, our fleet of trucks delivers your product on time, regardless of your location and schedule. Depending on the region and delivery point, Canam can transport parts in sizes up to 16 ft. (4.9 m) wide by 120 ft. (36.5 m) long. Canam is one of the largest structural steel and steel joists manufacturers in North America.

DISCLAIMER

This manual has been developed to assist you in understanding the Hambro composite floor system, and for you to have at hand the information necessary for the most efficient and economical use of our Hambro products.

Suggested detailing and design information throughout this manual illustrates methods of use. To achieve maximum economy and to save valuable time we suggest you contact your local Hambro representative. He/she is qualified and prepared to assist you in the selection of a Hambro system best suited to your project's requirements.

For any questions concerning the product, to request a quote, a visit from one of our representatives or for documentation, please contact us.

The information contained herein should not be used without examination and verification of its applications by a certified professional.

CAUTIONARY STATEMENT

Although every effort was made to ensure that the information contained in this catalog is factual and that the numerical values presented herein are consistent with applicable standards, Canam does not assume any responsibility whatsoever for errors or oversights that may result from the use or interpretation of this data.

Anyone making use of this catalog assumes all liability arising from such use. All comments and suggestions for improvements to this publication are greatly appreciated and will receive full consideration in future editions.

DESCRIPTION

The Hambro composite floor system consists of open web steel joist with a top chord embedded in a reinforced concrete slab. The combination of the joist and the slab performs as a “T” shaped beam. The concrete slab is reinforced with welded wire mesh and behaves structurally as a continuous one-way slab orientated perpendicularly to the joists.

The Hambro joist develops the composite action once the concrete has reached its required maximum compressive strength. It is obtained by the friction between the steel of the top chord and the concrete as well as by the horizontal bearing force of the joist shoe. It is important to respect a minimum of 6 in. (152 mm) of concrete between the center line of a joist and the edge of a slab opening in order to maintain the composite action.

The Hambro composite floor system is versatile and is used in different types of building construction, i.e. masonry, steel, cast in concrete and wood, ranging from the single-family homes to multi-story residential and office complexes. The following figures illustrate the most common bearing situations and uses of the system.

D500 on concrete wall

D500 on masonry wall

D500 on steel stud wall

D500 on wood wall

D500 on ICF wall

D500 on steel beam

MD2000 on concrete wall

MD2000 on masonry wall

MD2000 on steel stud wall

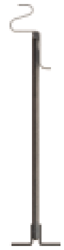
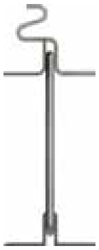
MD2000 on wood wall

MD2000 on ICF wall

MD2000 on steel beam

HAMBRO PRODUCTS

Our Hambro offer consists of the three following products: D500 and MD2000 joist systems, and composite girder. The selection of the product depends on the bearing conditions, the field situation, the loads and the spans.

Product	Series	Configuration
D500 joist system	H	
MD2000 joist system	MDH	
Composite girder	HJG	

JOIST COMPONENTS

The unique top chord section has four basic functions:

1. It acts as a compression member during the concreting stage.
2. It acts as the "high chair" for the welded wire mesh, developing negative moment capacity in the concrete slab where it is required - over the joist top chord.
3. It supports the slab forming system.
4. It automatically becomes a continuous shear connector for the composite stage.

The bottom chord acts as a tension member during both the concreting stage and the service life.

The web system ties the top and bottom chords together and resists the vertical shear in the conventional truss manner.

IMPORTANT NOTES FOR ENGINEERS

GRAVITY LOADS

The Hambro system is mainly designed to support gravity loads, however, lateral loads can also be applied. The lateral loads are transferred solely through the slab and the engineer responsible for the project is in charge of designing the necessary reinforcements. Canam engineering staff offers support in order to optimize the design of the slab as a diaphragm.

REACTION ON SUPPORT ELEMENTS

The engineer responsible for the project should take into consideration that the total end reaction is concentrated at the shoe when designing the supporting elements.

VIBRATION

The vibration for Hambro joists is calculated according to AISC Design Guide 11 named *Floor Vibration Due to Human Activity* accepted by the Canadian Institute of Steel Construction (CISC). The vibration calculation for the Hambro joist considers full height partition everywhere on the floor (heavy partition), it uses a beta ratio of 0.05 and takes into account rigid supports for joist bearing.

If the engineer responsible for the project requires a different criterion of vibration, he can specify a joist inertia minimum or provide a different damping beta ratio to respect.

WIRE MESH

The Canam engineering team is responsible for the design of the concrete slab to support the gravity loads, therefore Canam will specify which size of wire mesh shall be used as it varies according to the project. Wire mesh size should not be indicated on the structural drawings, please put a note referring to the Canam drawings.

DECK FASTENERS

The type of deck fasteners on the Hambro MD2000 system is at the preference of the erector with the project engineer's approval. However the choice must be made according to one of the options (welded or screwed) indicated on the Canam drawings.

PRECAUTION FOR COMPOSITE ACTION

In all instance, a minimum distance of 6 in. (152 mm) needs to be respected between the edge of slab and the center line of a joist in order to maintain the composite action.

INSTALLATION

The installation of the system is fast and simple and doesn't require shoring. For more information on the installation process please refer to the *Hambro D500 Installation Manual* that can be found at www.canam-construction.com.

STEEL

The Hambro joist and joist girder design makes use of high strength steel in accordance with the latest issue of the standards below:

- Cold formed angles, “S” shaped top chord, and U-shaped channels: ASTM A1011
- Hot rolled angles and round bars: CAN/CSA-G40.20/G40.21

The yield strengths of the different components are as followed:

- Top chords: 65 ksi (450 MPa)
- Hot or cold formed angles and channels: 50 ksi (350 MPa) min.
- Round bars: 50 ksi (350 MPa)

DESIGN STANDARDS

The Hambro joist and joist girder design is based on these issues of the following designs standards:

- CAN/CSA-S16-14
- CAN/CSA-S136-12
- NBCC 2010

The Hambro concrete slab design is based on the following design standard:

- CAN/CSA-A23.3-04

Whenever a design standard is mentioned in the following pages, it refers to the edition stated above.

QUALITY ASSURANCE

Over the years, we have established strict quality standards. All our welders, inspectors, and quality assurance technicians are certified by the Canadian Welding Bureau (CWB). We do visual inspections on 100% of the welded joints and non-destructive testing if required.

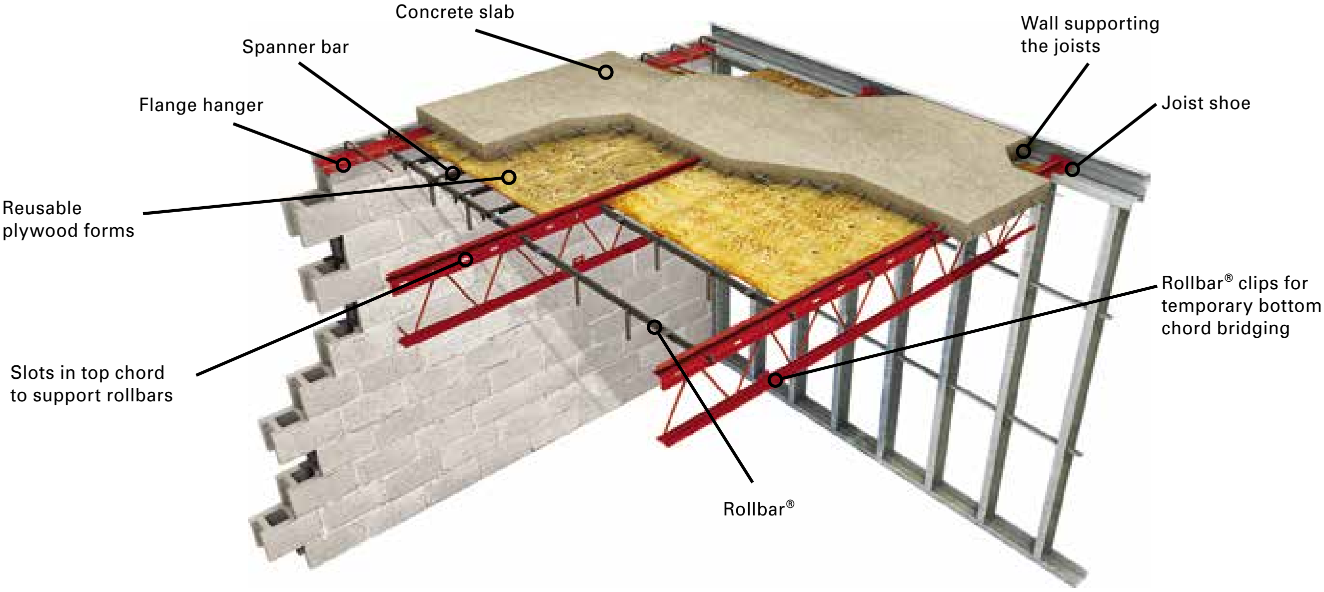
APPROVALS

The Hambro Composite Floor System is approved, classified, listed, recognized, certified or accepted by the following approving bodies or agencies:

1. CCMC No. 06292-R
   irc.nrc-cnrc.gc.ca/ccmc/registry/13/06292 f.pdf
2. International Conference of Buildings Officials (ICBO) Legacy Report No. PFC 2869
   www.icc-es.org/reports/pdf_files/UBC/pfc2869.pdf
3. Miami-Dade County, Florida
   Acceptance No. 16-0224.14
   www.miamidade.gov

JOIST MEMBERS

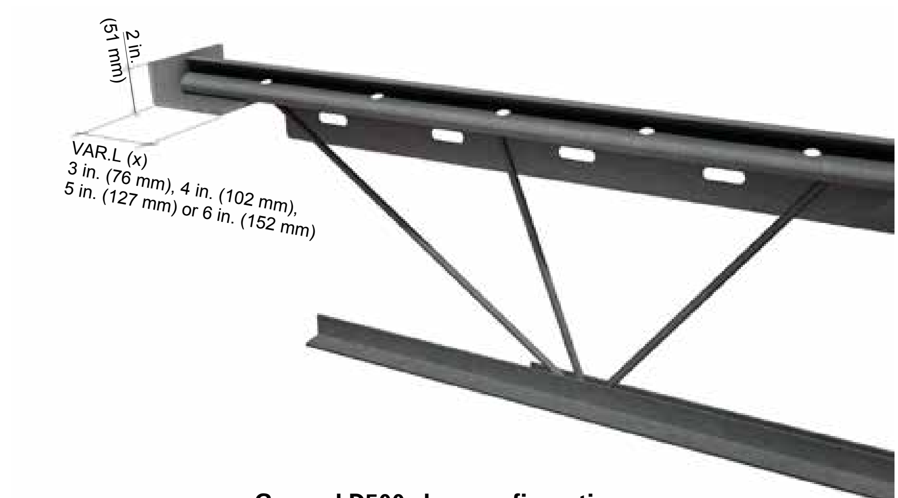
The D500 joist system (H series) features a top chord made of a cold formed “S” shaped section, an open web of bent steel rods and a wide range of two angles back-to-back (hot rolled and cold formed) as bottom chord.



D500 Hambro joist system

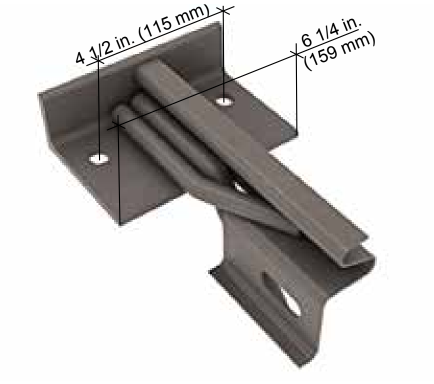
JOIST SHOE

The Hambro joist shoe consists of an angle with a vertical leg of 2 in. (51 mm), a horizontal leg of variable lengths between 3 in. (76 mm), 4 in. (102 mm), 5 in. (127 mm) or 6 in. (152 mm), a thickness of ¼ in. (6 mm) and a variable width depending on the fastening method.

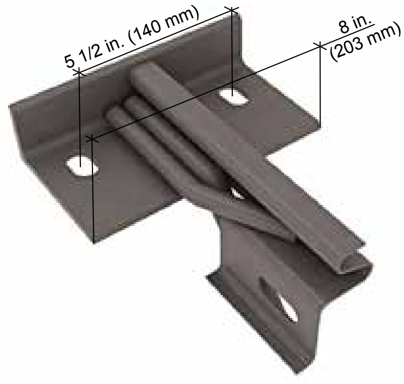


General D500 shoe configuration

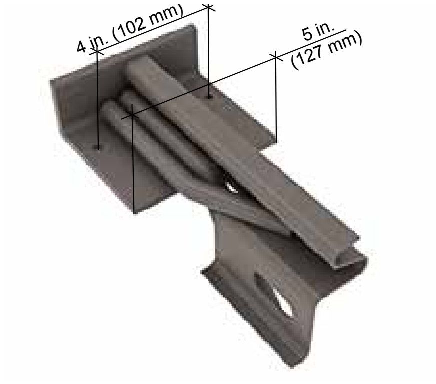
Shoe configuration is adapted according to the fastening method, options are shown in the following figures.



Bolted shoe - Option 1
Bolts ½ in. (13 mm)



Bolted shoe - Option 2
Bolts ¾ in. (19 mm)



Welded or mechanically anchored shoe

SPAN AND DEPTH

Span: up to 43 ft. (13,100 mm)

Depth: between 8 in. (200 mm) and 24 in. (600 mm)

JOIST SPACING

The standard joist spacing is 4 ft.-1¼ in. (1,251 mm), unless noted otherwise on Canam drawings.

MAXIMUM END REACTION

The maximum factored end reaction of the D500 joist is 17.8 kip (79.2 kN) at the composite stage.

FORMWORKS

Formworks for the D500 product consist of rollbars and plywood.

Rollbars are inserted into slots along the vertical portion of the top chord and spaced at every 7, 14 or 21 in. (178, 356 or 533 mm) according to the slab thickness.

Mainly, there are two types of rollbars:

1. Fixed: no movement allowed along the rollbar length [2 ft.-1¼ in. (641 mm), 4 ft.-1¼ in. (1,251 mm) and 5 ft.-1¼ in. (1,556 mm)].
2. Extensible: steel pieces can slip along the rollbar length to accommodate the joist spacing from 1 ft.-11½ in. to 4 ft.-4 in. (597 to 1,321 mm). Due to the fact that these rollbars are not fixed, additional steel stopper or wood pieces are required at their location to stabilize the system *(refer to Hambro D500 Installation Manual or Hambro drawings).*

Fixed rollbar

Extensible rollbar

Plywood sheets are installed over the rollbars to serve as formwork during the concrete pour. Plywood thickness is a function of rollbars spacing and slab thickness. Thicknesses of ½ in. (12.7 mm) and ⅜ in. (9.5 mm) are used. Most of the time, standard sheets dimensions [4 ft. x 8 ft. (1,220 mm x 2,440 mm)] can be used without cutting due to the standard joist spacing.

D500 formworks

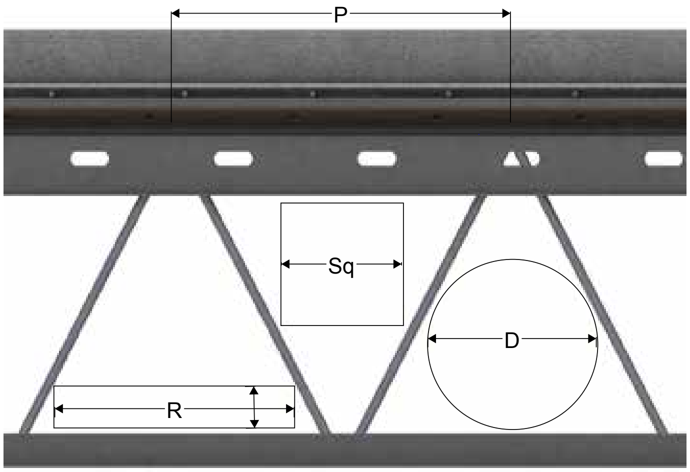
LATERAL STABILITY

At the non-composite stage, joists are braced at the top and bottom chords with rollbars in order to prevent lateral buckling and to hold the joist in the vertical plane during construction. These lateral support are temporary. These rollbars lines must be continuous. At the end of the bay, the rollbars must be firmly secured to a wall or steel beam that must be designed to carry the loads transferred by these rollbars lines. If there is no wall or beam at the end of the bay, then the bottom chord can be braced temporarily to the floor below.

At the composite stage, rollbars are removed. The lateral stability of the top chord is ensured by its embedment in the concrete slab.

MAXIMUM DUCT OPENING

The following table is a guideline for the maximum duct sizes that can fit through the openings of the different joist depths.



Duct opening for D500 joists

Maximum duct opening (in.)				
Joist depth	P	D	Sq	R
8	20	3½	3½	6x2½
10	20	5½	4½	7x3¼
12	24	7¼	5¾	9x4¼
14	24	8½	6¾	9½x5¼ 11x4¼
16	24	9½	7½	10½x5½ 13x4
18	24	10¼	8¼	11x6¼ 12½x5
20	24	11	9	12x6¼ 13x5½
22	24	12	9⅜	12x7½ 14x5½
24	24	12⅜	10	13x7 14x6

Maximum duct opening (mm)				
Joist depth	P	D	Sq	R
200	508	90	90	150x60
250	508	140	115	180x80
300	610	185	145	230x110
350	610	215	170	240x130 280x110
400	610	240	190	265x140 330x100
450	610	260	210	280x160 315x130
500	610	280	225	305x160 330x140
550	610	305	240	305x190 355x140
600	610	315	255	330x180 355x150

SLAB

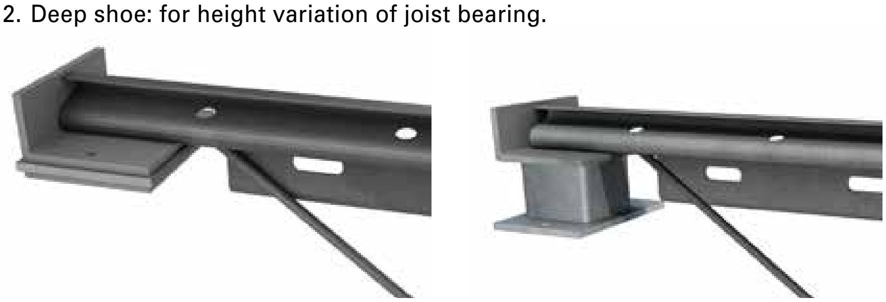
The minimum slab thickness is 3 in. (76 mm) and the slab capacity chart tables on pages 23 and 24, show the total allowable load (including the dead load of the slab) based on 3 ksi (20 MPa) concrete strength.

ACCESSORIES

Accessories are used to accommodate special cases.

1. Hanger plate: for extra slab thickness
   Extra thickness available: 2 in. (51 mm), 3 in. (76 mm), 5 in. (127 mm) and 6 in. (152 mm).
2. Deep shoe: for height variation of joist bearing.

Hanger plate



D500 deep shoes

MINI-JOIST

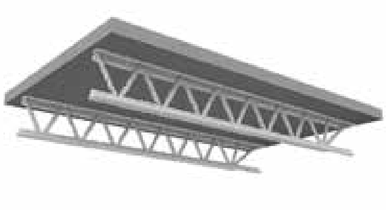
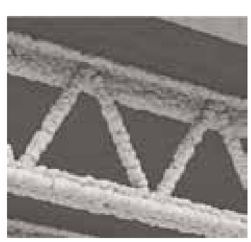
The Hambro D500 top chord section, being 3¾ in. (95 mm), possesses sufficient capacity to become the major steel component of the D500 mini-joist series. The three available types are illustrated below. The first type is called TC and has no reinforcement. The second one is the RTC with a rod reinforcement at the bottom of the vertical lip. The third and last one is the SRTC with a rod reinforcement into the "S" section and a steel angle at the bottom of the vertical lip. Full scale tests have demonstrated consistently that the TC and RTC types do not require a shoe, so the "S"part of the top chord bears directly on the support. The SRTC has a steel angle shoe, same as the D500 joist.

D500 mini-joist types

FIRE RATING

Fire protection floor/ceiling assemblies using Hambro have been tested by independent laboratories. Fire resistance ratings have been issued by Underwriters Laboratories Inc. (UL) and by Underwriters Laboratories of Canada (ULC). These tests cover gypsum board, acoustical tile and spray on protection systems.

Reference to these published listings should be made in the detailing of the ceiling construction. The following table is for information only, the original publication of these standards should be consulted before specifying it. The latest update of these listings is available on the UL directory or its website at www.ul.com or ULC website at www.ulc.ca.

Assembly	Assembly detail	Ceiling description	Design No.	Slab	Fire rating (h)	Beam rating (h)
		Gypsum board ½ in. (12.7 mm) Type C or *⅝ in. (16 mm) Type X	I506	2½ in. (65 mm)	2	-
				3½ in. (90 mm)	3	-
			I518	2½ in. (65 mm)	1.5	2
				2¾ to 3 in. (70 to 75 mm)	2	2
			G524	Varies	1 to 3	1 to 3
		Gypsum board ⅝ in. (16 mm) Type C	G525	3¼ in. (80 mm)	2 to 3	2 to 3
		Suspended or ceiling tile	G203	2¾ in. (70 mm)	1.5	1.5
				3¼ in. (80 mm)	2	2
			G213	3 in. (75 mm)	2	2
				4 in. (100 mm)	3	3
			G227	2½ in. (65 mm)	2	2
			G228	3¼ in. (80 mm)	1.5 to 2	1.5 to 2
			G229	2½ in. (65 mm)	1.5	1.5
				3 in. (75 mm)	2	2
				4 in. (100 mm)	3	3
		Spray on	G702	Varies	1 to 3	-
			I800	2½ to 3½ in. (65 to 90 mm)	1 to 2	-
			G802	Varies	1 to 3	-

*⅝ in. (16 mm) type X applicable only in G524 for 1 hour fire rating.

Please contact your Canam sales representative for any questions regarding the system's fire rating.

ACOUSTICAL PROPERTIES

SOUND TRANSMISSION CLASS (STC)

The STC is a rating that assigns a numerical value to the sound insulation provided by a partition separating rooms or areas. The rating is designed to match subjective impressions of the sound insulation provided against the sounds of speech, music, television, office machines and similar sources of airborne noise characteristic of offices and dwellings.

Here are the guidelines for a sample of STC ratings:

STC Rating	Practical guidelines
25	Normal speech easily understood
30	Normal speech audible, but not intelligible
35	Loud speech audible, fairly understandable
40	Loud speech audible, but not intelligible
45	Loud speech barely audible
50	Shouting barely audible
55	Shouting inaudible

IMPACT INSULATION CLASS (IIC)

The Impact Insulation Class (IIC) is a rating designed to measure the impact sound insulation provided by the floor/ceiling construction. The IIC of any assembly is strongly affected by and dependent upon the type of floor finish for its resistance to impact noise transmission.

ACOUSTICAL PERFORMANCES

The result in the following table have been obtained following laboratory testing. Field testing may vary depending on the quality of the assembly and the various materials used. Note that the minimum design slab thickness for Hambro D500 system is 3 in. (76 mm).

Hambro assemblies				STC	IIC	Laboratory
Assembly	Slab thickness in. (mm)	Gypsum thickness in. (mm)	# of gypsum layer			
	2½ (63.5)	½ (12.7)	1	53	26	NGC Testing Services Buffalo, NY, USA www.ngctestingservices.com
	2½ (63.5)	⅝ (15.9)	1	57	30	National Research Concil Ottawa, ON, CA http://www.nrc-cnrc.gc.ca
	4 (102)	½ (12.7)	1	N/A	32	NGC Testing Services Buffalo, NY, USA www.ngctestingservices.com
	4 (102)	½ (12.7)	2	63	36	NGC Testing Services Buffalo, NY, USA www.ngctestingservices.com

Since the assemblies can have a wide range of components and performances, please contact a Canam representative for further information on the STC and IIC scores.

The following chart is provided as a reference only. The calculations of sound rating and design of floor/ceiling assemblies with regard to acoustical properties are a building designer responsibility.

Floor Finishes	IIC Ratings
Carpet and pad	50
Homasote ½ in. (12.7 mm) ComfortBase® under wood laminate **www.homasote.com**	44
¼ in. (6 mm) cork under engineer hardwood	47
QT scu - QT4010 ⅜ in. (10 mm) underlayment under ceramic tile **www.ecoreintl.com**	46
QuietWalk® underlayment under laminate flooring **www.mpglobalproducts.com**	45
Insulayment under engineered wood **www.mpglobalproducts.com**	46
1½ in. (38.1 mm) Maxxon® gypsum underlayment over Enkasonic® sound control mat with quarry tile over NobleSeal® SIS **www.maxxon.com**	54
1½ in. (38.1 mm) Maxxon® gypsum underlayment over Enkasonic® sound control mat with wood laminate floor over Silentstep underlayment **www.maxxon.com**	55
1½ in. (38.1 mm) Maxxon® gypsum underlayment over Enkasonic® sound control mat with Armstrong Commission® Plus Sheet Vinyl **www.maxxon.com**	53

Notes:

All products tested were on a 2½ in. (63.5 mm) Hambro slab with a one layer ½ in. (12.7 mm) drywall ceiling. This chart is provided as a reference. The calculations of sound rating and design of floor/ceiling assemblies with regards to acoustical properties are a building designer/specialty engineer's responsibility. Actual field results may vary depending on installation and materials. All product tests were performed at NGC Testing Services, Buffalo, NY, USA (www.ngctestingservices.com). These IIC ratings can only be added to the IIC Hambro results for the 2½ in. (63.5 mm) slab.

ACOUSTICAL ASSOCIATIONS AND CONSULTANTS

Because sound transmission and impact insulation depend upon a number of variables relating to the installation and materials used, Canam makes no assessments about the sound transmission performance of its products as installed. You should consult with a qualified acoustical consultant if you would like information about the final sound performance on the project.

The following is a list of acoustical associations that may be found on the Internet:

1. National Council of Acoustical Consultants - www.ncac.com;
2. Canadian Acoustical Association – www.caa-aca.ca;
3. Acoustical Society of America – www.asa.aip.org;
4. Institute of Noise Control Engineering – www.inceusa.org.

As a convenience, Canam is providing the following list of vendors who have worked with the Hambro product. This list is not an endorsement. Canam has no affiliation with these providers, and makes no representations concerning their abilities.

Sieben Associates, Inc.
625 NW 60th Street, Suite C
Gainesville, FL
32607
United States

Acousti-Lab
Robert Ducharme
C.P. 5028
Ste-Anne-des-Plaines, QC
J0N 1H0
Canada

Octave Acoustique, Inc.
Christian Martel, M. Sc. Arch.
963, chemin Royal
Saint-Laurent-de-l'île-d'Orléans, QC
G0A 4N0
Canada

Acousti-Tech
Vincent Moreau
150, rue Léon-Vachon
Saint-Lambert-de-Lauzon, QC
G0S 2N0
Canada

SELECTION TABLES

D500 JOIST SPAN TABLES

The joist span tables are provided to assist engineers in selecting the most optimal depth of joist for a particular slab thickness and a specific loading. The engineer must specify the joist depth, slab thickness, the design loads, special point loads and linear loads where applicable. Canam will provide composite joists designed to meet these requirements.

The following load tables are guidelines and give the optimized depth for specific spans, slab thickness and loads. The optimal situation is represented by the value 1.00 in the tables. Values greater than 1.00 represent the additional weight percentage at the optimum value. The first depth recorded per table indicates the minimum that could be used for the length specified.

Other types of loading and slab thickness than the ones shown in this section can be used for the Hambro D500 system. If the criteria for your project are different from those contained in the tables, please contact a Canam representative for assistance.

Note:

The validation of the optimal depth must be done in conjunction with the validation of the concrete slab capacity.

Joist spacing and concrete strength table

Values indicated are calculated with a regular spacing of 4 ft.-1¼ in. (1,251 mm) and a concrete strength of 3 ksi (20 MPa).

Loads

Live load

The tables have been prepared for four categories of loading depending on the usage of the floor:

Use	Uniform load	or	Point load
Residential	40 psf (1.92 kPa)		1.01 kip (4.5 kN)
Office	50 psf (2.4 kPa)		2.02 kip (9 kN)
Corridor/lobby	100 psf (4.8 kPa)		1.01 kip (4.5 kN) or 2.02 kip (9 kN)
Garage	50 psf (2.4 kPa)		4.05 kip (18 kN)

Dead load

The tables have been prepared for different slab thicknesses, therefore different dead loads:

Slab thickness	Dead load
3 in. (76 mm)	65 psf (3.11 kPa)
3½ in. (89 mm)	71 psf (3.40 kPa)
4 in. (102 mm)	78 psf (3.73 kPa)
4½ in. (114 mm)	83 psf (3.97 kPa)
5 in. (127 mm)	89 psf (4.26 kPa)
5½ in. (140 mm)	95 psf (4.55 kPa)

Deflection criteria

For all cases presented in the tables, deflection for live load does not exceed $L/360$.

Vibration criteria

Maximum peak acceleration in full height partition: 0.5% a/g
Damping ratio beta: 5%

Joist designation

D500 joists are designated HXX (HXXX) on drawings. For example, H14 (H350) means that the joist is 14 in. (350 mm) depth. The depth of a joist is measured from the underside of the slab to the extremity of the bottom chord.

Example

Find the optimal depth and the minimum depth for the following office project with Hambro D500 joists (H series).

	Imperial	Metric
Span	32 ft.-0 in.	(9,755 mm)
Slab thickness	4 in.	(100 mm)
Joists spacing	4 ft.-1¼ in.	(1,251 mm)
Concrete strength	3 ksi	(20 MPa)
Concrete density	145 pcf	(2,400 kg/m^3)
Live load	50 psf	(2.4 kPa)
Dead load	78 psf	(3.73 kPa)
- Joist	3.15 psf	(0.15 kN/m^2)
- Concrete	49 psf	(2.35 kN/m^2)
- Mechanical	2.5 psf	(0.12 kN/m^2)
- Ceiling	3.15 psf	(0.15 kN/m^2)
- Partition	20 psf	(0.96 kN/m^2)

Using this information, you can find in the tables that:

1. The optimal joist depth is: 20 in. (500 mm).
2. The minimum joist depth is: 14 in. (350 mm).

D500 span tables

1.xx Most optimal situation of the live load category
1.xx Most optimal depth according to slab thickness
End joist reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity

		Residential					Office					Corridor/lobby					Garage
Live loads		40 psf (1.92 kPa)					50 psf (2.4 kPa)					100 psf (4.8 kPa)					50 psf (2.4 kPa)
Slab thickness (in.)		3	3½	4	4½	5	3	3½	4	4½	5	3	3½	4	4½	5	5½
Slab thickness (mm)		75	90	100	115	125	75	90	100	115	125	75	90	100	115	125	140
Length (ft. / mm)	Depth (in. / mm)																
12 ft. / 3,660 mm	8 in. / 200 mm	1.06	1.06	1.06	1.06	1.08	1.05	1.05	1.05	1.08	1.08	1.05	1.05	1.08	1.10	1.10	1.09
	10 in. / 250 mm	1.09	1.11	1.11	1.11	1.11	1.08	1.12	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
	12 in. / 300 mm	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.07
	14 in. / 350 mm	1.00	1.00	1.02	1.02	1.02	1.00	1.00	1.02	1.02	1.02	1.00	1.00	1.02	1.02	1.02	1.00
	16 in. / 400 mm	1.04	1.04	1.04	1.04	1.08	1.04	1.04	1.04	1.04	1.09	1.04	1.04	1.04	1.04	1.04	1.03
	18 in. / 450 mm	1.12	1.12	1.12	1.18	1.18	1.13	1.13	1.13	1.19	1.19	1.13	1.13	1.13	1.19	1.19	1.15
	20 in. / 500 mm	1.15	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.25
14 ft. / 4,270 mm	8 in. / 200 mm	1.02	1.04	1.04	1.04	1.04	1.05	1.05	1.06	1.06	1.06	1.04	1.04	1.04	1.11	1.11	1.05
	10 in. / 250 mm	1.07	1.07	1.07	1.07	1.07	1.10	1.10	1.10	1.10	1.10	1.07	1.10	1.10	1.14	1.14	1.14
	12 in. / 300 mm	1.03	1.03	1.03	1.09	1.09	1.02	1.02	1.02	1.02	1.08	1.00	1.06	1.06	1.06	1.06	1.08
	14 in. / 350 mm	1.00	1.00	1.03	1.03	1.03	1.00	1.00	1.00	1.04	1.04	1.01	1.01	1.01	1.01	1.01	1.00
	16 in. / 400 mm	1.06	1.06	1.06	1.06	1.08	1.06	1.06	1.06	1.06	1.06	1.04	1.04	1.04	1.06	1.06	1.05
	18 in. / 450 mm	1.14	1.14	1.17	1.17	1.17	1.15	1.15	1.18	1.18	1.18	1.15	1.15	1.15	1.15	1.15	1.19
	20 in. / 500 mm	1.20	1.20	1.20	1.20	1.20	1.21	1.21	1.21	1.21	1.21	1.19	1.19	1.24	1.24	1.24	1.23
16 ft. / 4,880 mm	8 in. / 200 mm	1.04	1.00	1.03	1.03	1.03	1.03	1.01	1.01	1.01	1.08	1.08	1.08	1.08	1.07	1.07	1.09
	10 in. / 250 mm	1.03	1.03	1.06	1.06	1.08	1.04	1.04	1.08	1.08	1.12	1.08	1.07	1.10	1.10	1.10	1.10
	12 in. / 300 mm	1.02	1.02	1.02	1.02	1.02	1.02	1.04	1.04	1.04	1.04	1.02	1.05	1.05	1.05	1.05	1.04
	14 in. / 350 mm	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.03	1.03	1.03	1.00	1.00	1.00	1.00	1.03	1.00
	16 in. / 400 mm	1.03	1.03	1.03	1.03	1.06	1.06	1.06	1.06	1.06	1.06	1.03	1.06	1.06	1.06	1.06	1.06
	18 in. / 450 mm	1.10	1.10	1.10	1.14	1.14	1.13	1.13	1.13	1.13	1.13	1.15	1.15	1.15	1.18	1.18	1.17
	20 in. / 500 mm	1.13	1.17	1.17	1.21	1.21	1.17	1.17	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.24
18 ft. / 5,490 mm	8 in. / 200 mm	1.16	1.00	1.03	1.04	1.06	1.15	1.00	1.06	1.06	1.08	1.19	1.07	1.09	1.15	1.16	1.12
	10 in. / 250 mm	1.03	1.04	1.04	1.04	1.04	1.03	1.03	1.06	1.06	1.06	1.06	1.03	1.03	1.07	1.08	1.08
	12 in. / 300 mm	1.03	1.03	1.03	1.06	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.05
	14 in. / 350 mm	1.01	1.01	1.01	1.03	1.03	1.02	1.02	1.02	1.02	1.02	1.00	1.00	1.00	1.00	1.00	1.00
	16 in. / 400 mm	1.03	1.05	1.05	1.06	1.06	1.05	1.05	1.05	1.05	1.08	1.03	1.03	1.03	1.03	1.03	1.05
	18 in. / 450 mm	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.15	1.15	1.16	1.11	1.11	1.14	1.14	1.14	1.12
	20 in. / 500 mm	1.16	1.16	1.16	1.16	1.16	1.19	1.20	1.20	1.20	1.20	1.18	1.18	1.18	1.18	1.20	1.22
20 ft. / 6,100 mm	8 in. / 200 mm	1.50	1.19	1.14	1.16	1.21	1.45	1.19	1.17	1.19	1.21	1.25	1.23	1.24	1.28	1.31	1.30
	10 in. / 250 mm	1.25	1.06	1.07	1.13	1.15	1.25	1.06	1.08	1.11	1.13	1.16	1.12	1.17	1.16	1.18	1.10
	12 in. / 300 mm	1.12	1.04	1.04	1.04	1.04	1.10	1.04	1.04	1.08	1.08	1.10	1.10	1.12	1.06	1.12	1.05
	14 in. / 350 mm	1.00	1.04	1.04	1.04	1.04	1.00	1.00	1.00	1.00	1.03	1.03	1.03	1.03	1.03	1.05	1.00
	16 in. / 400 mm	1.06	1.06	1.06	1.06	1.06	1.03	1.03	1.05	1.09	1.09	1.00	1.05	1.05	1.05	1.07	1.01
	18 in. / 450 mm	1.13	1.13	1.13	1.17	1.17	1.13	1.17	1.17	1.17	1.20	1.10	1.12	1.14	1.14	1.14	1.15
	20 in. / 500 mm	1.16	1.20	1.25	1.25	1.25	1.21	1.21	1.21	1.24	1.24	1.15	1.18	1.18	1.18	1.24	1.21

D500 span tables

1.xx Most optimal situation of the live load category
1.xx Most optimal depth according to slab thickness
End joist reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity

		Residential					Office					Corridor/lobby					Garage
Live loads		40 psf (1.92 kPa)					50 psf (2.4 kPa)					100 psf (4.8 kPa)					50 psf (2.4 kPa)
Slab thickness (in.)		3	3½	4	4½	5	3	3½	4	4½	5	3	3½	4	4½	5	5½
Slab thickness (mm)		75	90	100	115	125	75	90	100	115	125	75	90	100	115	125	140
Length (ft. / mm)	Depth (in. / mm)																
22 ft. / 6,710 mm	10 in. / 250 mm	1.50	1.27	1.18	1.20	1.23	1.47	1.22	1.18	1.20	1.27	1.30	1.20	1.22	1.22	1.22	1.20
	12 in. / 300 mm	1.26	1.07	1.07	1.07	1.16	1.22	1.04	1.11	1.12	1.14	1.07	1.09	1.11	1.13	1.13	1.07
	14 in. / 350 mm	1.09	1.00	1.00	1.00	1.04	1.06	1.00	1.06	1.06	1.08	1.00	1.01	1.01	1.01	1.05	1.04
	16 in. / 400 mm	1.03	1.03	1.05	1.09	1.09	1.02	1.06	1.06	1.09	1.09	1.01	1.01	1.01	1.01	1.01	1.00
	18 in. / 450 mm	1.09	1.17	1.17	1.17	1.17	1.13	1.13	1.16	1.16	1.16	1.05	1.05	1.10	1.10	1.10	1.10
	20 in. / 500 mm	1.20	1.20	1.20	1.23	1.23	1.17	1.20	1.20	1.23	1.25	1.11	1.11	1.14	1.16	1.16	1.13
	22 in. / 550 mm	1.25	1.25	1.28	1.31	1.33	1.24	1.27	1.29	1.29	1.29	1.20	1.20	1.20	1.20	1.20	1.21
24 ft. / 7,315 mm	10 in. / 250 mm	1.63	1.33	1.23	1.33	1.38	1.55	1.25	1.24	1.32	1.32	1.42	1.24	1.30	1.37	1.37	1.22
	12 in. / 300 mm	1.34	1.18	1.13	1.19	1.21	1.31	1.13	1.14	1.16	1.18	1.18	1.12	1.14	1.16	1.22	1.16
	14 in. / 350 mm	1.13	1.00	1.09	1.10	1.10	1.12	1.03	1.05	1.07	1.07	1.02	1.02	1.04	1.05	1.07	1.00
	16 in. / 400 mm	1.08	1.06	1.06	1.07	1.09	1.05	1.00	1.03	1.04	1.08	1.00	1.00	1.02	1.05	1.12	1.06
	18 in. / 450 mm	1.13	1.10	1.13	1.13	1.15	1.06	1.06	1.09	1.10	1.13	1.11	1.13	1.13	1.15	1.15	1.09
	20 in. / 500 mm	1.13	1.16	1.19	1.20	1.20	1.12	1.14	1.14	1.16	1.16	1.12	1.14	1.14	1.14	1.17	1.08
	22 in. / 550 mm	1.20	1.25	1.25	1.25	1.25	1.17	1.17	1.17	1.20	1.27	1.13	1.16	1.19	1.19	1.24	1.20
26 ft. / 7,925 mm	12 in. / 300 mm	1.39	1.19	1.13	1.13	1.23	1.36	1.16	1.14	1.15	1.24	1.22	1.13	1.15	1.16	1.23	1.16
	14 in. / 350 mm	1.21	1.04	1.06	1.07	1.10	1.18	1.04	1.06	1.07	1.13	1.00	1.03	1.08	1.11	1.12	1.06
	16 in. / 400 mm	1.10	1.00	1.04	1.06	1.08	1.08	1.00	1.06	1.09	1.09	1.02	1.03	1.04	1.06	1.06	1.00
	18 in. / 450 mm	1.07	1.02	1.07	1.09	1.11	1.06	1.05	1.08	1.09	1.10	1.02	1.05	1.05	1.08	1.10	1.03
	20 in. / 500 mm	1.05	1.08	1.08	1.11	1.13	1.06	1.08	1.08	1.08	1.16	1.05	1.07	1.07	1.11	1.12	1.04
	22 in. / 550 mm	1.12	1.12	1.15	1.15	1.21	1.12	1.12	1.18	1.21	1.24	1.15	1.15	1.15	1.15	1.15	1.08
	24 in. / 600 mm	1.16	1.16	1.26	1.29	1.29	1.22	1.26	1.26	1.28	1.28	1.15	1.15	1.15	1.17	1.17	1.12
28 ft. / 8,535 mm	12 in. / 300 mm	1.47	1.17	1.18	1.23		1.39	1.11	1.16	1.21		1.25	1.16	1.21	1.23		
	14 in. / 350 mm	1.24	1.02	1.07	1.08	1.18	1.18	1.00	1.08	1.09	1.16	1.08	1.06	1.07	1.09	1.14	1.05
	16 in. / 400 mm	1.12	1.00	1.04	1.09	1.10	1.07	1.00	1.01	1.05	1.06	1.00	1.01	1.02	1.05	1.06	1.00
	18 in. / 450 mm	1.07	1.04	1.06	1.06	1.10	1.02	1.01	1.03	1.04	1.14	1.00	1.04	1.09	1.10	1.11	1.02
	20 in. / 500 mm	1.06	1.03	1.04	1.06	1.15	1.00	1.01	1.06	1.12	1.16	1.05	1.05	1.06	1.08	1.10	1.05
	22 in. / 550 mm	1.07	1.08	1.10	1.12	1.14	1.04	1.06	1.06	1.06	1.10	1.03	1.03	1.08	1.08	1.12	1.05
	24 in. / 600 mm	1.13	1.13	1.16	1.16	1.16	1.10	1.10	1.11	1.11	1.13	1.07	1.07	1.10	1.10	1.10	1.26
30 ft. / 9,145 mm	12 in. / 300 mm	1.58	1.18	1.22			1.49	1.16	1.19			1.28	1.25	1.27			
	14 in. / 350 mm	1.32	1.05	1.13	1.15	1.18	1.26	1.04	1.12	1.14	1.15	1.13	1.10	1.12	1.20	1.20	
	16 in. / 400 mm	1.16	1.03	1.05	1.06	1.13	1.11	1.00	1.03	1.04	1.17	1.02	1.05	1.10	1.11	1.16	1.03
	18 in. / 450 mm	1.09	1.04	1.06	1.10	1.15	1.03	1.01	1.05	1.13	1.13	1.09	1.09	1.10	1.12	1.14	1.06
	20 in. / 500 mm	1.03	1.01	1.07	1.08	1.11	1.02	1.04	1.05	1.07	1.10	1.00	1.04	1.06	1.09	1.11	1.02
	22 in. / 550 mm	1.00	1.04	1.07	1.08	1.10	1.00	1.03	1.04	1.05	1.09	1.05	1.05	1.08	1.09	1.09	1.00
	24 in. / 600 mm	1.05	1.08	1.08	1.09	1.15	1.02	1.04	1.07	1.12	1.15	1.07	1.10	1.10	1.11	1.15	1.06

D500 span tables

- 1.xx Most optimal situation of the live load category
- 1.xx Most optimal depth according to slab thickness
- End joist reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity

		Residential					Office					Corridor/lobby					Garage
Live loads		40 psf (1.92 kPa)					50 psf (2.4 kPa)					100 psf (4.8 kPa)					50 psf (2.4 kPa)
Slab thickness (in.)		3	3½	4	4½	5	3	3½	4	4½	5	3	3½	4	4½	5	5½
Slab thickness (mm)		75	90	100	115	125	75	90	100	115	125	75	90	100	115	125	140
Length (ft. / mm)	Depth (in. / mm)																
32 ft. / 9,755 mm	14 in. / 350 mm	1.32	1.12	1.13			1.27	1.09	1.14			1.09	1.13	1.17			
	16 in. / 400 mm	1.16	1.02	1.11	1.12	1.15	1.11	1.00	1.15	1.16	1.18	1.05	1.06	1.08	1.13	1.18	
	18 in. / 450 mm	1.09	1.00	1.05	1.08	1.17	1.05	1.01	1.04	1.09	1.14	1.00	1.04	1.06	1.07	1.13	1.05
	20 in. / 500 mm	1.02	1.04	1.04	1.09	1.10	1.00	1.02	1.02	1.04	1.10	1.00	1.01	1.02	1.08	1.08	1.00
	22 in. / 550 mm	1.01	1.04	1.04	1.09	1.14	1.01	1.03	1.06	1.09	1.12	1.01	1.03	1.03	1.06	1.08	1.05
	24 in. / 600 mm	1.03	1.03	1.06	1.14	1.15	1.01	1.06	1.12	1.15	1.16	1.04	1.04	1.06	1.07	1.08	1.09
34 ft. / 10,365 mm	14 in. / 350 mm	1.39	1.15				1.32	1.13				1.22	1.20				
	16 in. / 400 mm	1.20	1.10	1.12	1.17		1.14	1.08	1.13	1.14		1.06	1.14	1.15			
	18 in. / 450 mm	1.12	1.06	1.10	1.15	1.17	1.09	1.06	1.07	1.11	1.18	1.04	1.05	1.07	1.15		
	20 in. / 500 mm	1.07	1.03	1.08	1.09	1.16	1.02	1.00	1.07	1.11	1.16	1.01	1.01	1.06	1.11		1.00
	22 in. / 550 mm	1.01	1.04	1.07	1.14	1.15	1.00	1.05	1.08	1.14	1.15	1.03	1.04	1.04	1.06		1.02
	24 in. / 600 mm	1.00	1.12	1.17	1.18	1.19	1.08	1.10	1.10	1.15	1.18	1.00	1.07	1.10	1.08		1.01
36 ft. / 10,975 mm	16 in. / 400 mm	1.24	1.14				1.18	1.10				1.17	1.17				
	18 in. / 450 mm	1.15	1.11	1.15	1.17		1.07	1.09	1.12	1.17		1.05	1.06				
	20 in. / 500 mm	1.04	1.05	1.08	1.17	1.21	1.00	1.06	1.13	1.18	1.19	1.04	1.05				
	22 in. / 550 mm	1.00	1.06	1.14	1.16	1.24	1.07	1.08	1.09	1.13	1.19	1.00	1.01				1.00
	24 in. / 600 mm	1.07	1.11	1.16	1.18	1.21	1.04	1.07	1.10	1.13	1.17	1.03	1.07				1.01
38 ft. / 11,585 mm	16 in. / 400 mm	1.16					1.09					1.24					
	18 in. / 450 mm	1.07	1.08	1.10			1.00	1.06	1.15			1.06					
	20 in. / 500 mm	1.00	1.01	1.13	1.16		1.00	1.07	1.11	1.11		1.02					
	22 in. / 550 mm	1.03	1.08	1.12	1.17	1.17	1.02	1.03	1.08	1.14	1.16	1.00					
	24 in. / 600 mm	1.06	1.07	1.11	1.15	1.23	1.02	1.05	1.12	1.14	1.17	1.02					1.00
40 ft. / 12,190 mm	18 in. / 450 mm	1.07	1.07				1.05	1.11									
	20 in. / 500 mm	1.00	1.12	1.13			1.03	1.07	1.11								
	22 in. / 550 mm	1.05	1.09	1.13	1.15		1.02	1.04	1.12	1.16							
	24 in. / 600 mm	1.03	1.06	1.16	1.19	1.23	1.00	1.08	1.09	1.18	1.19						
43 ft. / 13,110 mm	20 in. / 500 mm	1.07					1.03										
	22 in. / 550 mm	1.01	1.08	1.10			1.00	1.08									
	24 in. / 600 mm	1.00	1.12	1.13	1.13		1.03	1.08	1.11	1.11							

D500 MINI-JOIST SPAN TABLES

The following tables show the maximum total length of the three types of D500 mini-joist, considering a spacing of 4 ft.-1¼ in. (1,251 mm) and the uniform loads presented. The minimum length for the D500 mini-joist is 4 ft. (1,220 mm).

Maximum total span for D500 mini-joist					
Slab thickness (in.)	**3**	**3½**	**4**	**4½**	**5**
Dead load (psf)	**65**	**71**	**78**	**83**	**89**
Live load (psf)	up to 50				
TC	4'-7''	4'-7''	4'-4''	4'-2''	4'-1''
RTC	6'-0''	6'-0''	6'-0''	6'-0''	6'-0''
SRTC	8'-8''	8'-8''	8'-8''	8'-8''	8'-8''
Live load (psf)	up to 100				
TC	4'-2''	4'-2''	4'-1''	4'-0''	N/A
RTC	6'-0''	6'-0''	6'-0''	6'-0''	6'-0''
SRTC	8'-8''	8'-8''	8'-8''	8'-8''	8'-8''

Maximum total span for D500 mini-joist					
Slab thickness (mm)	**75**	**90**	**100**	**115**	**125**
Dead load (kPa)	**3.1**	**3.4**	**3.7**	**4.0**	**4.3**
Live load (kPa)	up to 2.4				
TC	1,397	1,397	1,321	1,270	1,245
RTC	1,829	1,829	1,829	1,829	1,829
SRTC	2,642	2,642	2,642	2,642	2,642
Live load (kPa)	up to 4.8				
TC	1,270	1,270	1,245	1,220	N/A
RTC	1,829	1,829	1,829	1,829	1,829
SRTC	2,642	2,642	2,642	2,642	2,642

Notes:

The total spans indicated in these tables are considered to be out to out, meaning they take into account a joist seat of normally 4 in. (102 mm) long at each end, therefore the maximum clear span (without the joist seats) is 8 ft. (2,438 mm).

SLAB TABLES FOR D500 PRODUCT

Mesh size

The typical wire mesh used has a yield strength of 65,000 psi minimum. The typical sizes used are indicated in the following table:

Metric	Imperial	Diameter		Area	
		in.	mm	in.²/lin. ft.	mm²/lin. m
152 x 152 MW18.7 x MW18.7	6 x 6 W2.9 / W2.9 (6x6-6/6)	0.192	4.88	0.059	123
152 x 152 MW25.7 x MW25.7	6 x 6 W4 / W4 (6x6-4/4)	0.226	5.74	0.081	170

Slab capacity under uniform load

D500 - Slab capacity chart for uniform loading (total factored load in psf)*

f'_c = 3,000 psi, ρ = 145 pcf, F_y = 65,000 psi			Joist spacing					
Slab thickness	Chair	Mesh size[(1)] (6 in. x 6 in.)	2'-1¼"		4'-1¼"		5'-1¼"	
			Exterior	Interior	Exterior	Interior	Exterior	Interior
3 in.	N/A	W6 / W6	868	995	228	261	147	169
		W4 / W4	1,154	1,359	303	357	196	231
3½ in.	N/A	W4 / W4	1,236	1,359	324	357	210	231
4 in.	N/A	W4 / W4	1,236	1,359	324	357	210	231
		2 layers W6 / W6	1,939	2,133	509	560	329	362
		2 layers W4 / W4	2,598	2,598	697	767	451	496
4½ in.	N/A	2 layers W6 / W6	1,939	2,133	509	560	329	362
		2 layers W4 / W4	2,654	2,920	697	767	451	496
5½ in.	3 in.	2 layers W6 / W6[(2)]	2,602	2,862	684	752	442	486
		2 layers W4 / W4[(2)]	3,484	3,864	923	1,015	597	656

D500 - Slab capacity chart for uniform loading (total factored load in kPa)*

f'_c = 20 MPa, ρ = 2,400 kg/m³, F_y = 450 MPa			Joist spacing					
Slab thickness	Chair	Mesh size[(1)] (152 mm x 152 mm)	641 mm		1,251 mm		1,556 mm	
			Exterior	Interior	Exterior	Interior	Exterior	Interior
76 mm	N/A	MW18.7 x MW18.7	41	47	10	12	7	8
		MW25.7 x MW25.7	55	65	14	17	9	11
90 mm	N/A	MW25.7 x MW25.7	59	65	15	17	10	11
102 mm	N/A	MW25.7 x MW25.7	59	65	15	17	10	11
		2 layers MW18.7 x MW18.7	92	102	24	26	15	17
		2 layers MW25.7 x MW25.7	124	124	33	36	21	23
115 mm	N/A	2 layers MW18.7 x MW18.7	92	102	24	26	15	17
		2 layers MW25.7 x MW25.7	127	139	33	36	21	23
140 mm	76 mm	2 layers MW18.7 x MW18.7[(2)]	124	137	32	36	21	23
		2 layers MW25.7 x MW25.7[(2)]	166	185	44	48	28	31

* Total factored load is taken as 1.25D + 1.5L
Where D = dead load
L = live load
(1) Mesh size is only a recommendation. A Canam engineer will determine the mesh size.
(2) One layer of wire mesh on top chord and one layer on high chair.

Slab capacity under concentrated load

D500 - Slab capacity chart for unfactored dead load (psf) with concentrated live load

f'_c = 3,000 psi, ρ = 145 pcf, Fy = 65,000 psi

	Concentrated load	Slab thickness	Mesh size[1] (6 in. x 6 in.)	Joist spacing					
				2'-1¼"		4'-1¼"		5'-1¼"	
				Exterior	Interior	Exterior	Interior	Exterior	Interior
f'_c = 3,000 psi	Classroom/Residential 1 kip on 30 in. x 30 in.	3 in.	W6 / W6	412	559	-	127	-	-
			W4 / W4	650	650	109	192	-	119
		3½ in.	W4 / W4	782	782	180	193	110	120
		4 in.	W4 / W4	783	812	181	194	111	120
			2 layers W6 / W6	912	912	320	332	200	210
			2 layers W4 / W4	912	912	460	463	291	300
		4½ in.	2 layers W6 / W6	1,039	1,039	321	333	201	210
			2 layers W4 / W4	1,039	1,039	461	473	295	301
	Office 2 kip on 30 in. x 30 in.	3½ in.	W4 / W4	636	643	-	143	-	-
		4 in.	W4 / W4	642	699	120	145	-	83
			2 layers W6 / W6	778	778	258	283	154	173
			2 layers W4 / W4	778	778	391	391	245	264
		4½ in.	2 layers W6 / W6	911	911	260	285	156	174
			2 layers W4 / W4	911	911	401	425	247	265
f'_c = 5,075 psi	Garage 4 kip on 4¾ in. x 4¾ in.	5½ in. + 3 in. High chair	2 layers W6 / W6[2]	555	628	-	-	-	-
			2 layers W4 / W4[2]	628	628	131	278	-	216

D500 - Slab capacity chart for unfactored dead load (kPa) with concentrated live load

f'_c = 20 MPa, ρ = 2,400 kg/m³, F_y = 450 MPa

	Concentrated load	Slab thickness	Mesh size[1] (152 mm x 152 mm)	Joist spacing					
				641 mm		1,251 mm		1,556 mm	
				Exterior	Interior	Exterior	Interior	Exterior	Interior
f'_c = 20 MPa	Classroom/Residential 4.5 kN on 750 mm x 750 mm	76 mm	MW18.7 x MW18.7	19	26	-	6	-	-
			MW25.7 x MW25.7	31	31	5	9	-	5
		90 mm	MW25.7 x MW25.7	37	37	8	9	5	5
		102 mm	MW25.7 x MW25.7	37	38	8	9	5	5
			2 layers MW18.7 x MW18.7	43	43	15	15	9	10
			2 layers MW25.7 x MW25.7	43	43	22	22	13	14
		115 mm	2 layers MW18.7 x MW18.7	49	49	15	15	9	10
			2 layers MW25.7 x MW25.7	49	49	22	22	14	14
	Office 9 kN on 750 mm x 750 mm	90 mm	MW25.7 x MW25.7	30	30	-	6	-	-
		102 mm	MW25.7 x MW25.7	30	33	5	6	-	4
			2 layers MW18.7 x MW18.7	37	37	12	13	7	8
			2 layers MW25.7 x MW25.7	37	37	18	18	11	12
		115 mm	2 layers MW18.7 x MW18.7	43	43	12	13	7	8
			2 layers MW25.7 x MW25.7	43	43	19	20	11	12
f'_c = 35 MPa	Garage 18 kN on 120 mm x 120 mm	140 mm + 76 mm High chair	2 layers MW18.7 x MW18.7[2]	26	30	-	-	-	-
			2 layers MW25.7 x MW25.7[2]	30	30	6	13	-	10

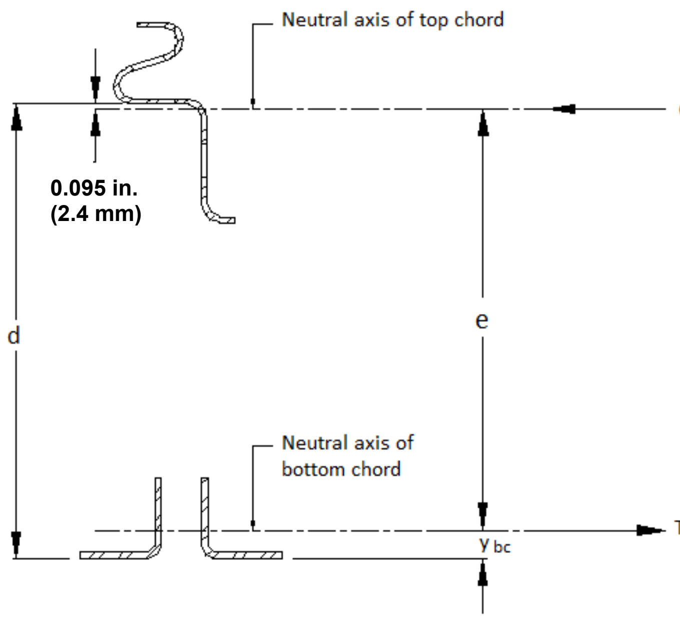
Note:
Needs to be used in conjuncture with uniform load table.

(1) Mesh size is only a recommendation. A Canam engineer will determine the mesh size.
(2) One layer of wire mesh on top chord and one layer on high chair.

DESIGN PRINCIPLES

NON-COMPOSITE DESIGN

During the formwork installation and pouring process, Hambro joists are considered non-composite. At this stage, the top chord capacity controls the design of the joist.



D500 non-composite neutral axis

Load distribution

At this stage, joist members behave in distinct ways:

1. The bottom chord, composed of two angles back-to-back, acts as a tension member.
2. The web, made of bent steel rods, acts as tension and compression member.
3. The “S” top chord, acts as a compression member.

Non-composite loads

1. Non-composite dead load
   The dead loads considered at the non-composite stage are from the concrete, formwork and joist self-weight.

Concrete:	*slab thickness x concrete density*
Example for a 3 in. (76 mm) slab:	$\left(\frac{3\text{ in.}}{12}\right)$ *x* 145 *lb./ft.*^{3} = 36.25 *psf* (0.076 *m x* 22.78 *kN/m*^{3} = 1.73 *kN/m*^{2})
Formwork and joist:	5 *psf* (0.24 *kN/m*^{2})
Total factored dead load:	1.25 *x* (*concrete* + *formwork* + *joist*)
Example:	1.25 *x* (36.25 + 5) = 51.6 *psf* (1.25 x (1.73 + 0.24) = 2.46 *kN/m*^{2})

2. Non-composite live load

Construction live load:	20 *psf* (0.96 *kN/m*^{2})
Total factored live load:	1.5 *x* (*construction live load*)
Example:	1.5 *x* 20 *psf* = 30 *psf* (1.5 *x* 0.96 $\frac{\text{kN}}{\text{m}^2}$ = 1.44 $\frac{\text{kN}}{\text{m}^2}$)

3. Total factored load

Example:	51.6 + 30 = 81.60 *psf* (2.46 + 1.44 = 3.90 *kN/m*^{2})

Factored moment resistance

$M_{r\,nc} = C_r e \text{ or } T_r e \quad i.e.$

$\frac{W_{nc}L^2}{8} = C_r e \text{ or } T_r e \text{ whichever the lesser}$

Where:

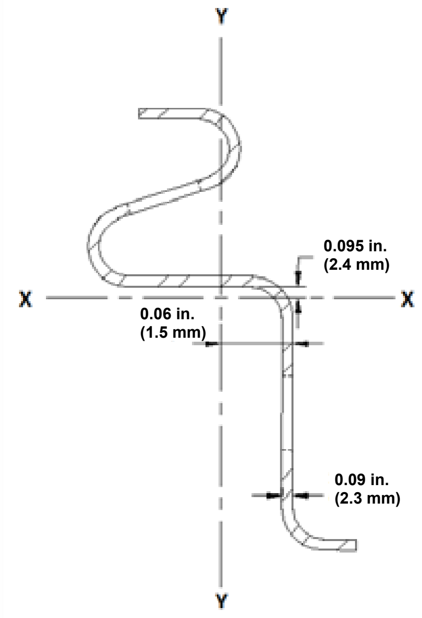
$$
\begin{aligned}
W_{nc} &= \frac{81.60\ psf\ (3.90\ kN)}{ft.^2\ (m^2)}\ x\ joist\ spacing\ (plf\ or\ kN/m) \\
L &= joist\ length\ (ft.\ or\ m) \\
C_r &= area\ of\ top\ chord\ x\ factored\ compressive\ resistance\ (kip\ or\ kN) \\
T_r &= area\ of\ bottom\ chord\ x\ factored\ tensile\ resistance\ (kip\ or\ kN) \\
e &= effective\ lever\ arm\ at\ non-composite\ stage \\
&= (d - 0.095\ in.\ (2.4\ mm) - y_{bc})\ (in.\ or\ mm) \\
d &= depth\ of\ joist\ (in.\ or\ mm) \\
y_{bc} &= neutral\ axis\ of\ bottom\ chord\ (in.\ or\ mm)
\end{aligned}
$$

From the above formula, the maximum limiting span for unreinforced top chord may be computed for the non-composite stage. For spans beyond this value, the top chord must be strengthened. Strengthening of the top chord, when required, is usually accomplished by installing one or two rods in the curvatures of the "S" part of the top chord.

As for the bottom chord, it is sized for the total factored load which is more critical than the construction load; the design method is explained in the Composite design section.

Top chord properties

The information below presents the Hambro D500 top chord properties.



D500 top chord geometry

$$
\begin{aligned}
t &= 0.09\ in.\ (2.3\ mm) \\
A_{gross} &= 0.618\ in.^2\ (398.71\ mm^2) \\
A_{net} &= 0.506\ in.^2\ (326.45\ mm^2) \\
A_{effective} &= 0.487\ in.^2\ (314.19\ mm^2) \\
I_{x\ gross} &= 0.744\ in.^4\ (3.097\ x\ 10^5\ mm^4) \\
I_{y\ gross} &= 0.217\ in.^4\ (9.032\ x\ 10^4\ mm^4) \\
I_{x\ net} &= 0.650\ in.^4\ (2.706\ x\ 10^5\ mm^4) \\
I_{y\ net} &= 0.185\ in.^4\ (7.700\ x\ 10^4\ mm^4) \\
F_{y\ top\ chord} &= 65\ ksi\ (450\ MPa)
\end{aligned}
$$

COMPOSITE DESIGN

Joist composite design

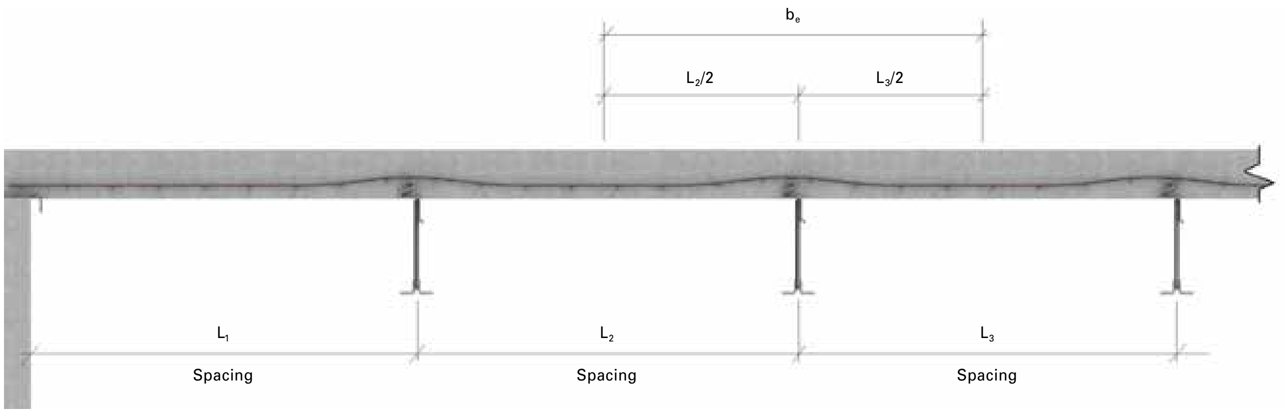
For the design of the composite action, the effective width of concrete slab for an interior joist is taken as the minimum between:

$$b_e = min.\left({}^{L}/_{4};\ \frac{(L_2+L_3)}{2}\right)$$

Where:

L = *span of joist*

L_2 *and* L_3 = *spacings adjacent to the joist*



Effective width of interior D500 joists

The effective width of concrete slab for a perimeter joist:

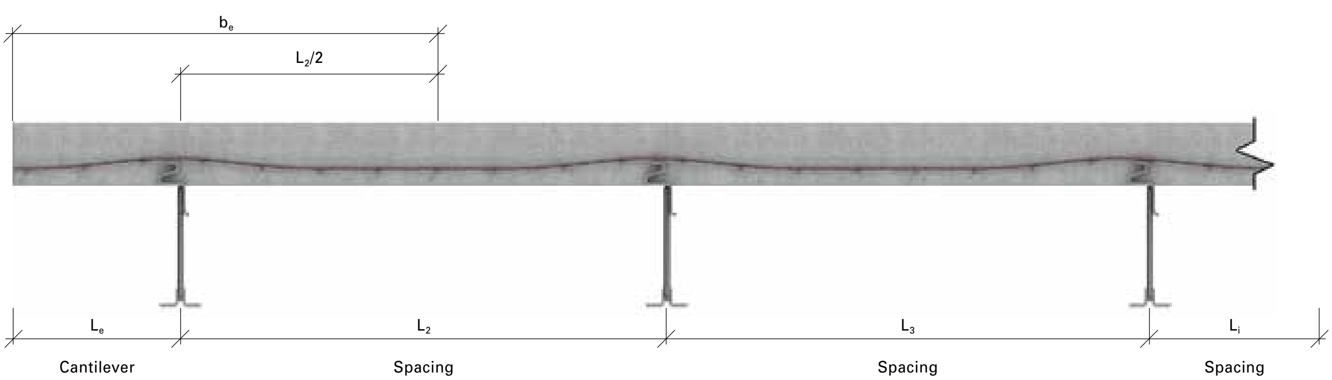
$$b_e = L_e + min.\ (\ L/10;\ L_2/2)$$

Where:

L = *span of joist*

L_e = *length of cantilever*

L_2 = *first interior spacing*



Effective width of D500 perimeter joists

Flexure design

The flexure design is calculated with the ultimate strength approach which is based on the actual failure strengths of the component materials. This method is initially used for composite beam or joist with stud connectors, and is applicable to the Hambro D500 joist as well.

Load capacity calculations involve the equilibrium of internal factored forces $C'_r = T_r$. In order to use this method, some assumptions need to be made:

1. The plastic neutral axis is strictly in the slab so that the whole steel section of the system works in tension.
2. The wire mesh reinforcement in the slab has been neglected in compression.
3. $\alpha_1 = 0.85$ since $f'_c \leq 4.35\ ksi\ (30\ MPa)$[1].
4. Composite action is considered at 100%.

The simplified concrete stress block is used to find the ultimate tension. According to CAN/CSA-S16, clause 17.9.3 and CAN/CSA A23.3, clause 10.1.7, the factored resisting moment of the composite section is given by:

$$M_{rc} = \varnothing_s A_b F_y e' = T_r e'$$

Where :

e' $= lever\ arm\ at\ composite\ stage = d + slab\ thickness - a/2 - y_{bc},\ in.\ (mm)$

d $= joist\ depth,\ in.\ (mm)$

y_{bc} $= neutral\ axis\ of\ bottom\ chord,\ in.\ (mm)$

a $= depth\ of\ compression\ block = \dfrac{\varnothing_s A_b F_y}{\alpha_1 \varnothing_c f_c' b_e},\ in.\ (mm)$

$\varnothing_s = 0.9$

A_b $= area\ of\ bottom\ chord,\ in.^2\ (mm^2)$

F_y $= yield\ stress\ of\ steel,\ ksi\ (MPa)$

$\alpha_1 = 0.85$

$\varnothing_c = 0.65$

f_c' $= concrete\ compressive\ strength,\ ksi\ (MPa)$

b_e $= effective\ width\ of\ concrete,\ in.\ (mm)$

The factored resisting moment can then be compared to the factored moment:

$$M_f = \frac{W_f L^2}{8}$$

Where:

W_f $= total\ \ factored\ uniform\ load,\ plf\ (kN/m)$

L $= span\ of\ joist,\ ft.\ (m)$

[1] Denis BEAULIEU and André PICARD. Calcul des charpentes d'acier : Tome II, Chapitre IX – Poutres mixtes. Markham, Ontario, Institut canadien de la construction en acier (ICCA), 2010. (French only)

Web design

Vertical shear

The web of the steel joist is designed according to CAN/CSA-S16, clause 17.3.2, requires the web system to be proportioned to carry the total vertical shear V_f.

According to clause 16.5.1, the loading applied to the joist is as follows:

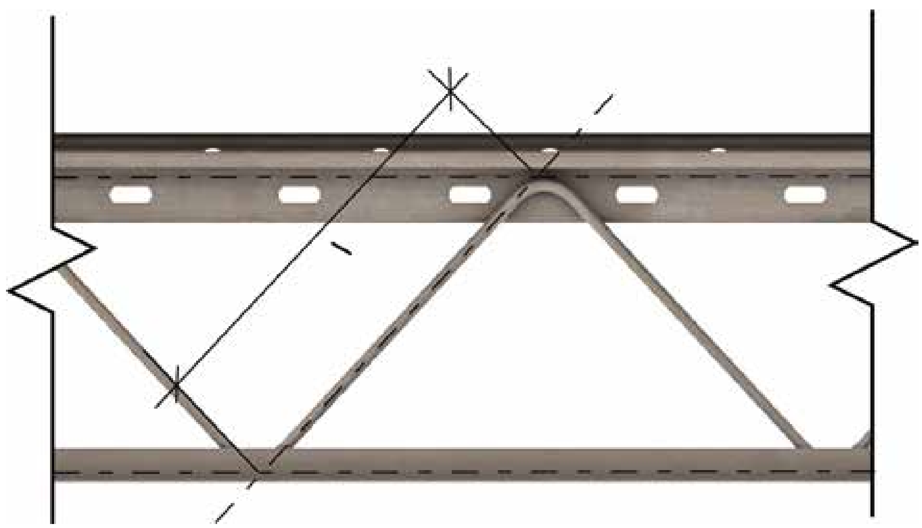
1. The total factored dead and live loads specified by the building designer.
2. The total dead load and an unbalanced load of 100% of the live load on any continuous portion of the joist and 0% of the live load on the remainder to produce the most critical effect on any component.
3. Factored dead load plus the appropriate factored concentrated load from the NBCC applied at any panel point to produce the most critical effect on any web members.

The above loadings do not need to be applied simultaneously.

Tension and compression diagonal

The web members are sized for the specified loading including concentrated loads where applicable.

The effective length of web member Kl is taken from the top chord neutral axis to the bottom chord neutral axis.



Length "l" of D500 web member

For webs in tension, the slenderness ratio is not limited (clause 16.5.8.5), they are dimensioned using clause 13.2; generally this formula controls:

$$T_r = \varnothing A_g F_y$$

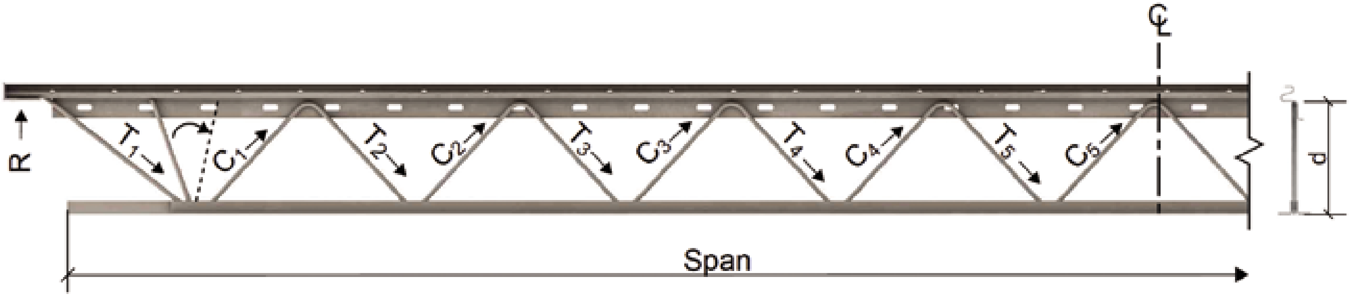
For webs in compression, the slenderness ratio shall not exceed 200 (clause 16.5.8.6); they are dimensioned using clause 13.3. Rods are used, therefore this equation applies:

$$C_r = \varnothing A_g F_y (1+\lambda^{2n})^{-1/n}$$

Where:

$$\lambda = \sqrt{\frac{F_y}{F_e}}$$

$$F_e = \frac{\pi^2 E}{\left(\frac{K l}{r}\right)^2}, \ ksi\ (MPa)$$

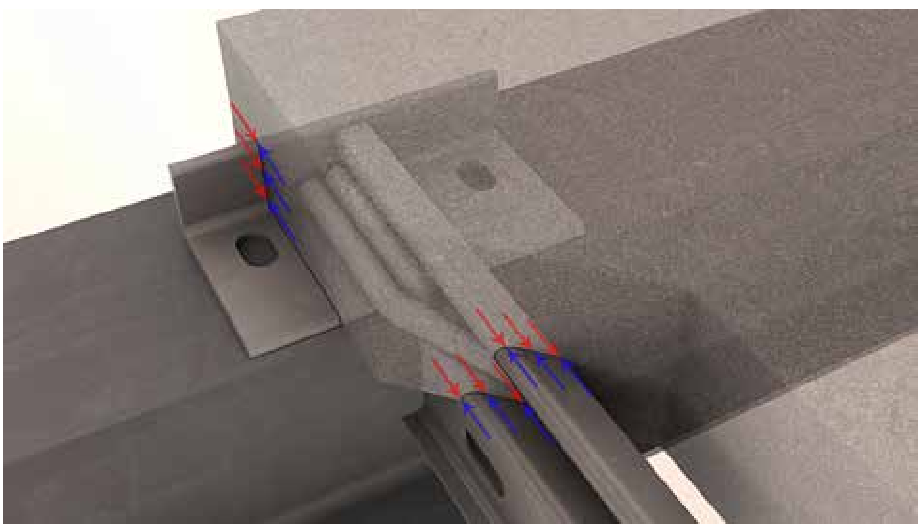


Efforts in D500 web members

Interface shear

The Hambro joist comprises a composite concrete slab-steel joist system with composite action achieved by the shear connection developed by two mechanisms:

1. Horizontal bearing forces
   The bearing shoe of the joist consists of angles that are embedded in the concrete. They act as an anchorage for the first diagonal member producing a horizontal bearing force when the joist is loaded.
2. Steel/concrete interface
   Once embedded in the slab, the top chord bonds with the concrete in order to provide a shear-friction resistance. There are also holes in the “S” part of the top chord, which help reinforce the bond between the steel/concrete interface.



D500 horizontal bearing force and friction at the steel/concrete interface

Shear resistance of the steel/concrete interface can be evaluated by either elastic or ultimate strength procedures; both methods have shown good correlation with the test results. The interface shear force resulting from superimposed loads on the composite joist may be calculated, using the “elastic approach” by the equation:

$$q = VQ/I_c$$

Where :

q = *horizontal shear flow, lb./in. (N/mm)*

V = *vertical shear force due to superimposed loads, lb. (N)*

I_c = *moment of inertia of the composite joist, in.^{4} (mm^4)*

Q = *statical moment of the effective concrete in compression (hatched area) about the elastic neutral axis of the composite section, in.^{3} (mm^3)*

$= (by/n)\,(Y_c - y/2)$ *and* $y = y_c \leq t$

b_e = *effective concrete width, in. (mm)*

n = *modular ratio*

$= E_s/E_c = 9.4$ (*for* $f'_c = 3$ ksi (20 *MPa*))

t = *slab thickness, in. (mm)*

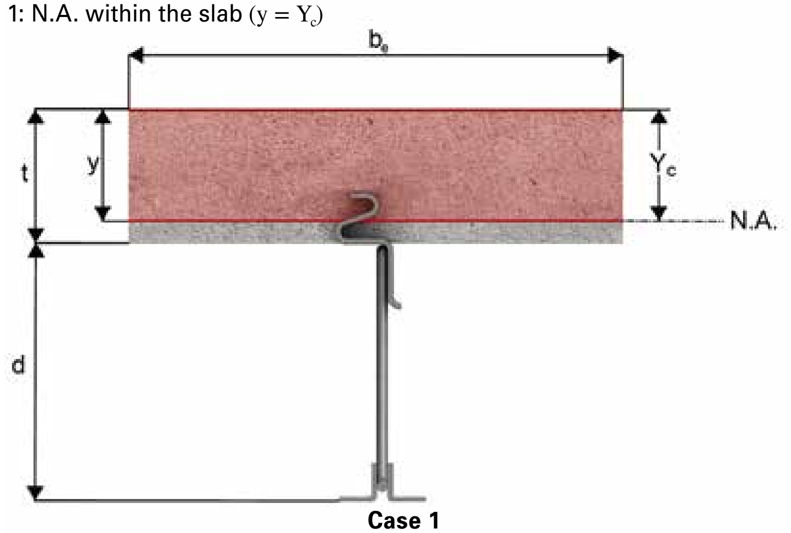
Y_c = *depth of neutral axis from top of concrete slab, in. (mm)*

y = *neutral axis of composite joist, in. (mm)*

$= Y_c \rightarrow$ *when elastic neutral axis lies within slab*

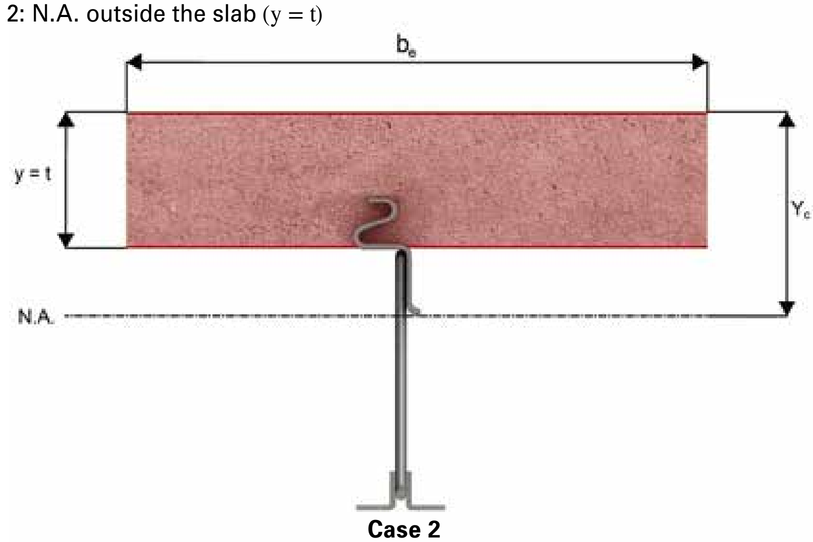
$= t \rightarrow$ *when elastic neutral axis lies outside slab*

Case 1: N.A. within the slab ($y = Y_c$)



Case 1

Case 2: N.A. outside the slab ($y = t$)



Case 2

The most recent full testing programs have consistently established a failure value for the horizontal bearing forces and the friction between steel and concrete. An additional contributing factor is a hole in the section at each 7 in. (178 mm) on the length.

1. Horizontal bearing forces
   The test has defined an ultimate value for the end bearing shoe equal to 50 kip (222 kN) for a concrete strength of 3 ksi (20 MPa).
2. Friction between concrete and top chord
   The failure value for the interface shear is 255 lb./in. (44.7 N/mm).

Slab design

Note: The calculations attached to slab design are metric only.

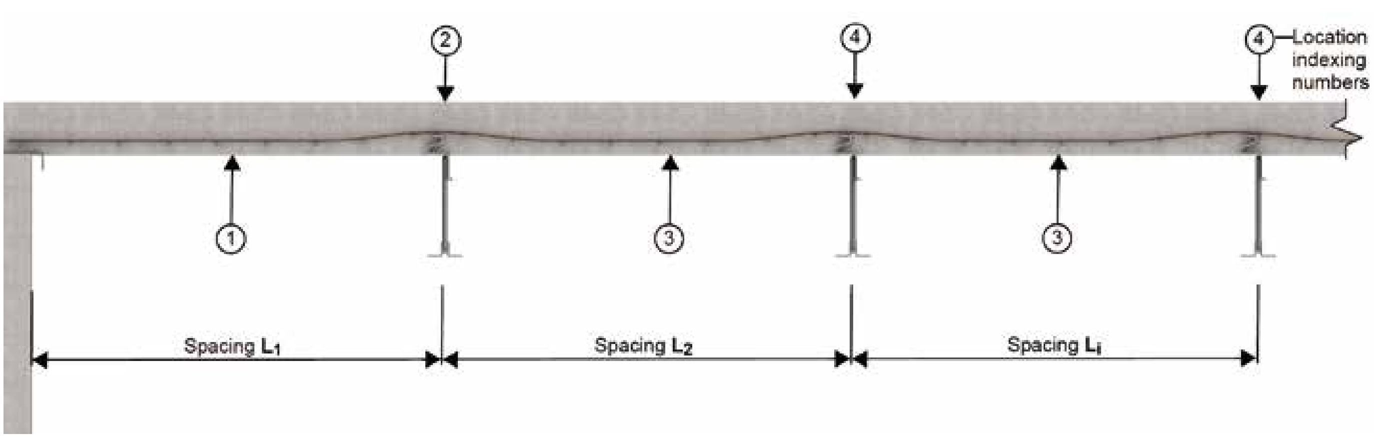
The slab component of the D500 Hambro composite floor system behaves as a one-way slab carrying loads transversely to the joists. The slab design is based on CAN/CSA-A23.3, Design of Concrete Structures. This standard stipulates that in order to provide adequate safety level, the factored effects shall be less than the factored resistance.

Uniform load – load distribution

Continuous span
The standard CAN/CSA-A23.3, clause 9.2.3.1, requires that factored dead load to act simultaneously with the factored live load apply on:

- Adjacent spans (maximum negative moment at support); or
- Alternate spans (maximum positive moment at mid-span).

If criteria (a) to (e) of clause 9.3.3 are satisfied, the following approximate value may be used in the design of one-way slabs. Refer to figure below for location of moments and shear efforts.



D500 continuous span slab design

1. Positive moment
   Exterior span (location 1): $M_f = W_f L_1^2/11$
   Interior span (location 3): $M_f = W_f L_i^2/16$
2. Negative moment
   First interior support (location 2): $M_f = W_f L_a^2/10$
   Other interior support (location 4): $M_f = W_f L_a^2/11$

Shear
   Face of first interior support (location 2): $V_f = 1.15\ W_f L_1/2$
   Other interior support (location 4): $V_f = W_f L_i/2$

Where :

W_f = *total factored design load* (kN/m)
L_1 = *first span exterior span* (m)
L_i = *interior spans → joists spacing* (m)
L_a = *average of two adjacent spans* (m)

Single span
However, if at least one of the criteria of CAN/CSA-A23.3, clause 9.3.3, is not met, the slab must be considered as simply supported and the distribution of forces will be as follow (refer to the figure on page 32 for location of moment and shear):

1. Positive moment
   All spans (locations 1 and 3): $M_f = W_f L_i^2/8$
2. Shear
   All supports: $V_f = W_f L_i/2$

<u>Concentrated load – load distribution</u>

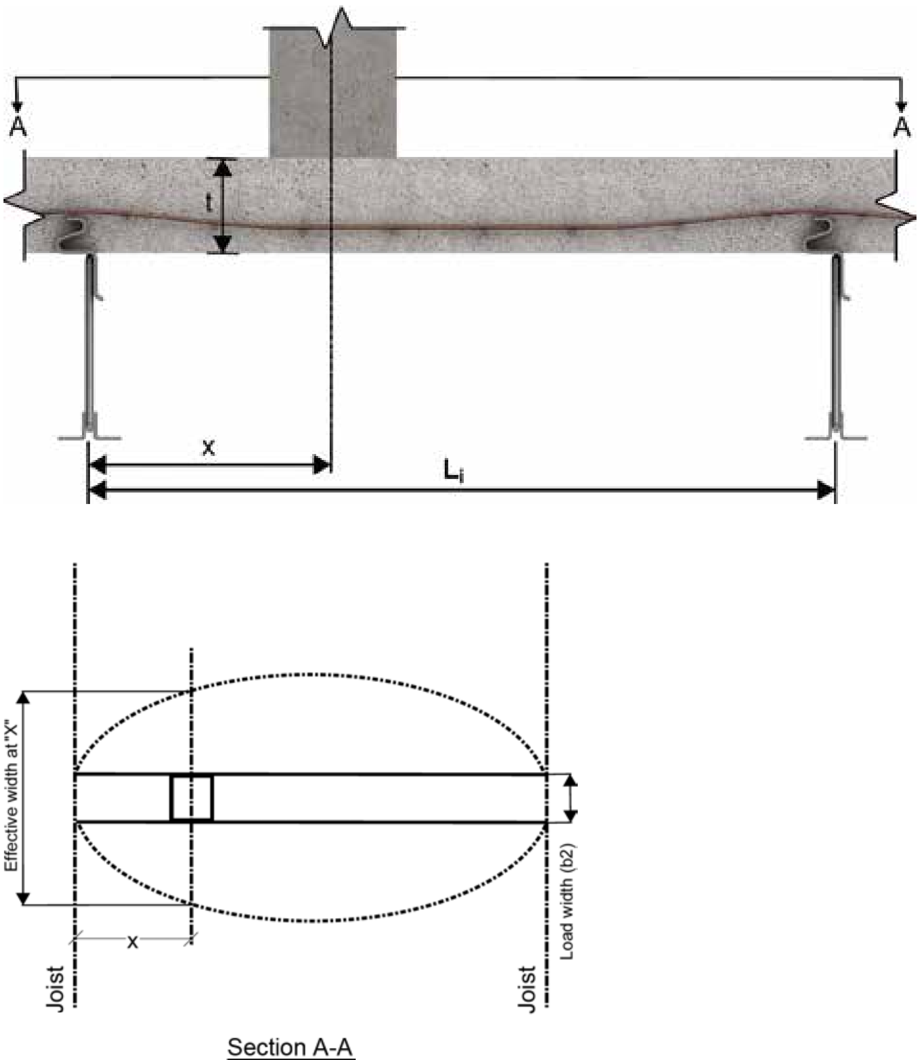
In addition to the previous verification, the Division B of the National Building Code of Canada (NBCC), clause 4.1.5.9 1), requires consideration for a minimum concentrated live load to be applied over a specified area. The magnitude of the load depends on the occupancy. This loading does not need to be considered to act simultaneously with the specified uniform live load.

The area of an applied concentrated load on the slab can be distributed laterally to reduce its intensity. Since the Canadian codes and standards do not provide a precise method, the following calculations for the effective widths of concentrated load, b_e, are based on the SDI approach. CSSBI standard 12M-15 states that for special cases not covered, it is possible to refer to other standards.

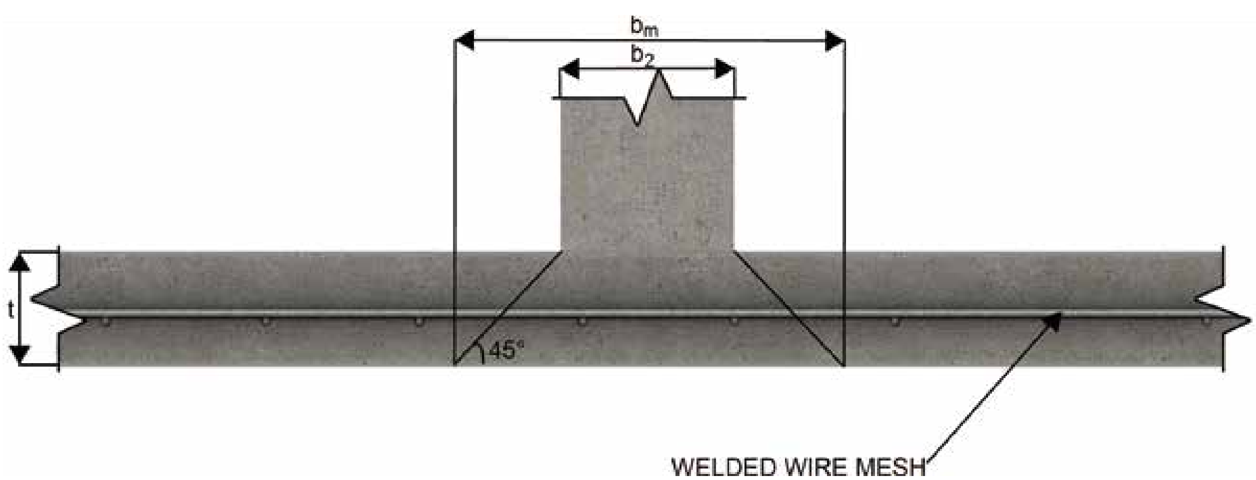
1. For moment calculation:
   $b_e = b_m + (4/3)\,(1 - x/L)x \leq 106.8\,(t_c/h)$
2. For shear calculation:
   $b_e = b_m + (1 - x/L_i)x$

   Where :

   $b_m = b_2 + 2\,t_c$ (mm)
   b_2 = *load width* (mm)
   t_c = *slab thickness* (mm)



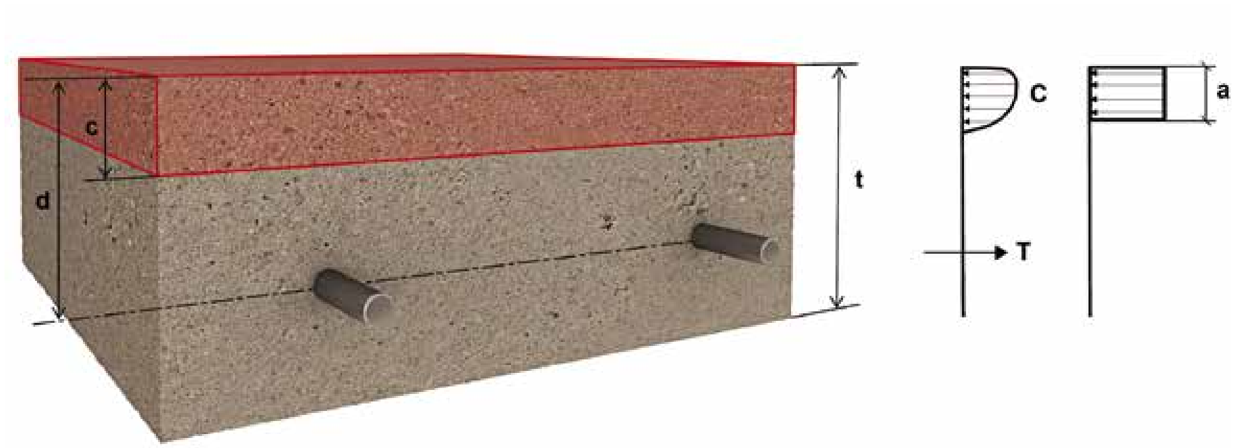
Concentrated load distribution for effective width



Projected width of concentrated load

Moment capacity

The factored moment resistance (M_r) of a reinforced concrete section, using an equivalent rectangular concrete stress distribution is given by (CAN/CSA-A23.3, clause 10.1.7):



Moment capacity block

$$M_r = \varnothing_s A_s F_y \,(d - a/2)$$

$$a = \frac{\varnothing_s A_s F_y}{\alpha_1 \varnothing_c f'_c b}$$

$$\alpha_1 = 0.85 - 0.0015\, f'_c \geq 0.67$$

Where:

a = *depth of the equivalent concrete stress block* (*mm*)

F_y = *yield strength of reinforcing steel* (450 *MPa min.*)

f'_c = *compressive strength of concrete* (20 *MPa min.*)

A_s = *area of reinforcing steel in the direction ofanalysis* (mm^2/m *width*)

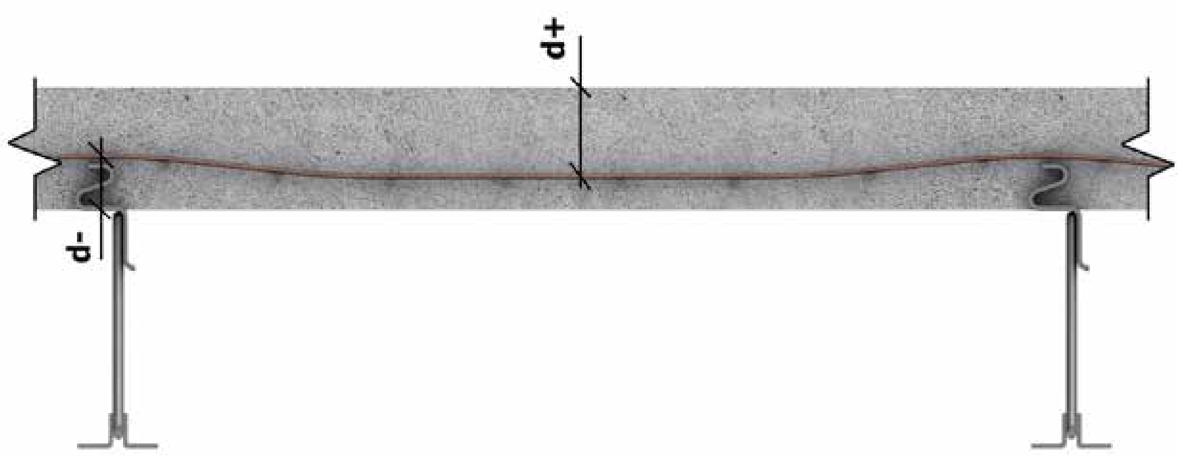
b = *unit slab width* (*mm*)

d^+ *or* d^- = *distance from extreme compression fiber to centroïd of tension reinforcement* (*mm*)

t = *thickness of the slab* (*mm*)

$\varnothing_s$ = *performance factor of reinforcing steel* (0.85)

$\varnothing_c$ = *performance factor of concrete* (0.65)



D500 wire mesh position (d+, d-)

Shear capacity

The shear stress capacity (V_r), which is a measure of diagonal tension, is unaffected by the embedment of the top chord section as this principal tensile crack would be angled and radiate away from the top chord. The factored shear capacity is given by CAN/CSA-A23.3, clause 11.3.4:

$$V_r = V_c = \varnothing_c \lambda \beta \sqrt{f'_c} b_w d_v$$

Where:

$\lambda \;=\; 1\ (\textit{for normal density concrete})$

$\beta \;=\; \dfrac{230}{(1{,}000 + d_v)}$

$d_v \;=\; 0.9\ d^+ \textit{or}\ 0.9\ d^- \geq 0.72\ t\ (mm)$

$d^+\ \textit{or}\ d^- = \textit{distance from extreme compression fiber to centroïd of tension reinforcement}\ (mm)$

$b_w \;=\; b = \textit{width of the slab}\ (mm)$

Serviceability limit states

Crack control parameter

When the specified yield strength, F_y, for tension reinforcement exceeds 300 MPa, cross sections of maximum positive and negative moments shall be so proportioned that the quantity Z does not exceed 30,000 N/mm for interior exposure and 25,000 N/mm for exterior exposure. Refer to CAN/CSA-A23.3, clause 10.6.1.

The quantity Z limiting distribution of flexural reinforcement is given by:

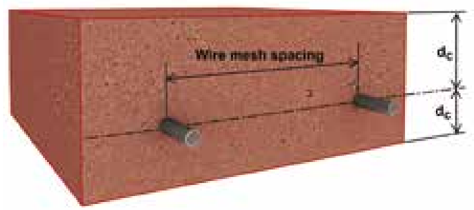
$$Z = f_s \sqrt[3]{d_c A}$$

Where:

f_s = *stress in reinforcement at specified loads taken as* $0.6\ F_y\ (MPa)$

d_c = *thickness of concrete cover measure from extreme tension fibre to the center of the reinforcing bar located closest thereto* $\leq 50\ mm$

$A = 2\ d_c$ *x wire mesh spacing* (mm^2)



Crack control parameter

Deflection control
For one-way slabs not supporting or attached to partitions of other construction likely to be damaged by large deflections, deflection criteria are considered to be satisfied if the following span/depth ratios are met (CAN/CSA-A23.3, Table 9.2):

Exterior span : $t \geq L_i/24$

Interior span : $t \geq L_i/28$

Where:

L_i = *spacing between joists* (mm)

Slab design example

Verify the standard Hambro slab under various limit states (strength and serviceability) for residential loading.

	Metric
Dead load	3.1 kPa
Live load	1.9 kPa
Concentrated load	4.5 kN on 750 mm x 750 mm everywhere
Slab thickness (t)	76 mm
Joists spacing (L_i)	1,250 mm
Concrete strength (f'_c)	20 MPa
Wire mesh	152 x 152 MW25.7 x MW25.7
Area of steel (A_s)	170 mm²/mm
Wire mesh diameter	5.74 mm

1. Loads and efforts per meter of slab

Factored load

$$W_f = 1.25 \ x \ 3.1 + 1.5 \ x \ 1.9 = 6.73 \ kN/m^2$$

Maximum positive moment at location 1

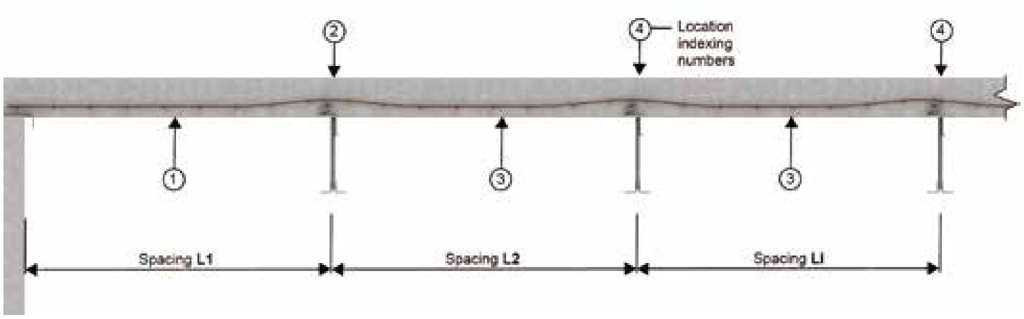
$$M_f^+ = \frac{6.73 \ x \ 1.25^2}{11} \ x \ 1 \ m = 0.96 \ kNm$$

Maximum negative moment at location 2

$$M_f^- = \frac{6.73 \ x \ 1.25^2}{10} \ x \ 1 \ m = 1.05 \ kNm$$

Maximum shear

$$V_f = \frac{6.73 \ x \ 1.15 \ x \ 1.25}{2} = 4.84 \ kN$$



D500 slab design example

2. Resistance under uniform load

Positive moment capacity

$$d^+ = t - 38.1 \ mm - \varnothing_{mesh}/2$$

$$d^+ = 76 - 38.1 - \frac{5.74}{2} = 35.03 \ mm$$

$$\alpha_1 = 0.85 - 0.0015 \ x \ 20 = 0.82 \geq 0.67 \rightarrow OK$$

$$a = \frac{\varnothing_s A_s F_y}{\alpha_1 \varnothing_c f'_c b} = \frac{0.85 \ x \ 170 \ x \ 450}{0.82 \ x \ 0.65 \ x \ 20 \ x \ 1{,}000} = 6.1 \ mm$$

$$M_r^+ = \varnothing_s A_s F_y \ (d^+ - a/2) = 0.85 \ x \ 170 \ x \ 450 \ (35.03 - 6.1/2) = 2.08 \ kNm > M_f^+ = 0.96 \ kNm \rightarrow OK$$

Negative moment capacity

$$d^- = t - d^+$$
$$d^- = 76 - 35.03 = 40.97 \ mm$$

$$\alpha_1 = 0.85 - 0.0015 \ x \ 20 = 0.82 \geq 0.67 \rightarrow OK$$

$$a = \frac{\varnothing_s A_s F_y}{\alpha_1 \varnothing_c f'_c b} = \frac{0.85 \ x \ 170 \ x \ 450}{0.82 \ x \ 0.65 \ x \ 20 \ x \ 1{,}000} = 6.1 \ mm$$

$$M_r^- = \varnothing_s A_s F_y \ (d^- - a/2) = 0.85 \ x \ 170 \ x \ 450 \ (40.97 - 6.1/2) = 2.47 \ kNm > M_f^- = 1.05 \ kNm \rightarrow OK$$

Shear capacity

$$d_v = 0.9 \ d^- \geq 0.72 \ t$$
$$d_v = 0.9 \ x \ 40.97 \geq 0.72 \ x \ 76 \rightarrow 36.87 \ mm \geq 54.72 \ mm \rightarrow d_v = 54.72 \ mm$$

$$\beta = \frac{230}{(1{,}000 + d_v)}$$

$$\beta = \frac{230}{(1{,}000 + 54.72)} = 0.218$$

$$V_r = \varnothing_c \lambda \beta \sqrt{f'_c} b_w d_v$$
$$V_r = 0.65 \ x \ 1 \ x \ 0.218\sqrt{20} \ x \ 1{,}000 \ x \ 54.72 = 34.68 \ kN > V_f = 4.84 \ kN$$

3. Resistance under concentrated load

   Refer to table Slab capacity under concentrated load on page 24.

   The slab can carry a dead load of 5 kPa which is higher than the specified loads of 3.1 kPa. Then, the reinforcement is ok.

4. Serviceability

   Crack control

$$d_c = max\ [t - 38.1 - \varnothing_{mesh}/2;\ 38.1 + \varnothing_{mesh}/2]$$

$$d_c = max\ [76 - 38.1 - 5.74/2;\ 38.1 + 5.74/2] = max\ [35.03;\ 40.97] = 40.97\ mm$$

$$A = 2\ d_c\ x\ wire\ mesh\ spacing$$
$$A = 2\ x\ 40.97\ x\ 152 = 12{,}454.88\ mm^2$$

$$f_s = 0.6\ F_y$$
$$f_s = 0.6\ x\ 450 = 270\ MPa$$

$$Z = f_s \sqrt[3]{d_c A}$$

$$Z = 270 \sqrt[3]{40.97\ x\ 12{,}454.88} = \frac{21{,}576\ N}{mm} < \frac{30{,}000\ N}{mm} \rightarrow OK$$

   Deflection control

$$\frac{span}{depth} = \frac{1{,}251}{76} = 16.46$$

$$\text{Exterior span: } t \geq L_i\ /24 \rightarrow t \geq \frac{1{,}251}{24} = 52.13 > 16.46 \rightarrow OK$$

$$\text{Interior span: } t \geq L_i\ /28 \rightarrow t \geq \frac{1{,}251}{28} = 44.68 > 16.46 \rightarrow OK$$

DIAPHRAGM

Note: The calculations attached to diaphragm design are metric only.

THE HAMBRO SLAB AS A DIAPHRAGM

With the increasing use of the Hambro system for floor-building in earthquake or in hurricane prone areas as well as for multi-story buildings where shear transfer could occur at some level of the building due to the reduction of the floor plan, it is important to develop an understanding of how the slabs will be able to transmit horizontal loads while being part of the Hambro floor system.

The floor slab, part of the Hambro system, must be designed by the project structural engineer as a diaphragm to resist horizontal loads and transmit them to the vertical lateral resisting system. Take note that the Hambro joist doesn't transfer lateral loads and that drag struts or connectors should be designed in order to transfer these loads to the perimeter elements. The Canam engineering team is available for technical support for diaphragm design.

A diaphragm works as the web of a beam spanning between or extending beyond the supports. In the case of a floor slab, the slab is the web of the beam spanning between or extending beyond the vertical elements designed to transmit to the foundations the horizontal loads produced by earthquake or wind.

Any diaphragm has the following limit states:

1. Shear strength between the supports;
2. Out of plane buckling;
3. In plane deflection of the diaphragm;
4. Shear transmission at the supports.

We will use a simple example of wind load acting on a diaphragm part of a horizontal beam forming a single span between end walls. The structural engineer responsible for the design of the building shall establish the horizontal loads that must be resisted at each floor of the building for the wind and earthquake conditions prevailing at the building location. The structural engineer must also identify the vertical elements that will transmit the horizontal loads to the foundations in order to calculate the shear that must be resisted by the floor slab.

Shear strength between supports

A series of fourteen specimens of concrete slabs, part of a Hambro D500 floor system, were tested in the Carleton University's laboratories in Ottawa. The purpose of the tests was to identify the variables affecting the in-plane shear strength of the concrete slab reinforced with welded wire mesh.

The specimens were made of slabs with a concrete thickness of 64 mm or 68 mm forming a beam with a span of 610 mm and a depth of 610 mm. This beam was loaded with two equal concentrated loads at 152 mm from the supports. The other variables were:

1. The size of the wire mesh;
2. The presence or absence of the Hambro joist's embedded top chord parallel to the load in the shear zone;
3. The concrete strength.

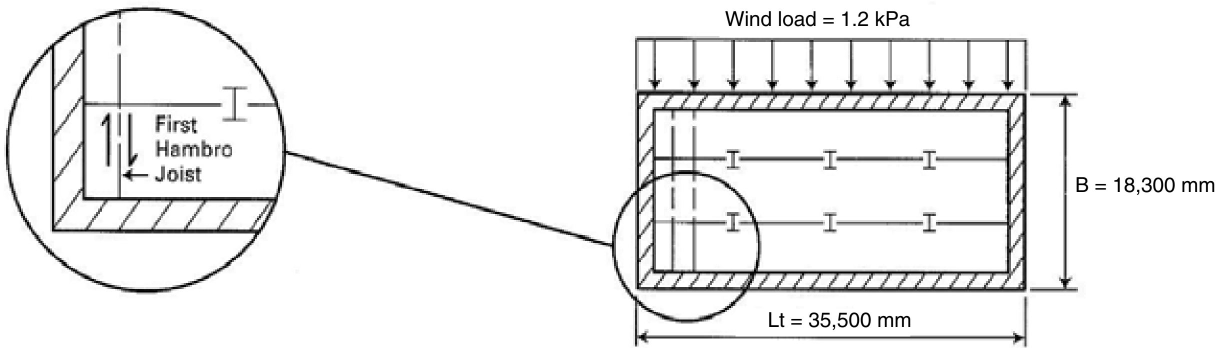
It was found that the shear resistance of the slab is minimized when the shear stress is parallel to the Hambro joist's embedded top chord. A conservative assumption could be made that the concrete confined **steel wire mesh is the only element that will transmit the shear load** over the embedded top chord. In other cases, the shear forces are taken up by the reinforced concrete slab and calculated by the structural engineer responsible for the design of the building.

As recommended in the report produced as a result of tests conducted at the Carleton University, in the following example of the design procedure, we will take into account that the steel wire mesh is already under tension stress produced by the continuity of the slab over the Hambro joist, and that the remaining capacity of the steel wire mesh will be the limiting factor for the shear strength of the slab over the Hambro joist.

Design example

The diaphragm example (see figure on page 41) illustrates a simple building with a slab in diaphragm. Hambro system values are taken from the slab design example on page 37. Other necessary values are listed below.

	Metric
Total wind pressure load from leeward and windward faces (W)	1.2 kPa
Story height (h_s)	3.7 m
Span of the beam with the floor slab acting as web (Lt)	35.5 m
Length of the bearing elements parallel to the horizontal force (B)	18.3 m



Diaphragm example

1. Non-factored moments

   The ending moment over the embedded top chord is calculated for one meter width. In using the data from the slab design example, the non-factored moments for a joist with a spacing of 1,251 mm is:

   Dead load: $Mf_d^- = \frac{3.1\ kPa\ x\ 1.251^2}{10}\ x\ 1\ m = 0.49\ kNm$

   Live load: $Mf_L^- = \frac{1.9\ kPa\ x\ 1.251^2}{10}\ x\ 1\ m = 0.30\ kNm$

2. Bending moment in the slab between joists due to gravity loads

   The lever arm between the compression concrete surface and the tension steel of the wire mesh at the top chord allows us to calculate the factored bending capacity of the slab to be $M_r^- = 2.47\ kNm$.

3. Horizontal shear

   We can establish the horizontal shear that the floor diaphragm will have to resist in order to transfer the horizontal load from the walls facing the wind to the perpendicular walls where a vertical lateral resisting system will bring that load down to the foundation.

   For the purpose of our example, the factored wind load is the maximum horizontal load calculated according to the provisions of the local building code, but earthquake load shall also be calculated by the structural design engineer of the project and the maximum of the two loads should be used in the calculation.

$$
\begin{aligned}
V_f &= h_s W \frac{Lt}{2} \\
&= 3.7\ x\ 1.2\ \frac{35.5}{2} \\
&= 78.8\ kN
\end{aligned}
$$

   In our example, the end reaction is distributed along the whole length (18.3 m) of the end wall used to transfer the load.

$$
\begin{aligned}
V_f &= \frac{78.8}{18.3} \\
&= 4.3\ \text{kN/m}
\end{aligned}
$$

4. Steel shear capacity

   To establish the shear capacity of steel wire mesh for a slab unit width of one meter, we use the following formula adapted from CSA-A23.3, clause 11.5, and simplify it to calculate the resistance of the reinforcing steel only, considering a shear crack developing at a 45 degree angle and intersecting the wire mesh in both directions.

$$\begin{aligned} V_r &= \varnothing_s A_s F_y \cos 45^\circ \\ &= (0.85\ x\ 2\ x\ 170\ x\ 450\ x\ \cos 45^\circ)/1{,}000 \\ &= 98.89\ kN/\mathrm{m} \end{aligned}$$

   The steel area is multiplied by two since the crack is developing at a 45 degree angle, crossing both directions of the wire mesh.

5. Interaction formulas

   Considering the reduction factor from the NBCC for the simultaneity of gravity live load and horizontal wind load for our example, the structural engineer of the project needs to verify the diaphragm capacity of the floor slab and its reinforcement by verifying that the moment and shear interaction formulas used below are less than unity:

   Load Combination 1:

$$1.25\,\frac{Mf_d^-}{M_r} + 1.5\,\frac{Mf_L^-}{M_r} \leq 1$$

$$1.25\,\frac{0.49}{2.47} + 1.5\,\frac{0.30}{2.47} = 0.43 \leq 1 \rightarrow \mathit{OK}\ \text{(Doesn't control)}$$

   Load Combination 2:

$$1.25\,\frac{Mf_d^-}{M_r} + 1.5\,\frac{Mf_L^-}{M_r} + 0.4\,\frac{V_f}{V_r} \leq 1$$

$$1.25\,\frac{0.49}{2.47} + 1.5\,\frac{0.30}{2.47} + 0.4\,\frac{4.3}{98.89} = 0.45 \leq 1 \rightarrow \mathit{OK}\ \text{(Controls)}$$

   Load Combination 3:

$$1.25\,\frac{Mf_d^-}{M_r} + 0.5\,\frac{Mf_L^-}{M_r} + 1.4\,\frac{V_f}{V_r} \leq 1$$

$$1.25\,\frac{0.49}{2.47} + 0.5\,\frac{0.30}{2.47} + 1.4\,\frac{4.3}{98.89} = 0.37 \leq 1 \rightarrow \mathit{OK}\ \text{(Doesn't control)}$$

These verifications indicate that the wire mesh embedded in the slab would provide enough shear strength to transfer those horizontal loads over the Hambro joist.

Out of plane buckling

The floor slab, when submitted to a horizontal shear load, may tend to buckle out of plane like a sheet of paper being twisted. The minimum thickness of Hambro concrete slab of 76 mm is properly held in place by the Hambro joists spaced at a maximum of 1,555 mm and which are attached at their ends to prevent vertical movement. The buckling length of the slab itself will then be limited to the spacing of the joist and the buckling of a floor will normally not be a factor in the design of the slab as a diaphragm.

In plane deflection of the diaphragm

As for every slab used as a diaphragm, the deflection of the floor as a horizontal member between the supports provided by the vertical bracing system shall be investigated by the structural engineer of the building to verify that the horizontal deflection remains within the allowed limits.

Beam effect

The structural engineer of the project shall indicate the required steel reinforcement on his drawings according to the beam effect calculations.

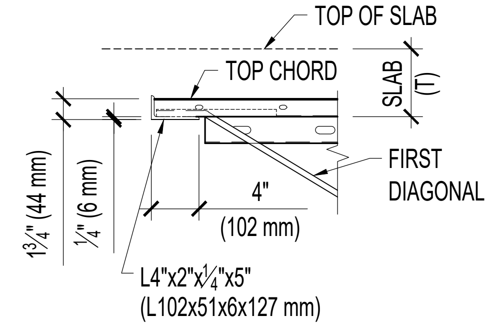
Shear transmission to the vertical bracing system

The structural engineer of the project shall design and indicate on his drawings proper methods and/or reinforcement to attach the slab to the vertical bracing system over such a length as to prevent local overstress of the slab capacity to transfer shear.

ENGINEERING TYPICAL DETAILS – HAMBRO D500 (H SERIES)

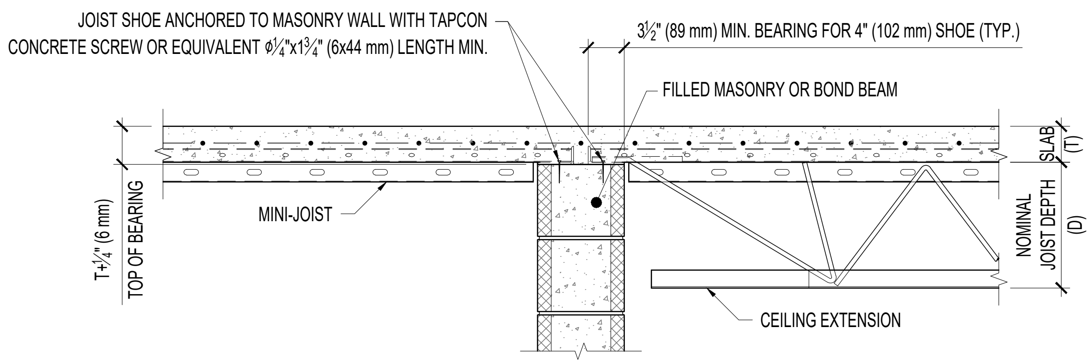
DETAIL 1

D500
STANDARD SHOE



DETAIL 2

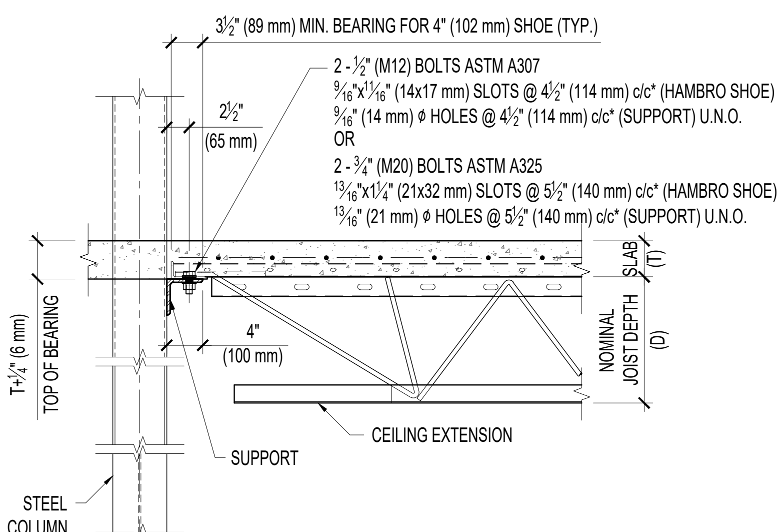
STANDARD SHOE / MINI-JOIST



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 3

BOLTED JOIST ON STEEL COLUMN (FLANGE / WEB)

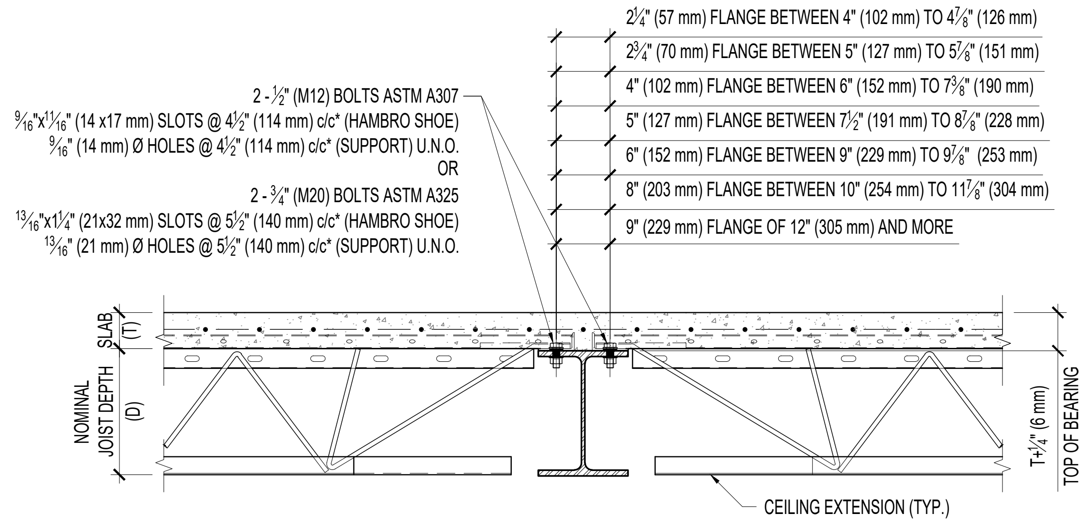


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

* WHEN DEEP SHOE, THE c/c OF HOLE IS DIFFERENT, CONSULT THE APPROPRIATE DETAILS ON PLAN.

DETAIL 4

BOLTED JOIST ON INTERIOR STEEL BEAM

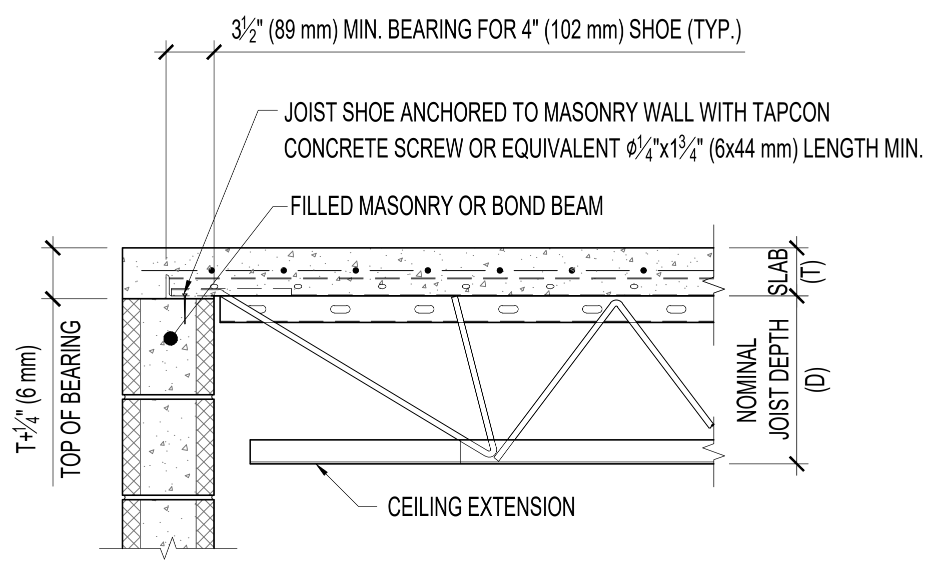


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE FLANGE BEAM IS LESS THAN 8" (203 mm).
* WHEN DEEP SHOE, THE c/c OF HOLE IS DIFFERENT, CONSULT THE APPROPRIATE DETAILS ON PLAN.

DETAIL 5

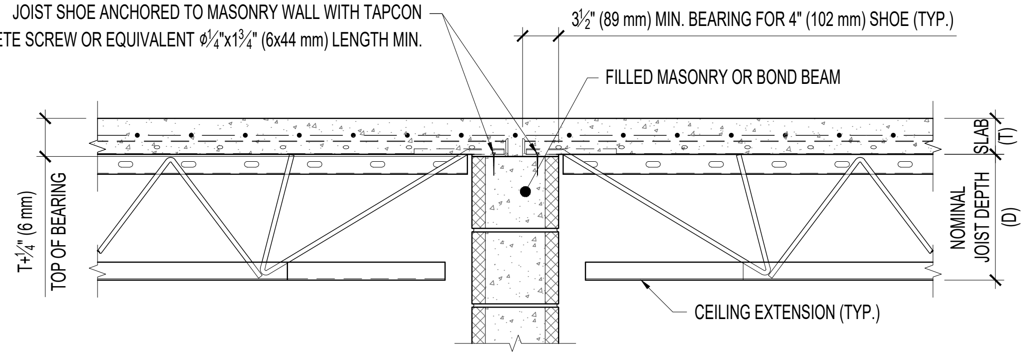
JOIST BEARING ON EXTERIOR MASONRY OR CONCRETE WALL



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 6

JOIST BEARING ON INTERIOR MASONRY OR CONCRETE WALL

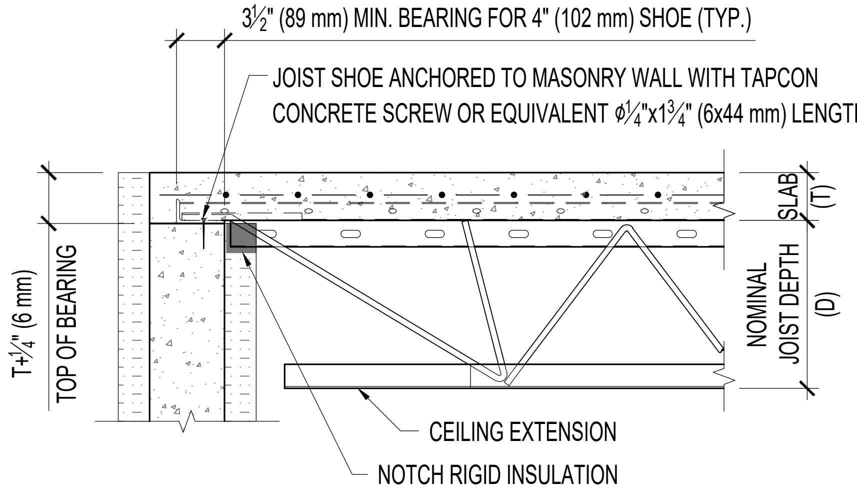


T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 7

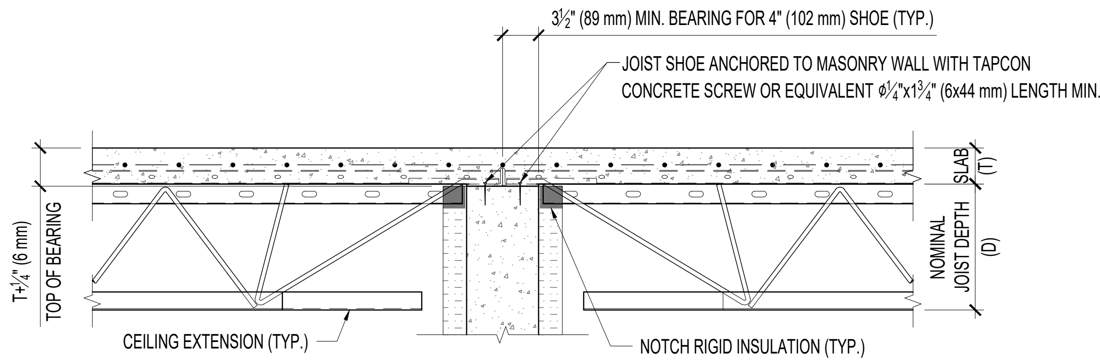
JOIST BEARING ON EXTERIOR INSULATED CONCRETE WALL



T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 8

JOIST BEARING ON INTERIOR INSULATED CONCRETE WALL

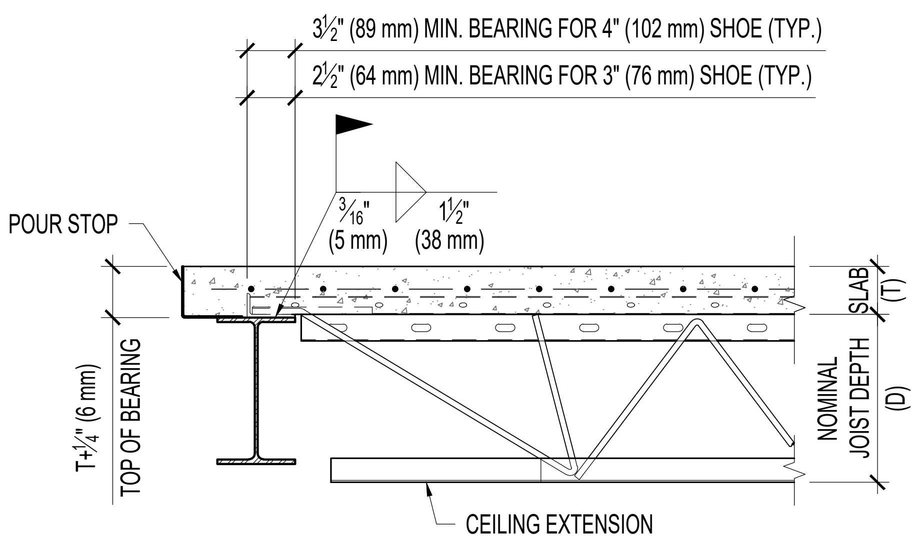


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 9

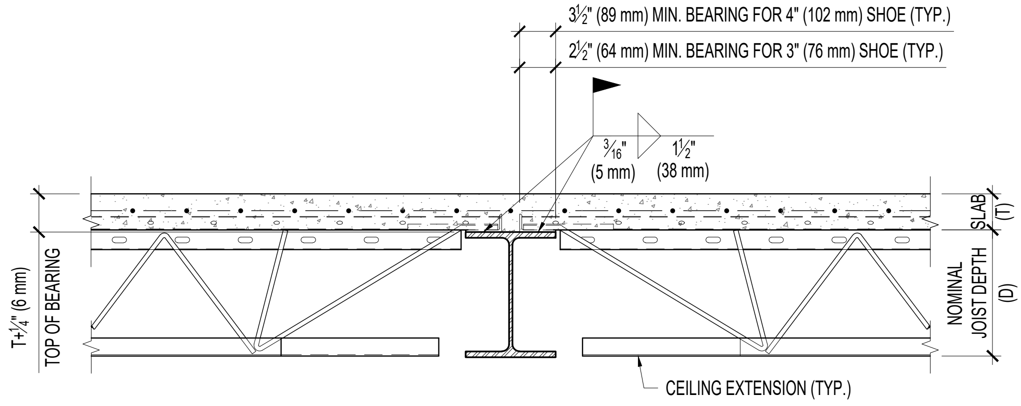
JOIST BEARING ON EXTERIOR STEEL BEAM



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 10

JOIST BEARING ON INTERIOR STEEL BEAM

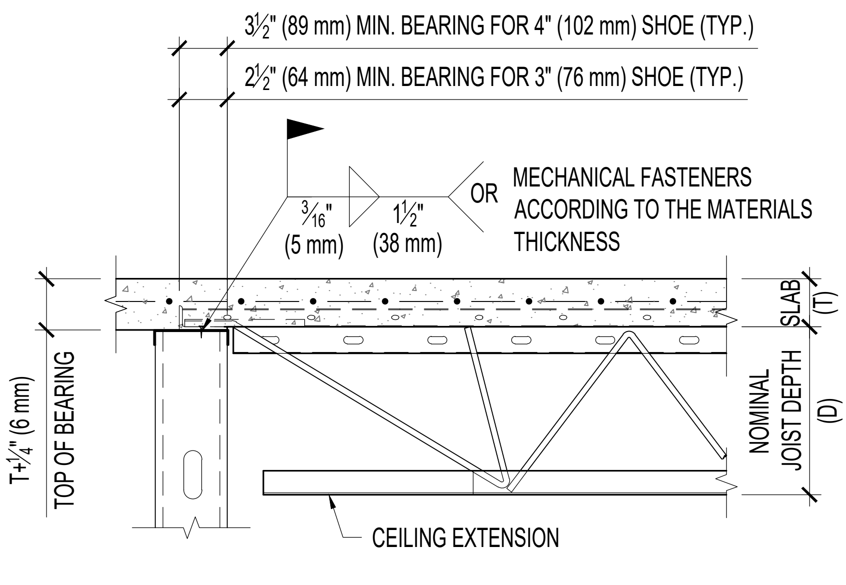


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE FLANGE BEAM IS LESS THAN 8" (203 mm).

DETAIL 11

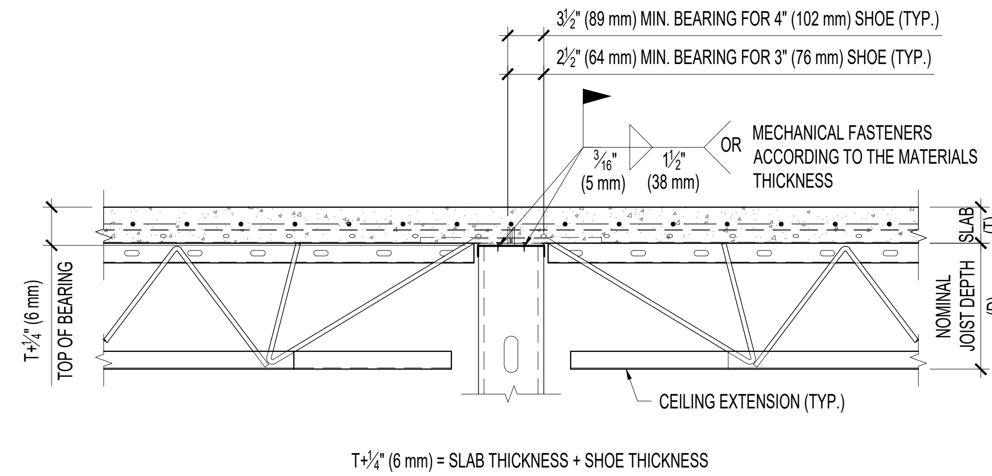
JOIST BEARING ON INTERIOR STEEL STUD WALL



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 12

JOIST BEARING ON INTERIOR STEEL STUD WALL

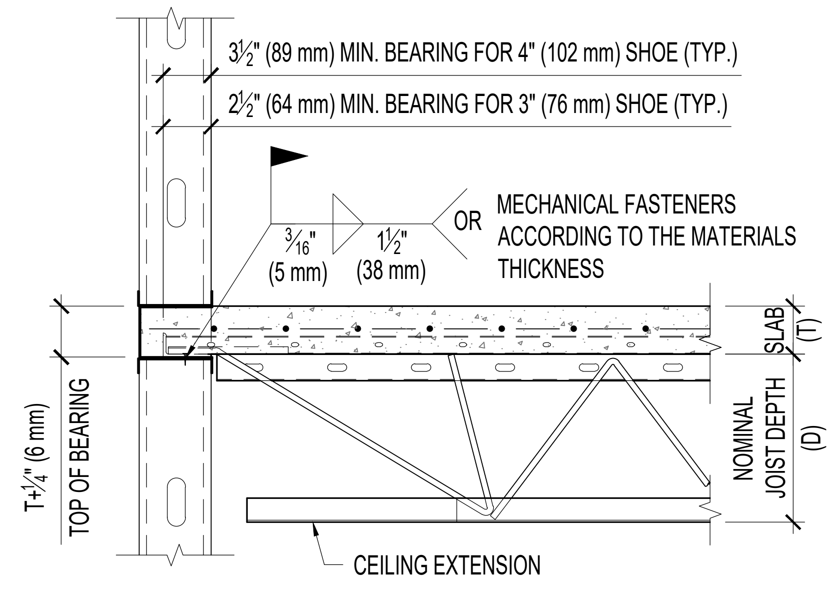


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 13

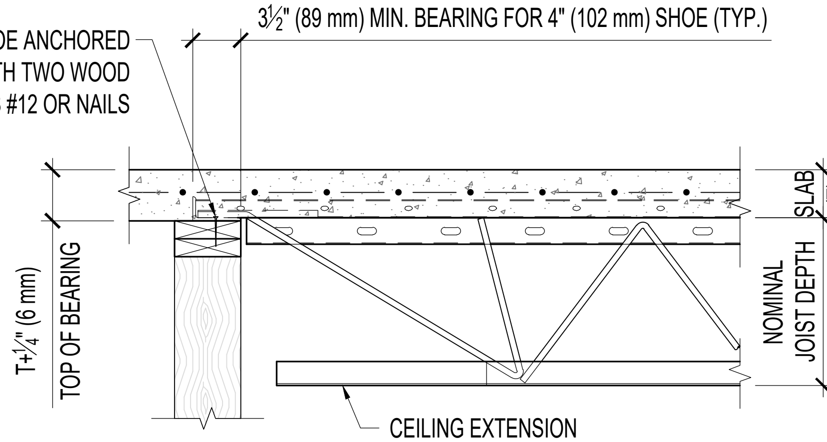
JOIST BEARING ON EXTERIOR STEEL STUD WALL



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 14

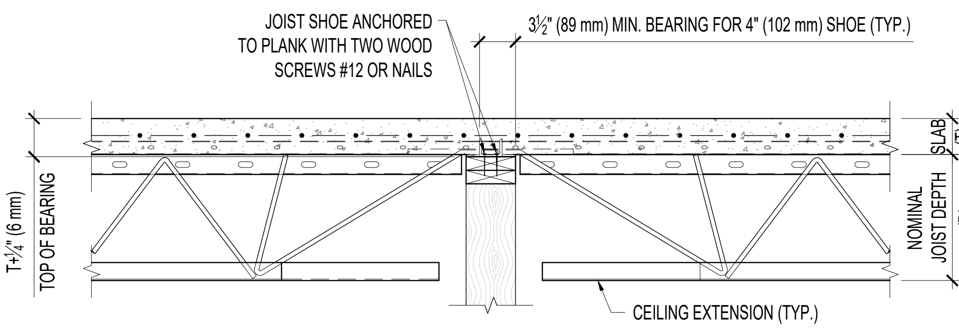
JOIST BEARING ON EXTERIOR WOOD STUD WALL



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 15

JOIST BEARING ON INTERIOR WOOD STUD WALL

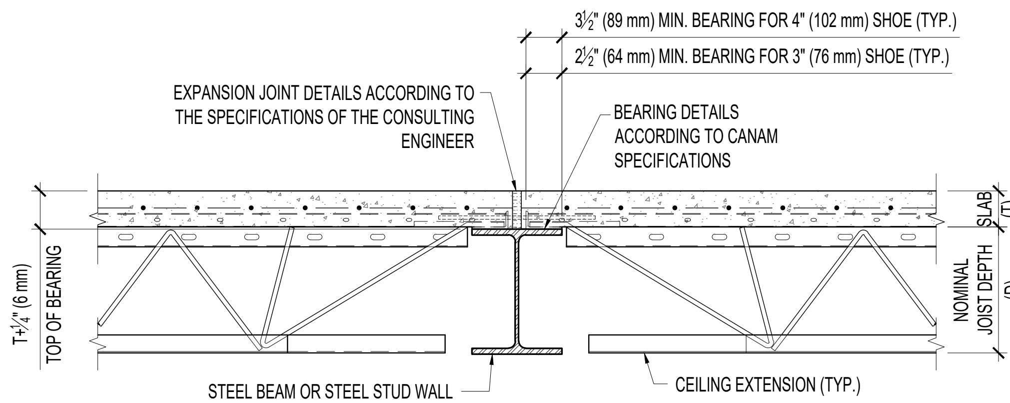


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 16

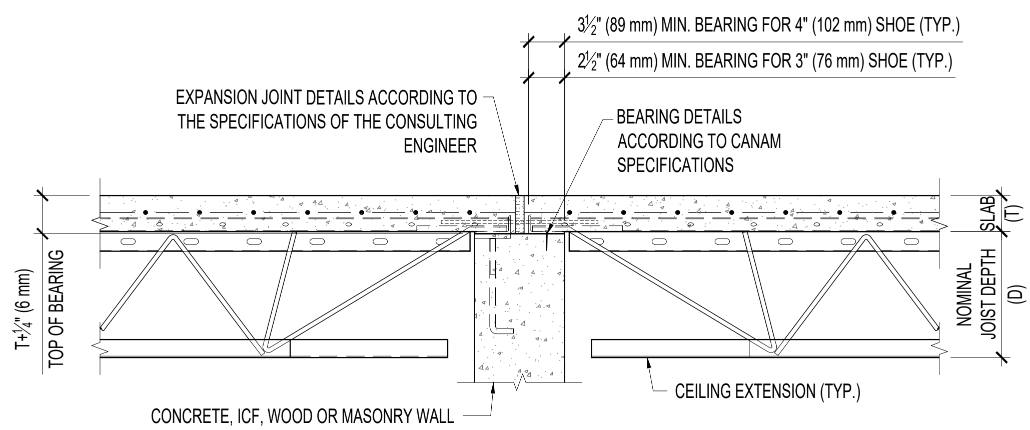
EXPANSION JOINT AT ROOF (STEEL BEAM)



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 17

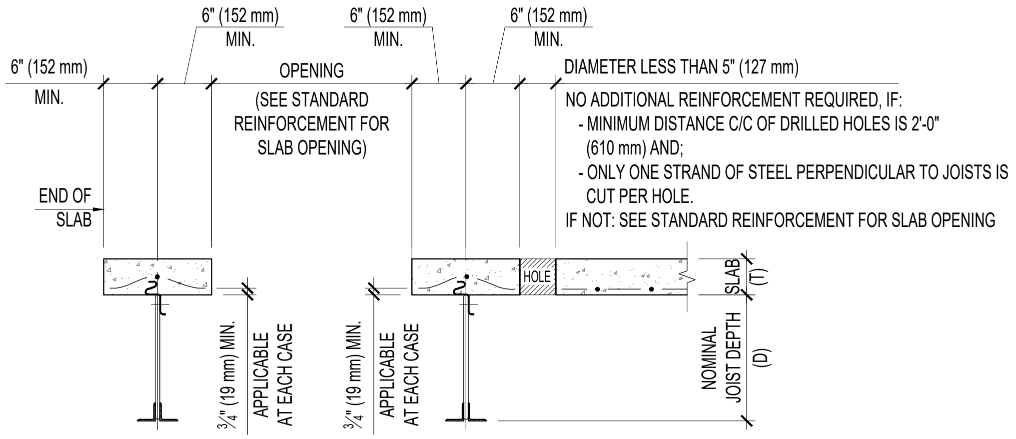
EXPANSION JOINT AT ROOF

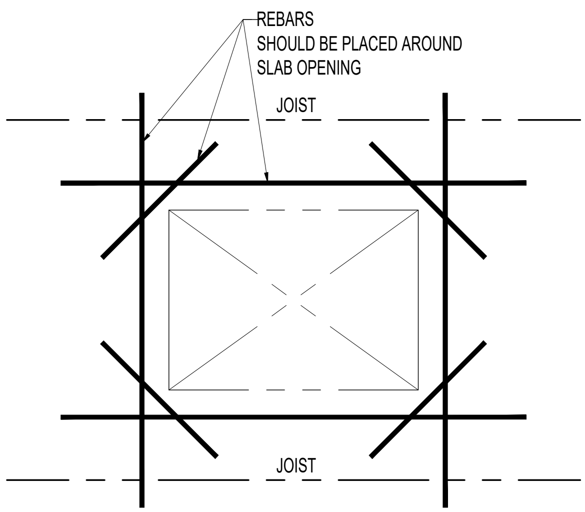


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 18

MINIMUM CLEARANCE OPENING AND HOLE IN THE SLAB



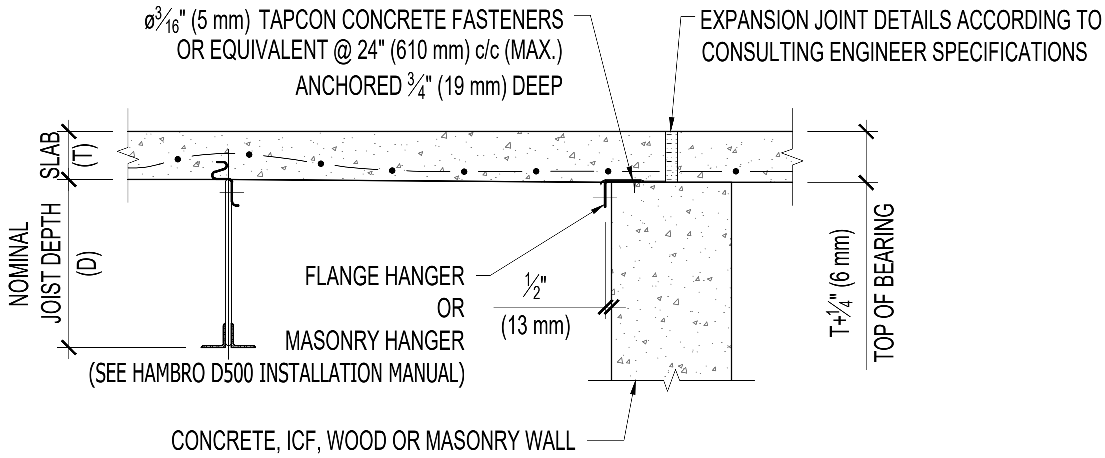


IF SLAB OPENING IS:
- LESS THAN 1'-5" (430 mm), REINFORCE THE AREA WITH AN ADDITIONAL LAYER OF WIRE MESH LAPPED 1'-0" (305 mm) ALL AROUND OPENING
- 1'-5" (430 mm) OR MORE, FOLLOW THE ENGINEER OF RECORDS' DETAIL.

STANDARD REINFORCEMENT FOR SLAB OPENING

DETAIL 19

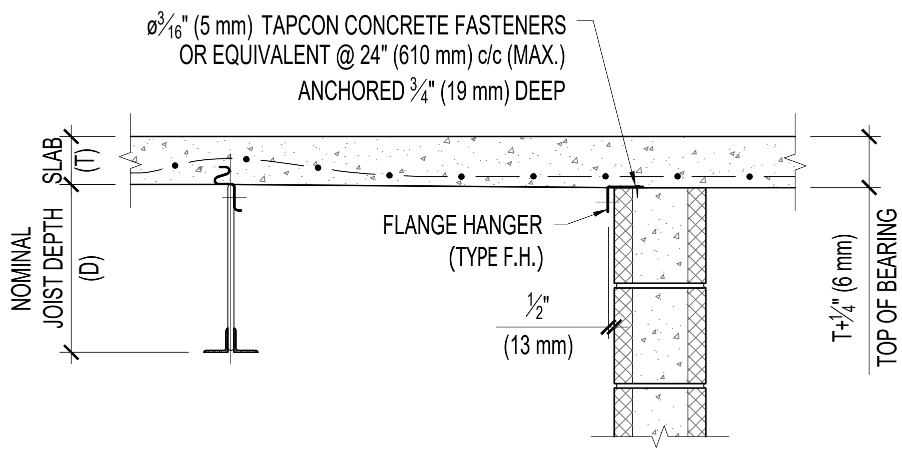
JOIST PARALLEL TO EXPANSION JOINT



T+1⁄4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 20

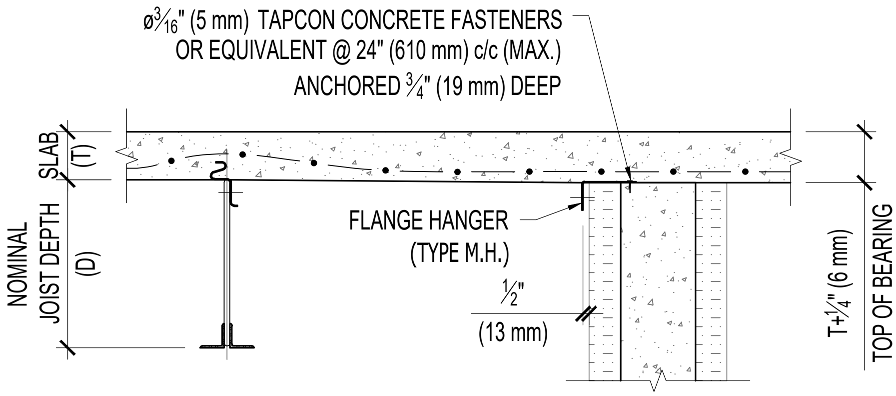
JOIST PARALLEL TO A MASONRY OR CONCRETE WALL



T+1⁄4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 21

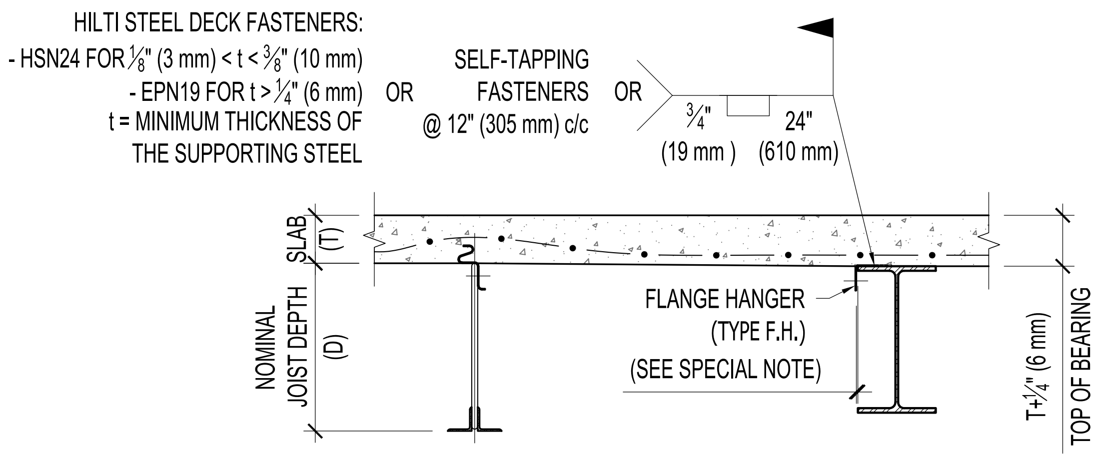
JOIST PARALLEL TO INSULATED CONCRETE WALL



T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 22

JOIST PARALLEL TO A STEEL BEAM

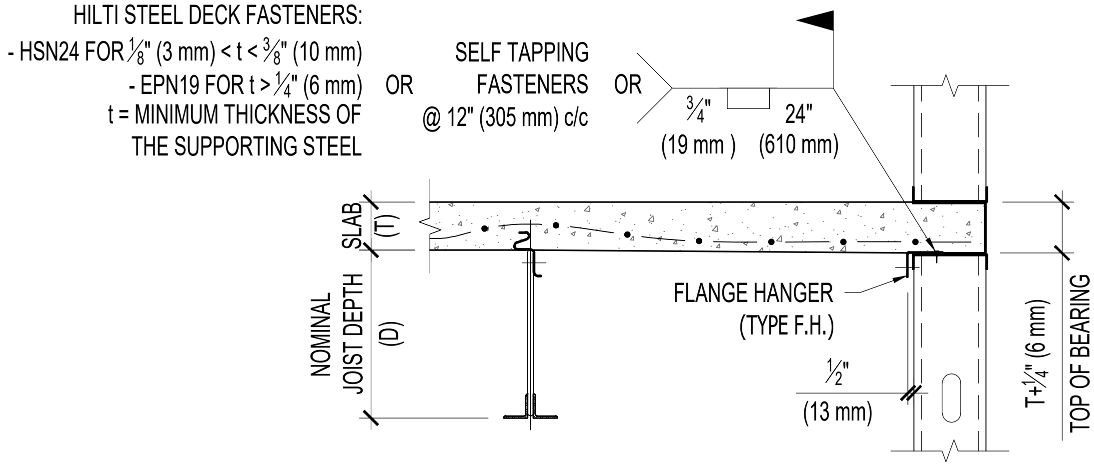


T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

SPECIAL NOTE:
IF THE FLANGE THICKNESS IS MORE THAN 11/16" (17 mm), INSTALL THE FLANGE HANGER AT 1/2" (13 mm) TO THE FACE OF FLANGE.

DETAIL 23

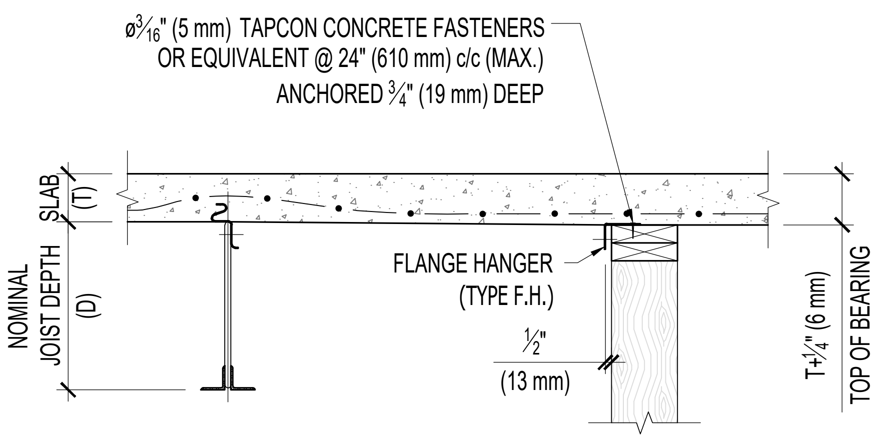
JOIST PARALLEL TO A STEEL STUD WALL



T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 24

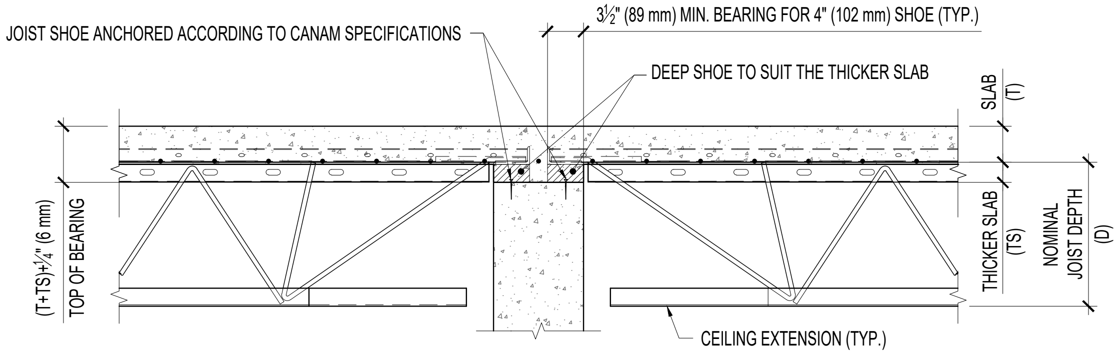
JOIST PARALLEL TO A WOOD WALL



T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 25

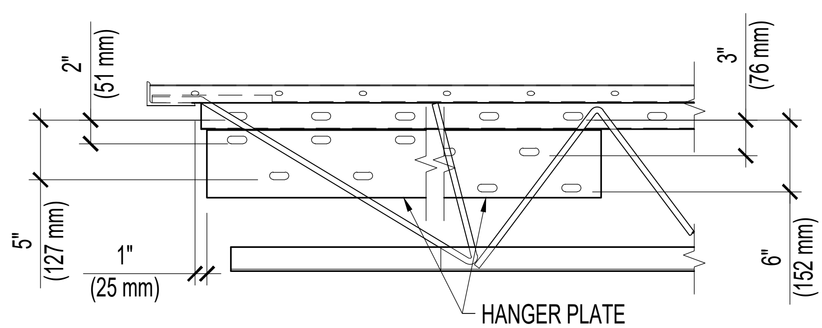
DEEP SHOE TO SUIT SLAB THICKNESS



(T+TS)+¼" (6 mm) = (SLAB THICKNESS + THICKER SLAB) + SHOE THICKNESS

DETAIL 26

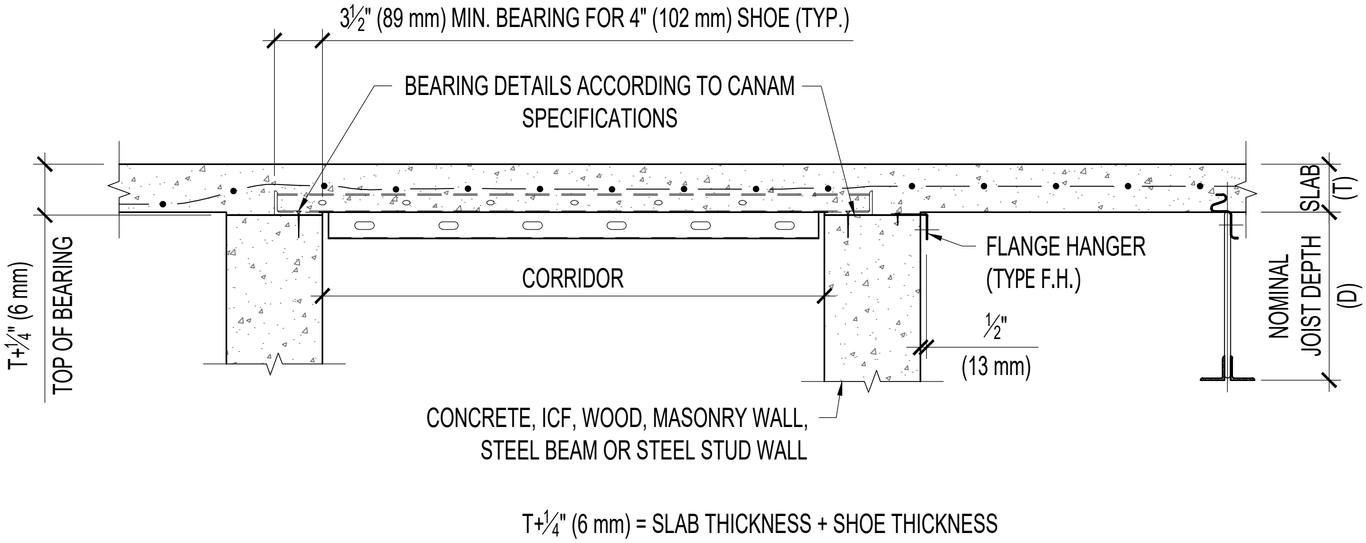
THICKER SLAB



NOTES:
-THE HANGER PLATE IS USED TO THICKER THE UNDER SIDE OF THE CONCRETE SLAB.
-FOUR DIFFERENT STANDARDS THICKNESS SLAB CAN BE CONSIDERED WITH THE HANGER PLATE (SEE DETAIL).

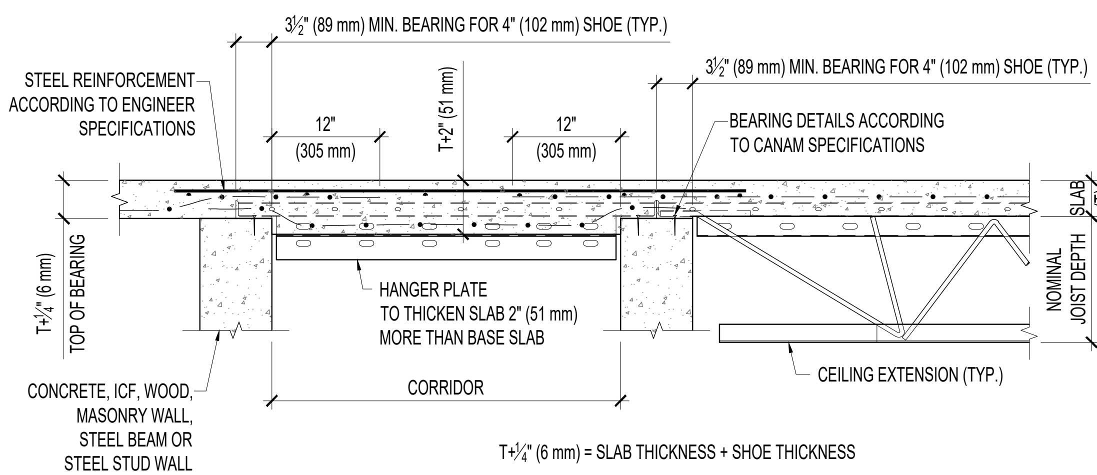
DETAIL 27

MINI-JOIST AT CORRIDOR



DETAIL 28

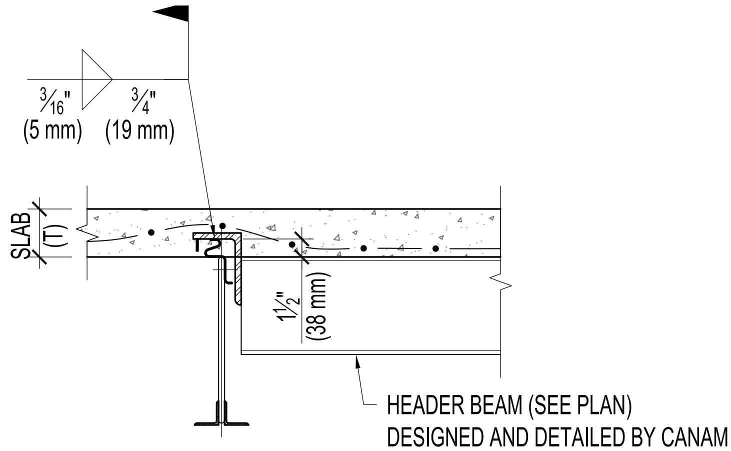
MINI-JOIST WITH HANGER PLATE AT CORRIDOR



NOTE:
STAGGERED JOISTS, IF THE SUPPORT ELEMENT IS LESS THAN 8" (203 mm).

DETAIL 29

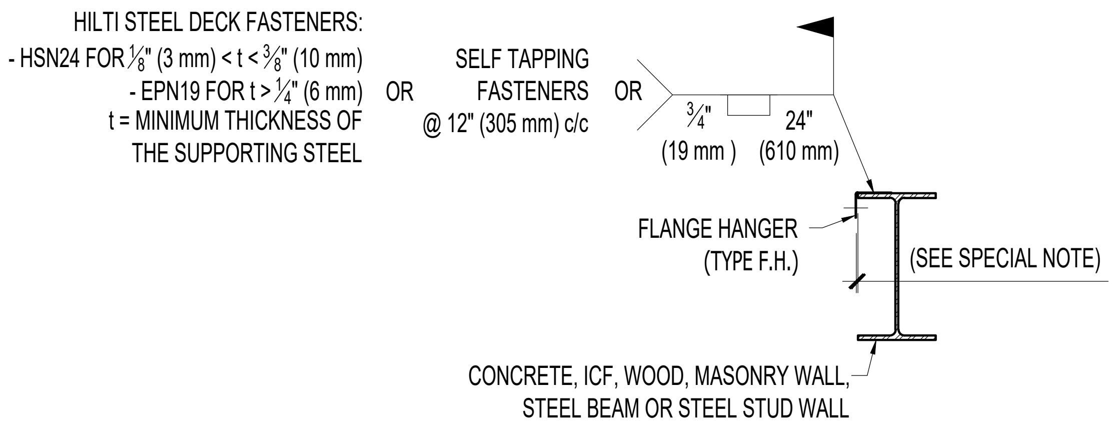
HEADER SUPPORT



NOTE:
IF THERE IS A JOIST SITTING ON THE HEADER BEAM,
THE DIMENSION $1\frac{1}{2}$" (38 mm) WILL BECOME $1\frac{3}{4}$" (44 mm) AND
"T" WILL BECOME "T+$\frac{1}{4}$" (6 mm) = SLAB THICKNESS + SHOE THICKNESS".

DETAIL 30

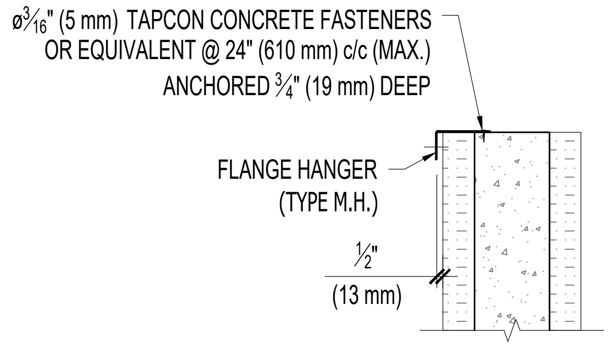
FLANGE HANGER FOR BEAM AND WALL



SPECIAL NOTE:
IF THE FLANGE THICKNESS IS MORE THAN $\frac{11}{16}$" (17 mm), INSTALL THE
FLANGE HANGER AT $\frac{1}{2}$" (13 mm) TO THE FACE OF FLANGE.

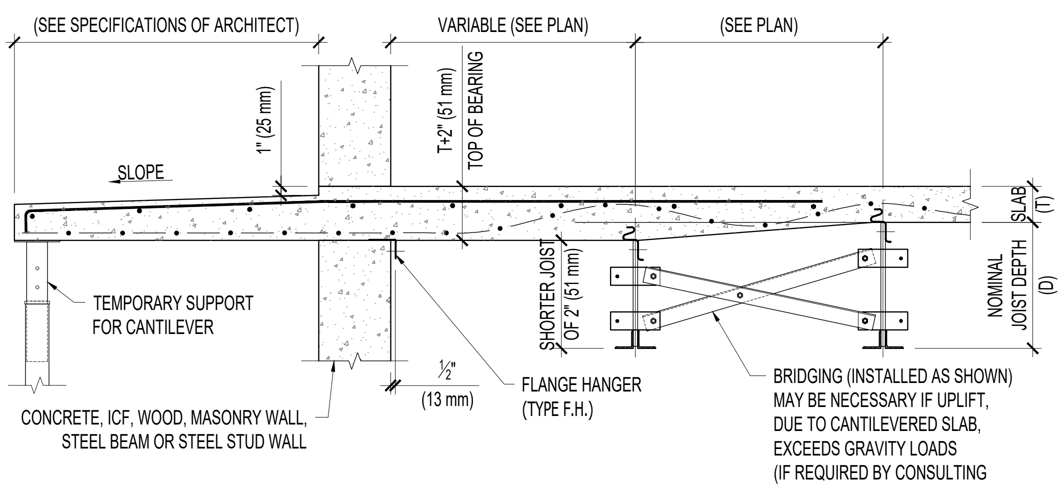
DETAIL 31

FLANGE HANGER FOR INSULATED CONCRETE WALL



DETAIL 32

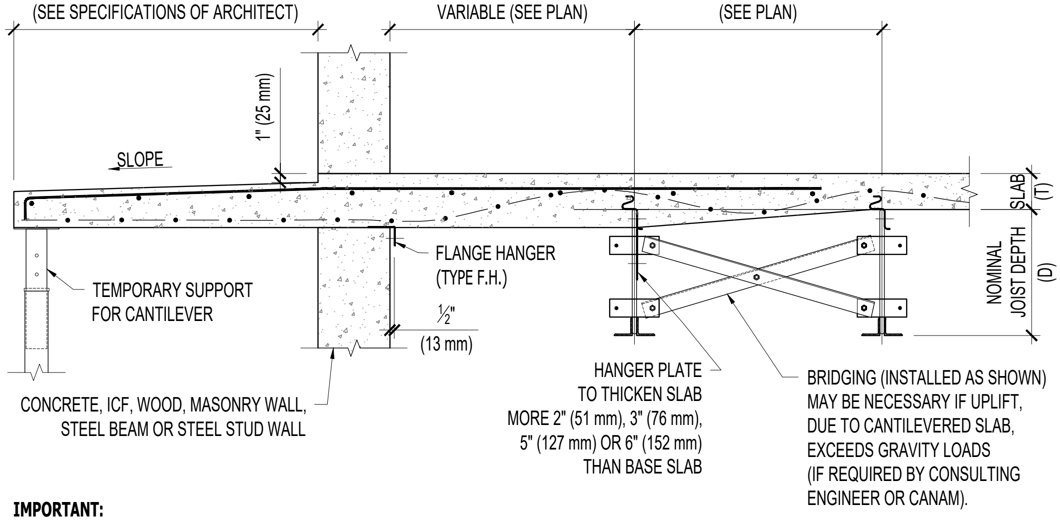
CANTILEVERED BALCONY (SHALLOW JOIST PARALLEL TO BALCONY)



IMPORTANT:
BRIDGING ANGLES, TO BE INSTALLED AFTER FORMS, ARE STRIPPED BUT BEFORE REMOVAL OF CANTILEVER TEMPORARY SUPPORTS.

DETAIL 33

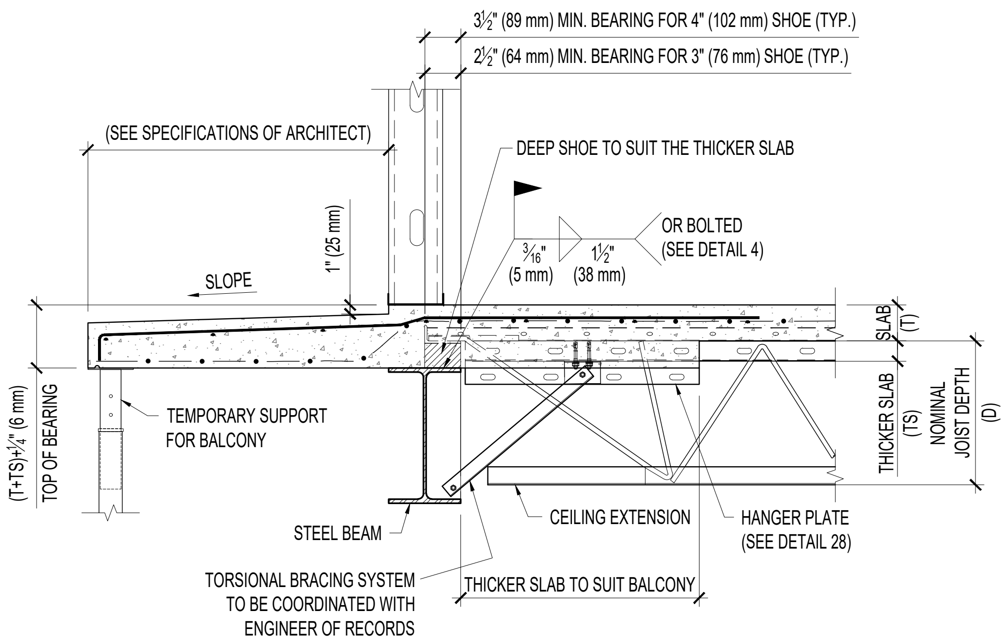
CANTILEVERED BALCONY (JOIST PARALLEL TO BALCONY)



IMPORTANT:
BRIDGING ANGLES, TO BE INSTALLED AFTER FORMS, ARE STRIPPED BUT BEFORE REMOVAL OF CANTILEVER TEMPORARY SUPPORTS.

DETAIL 34

CANTILEVERED BALCONY (JOIST PERPENDICULAR TO BALCONY)

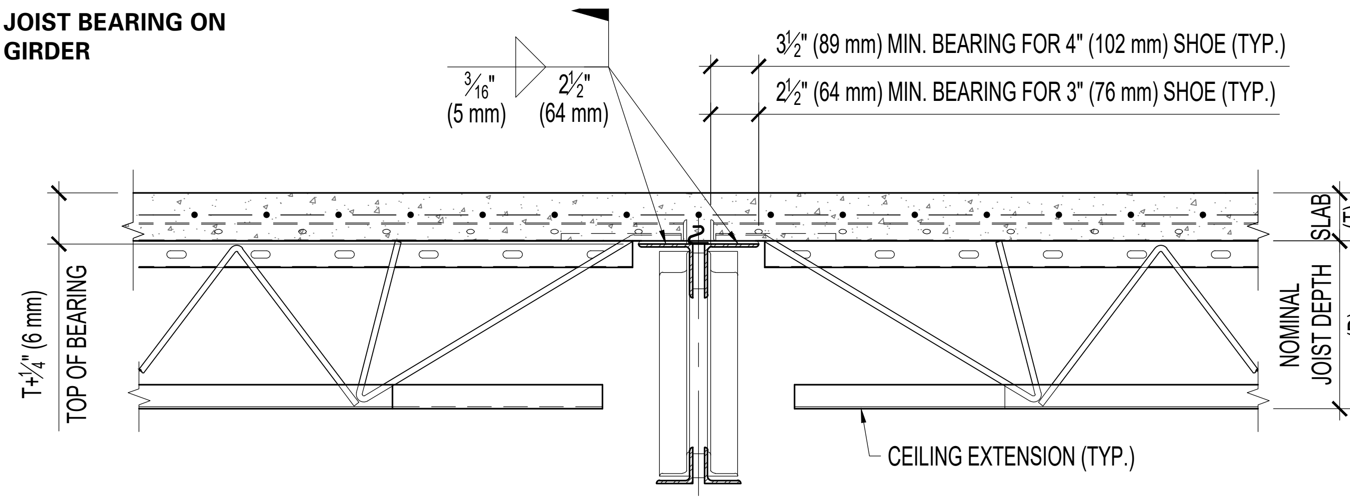


(T+TS)+¼" (6 mm) = (SLAB THICKNESS + THICKER SLAB) + SHOE THICKNESS

ENGINEERING TYPICAL DETAILS – HAMBRO D500 ON GIRDER

DETAIL 35

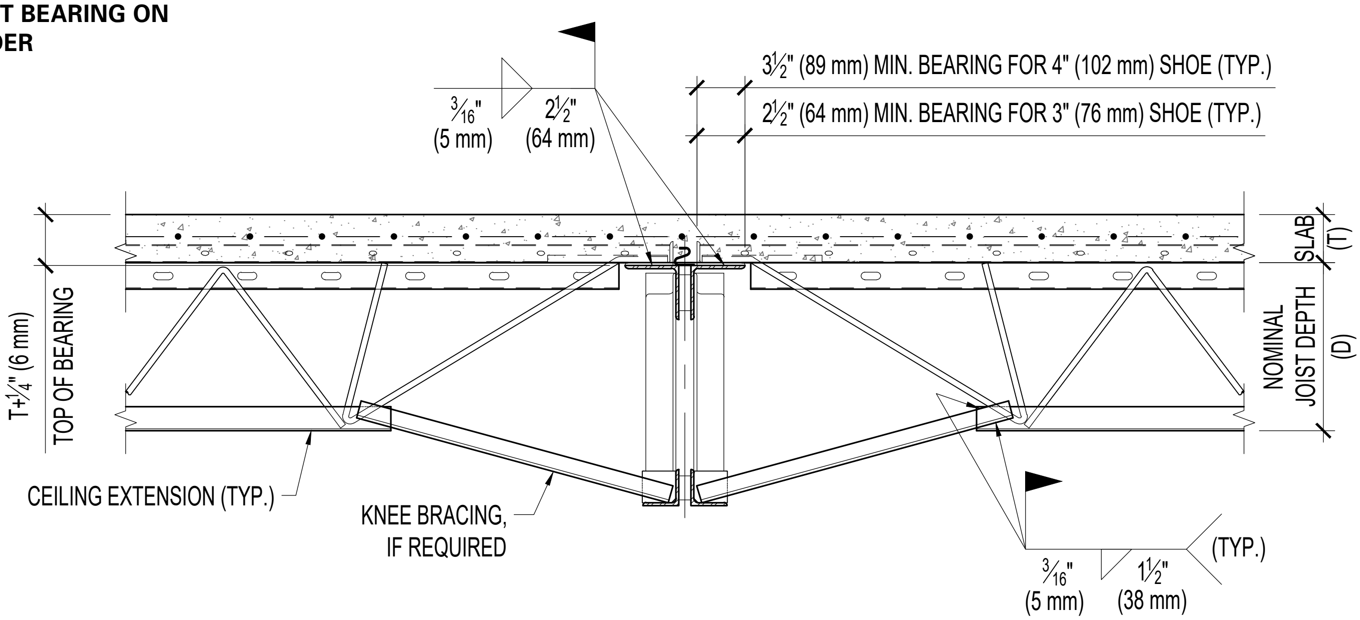
JOIST BEARING ON GIRDER



T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

DETAIL 36

JOIST BEARING ON GIRDER

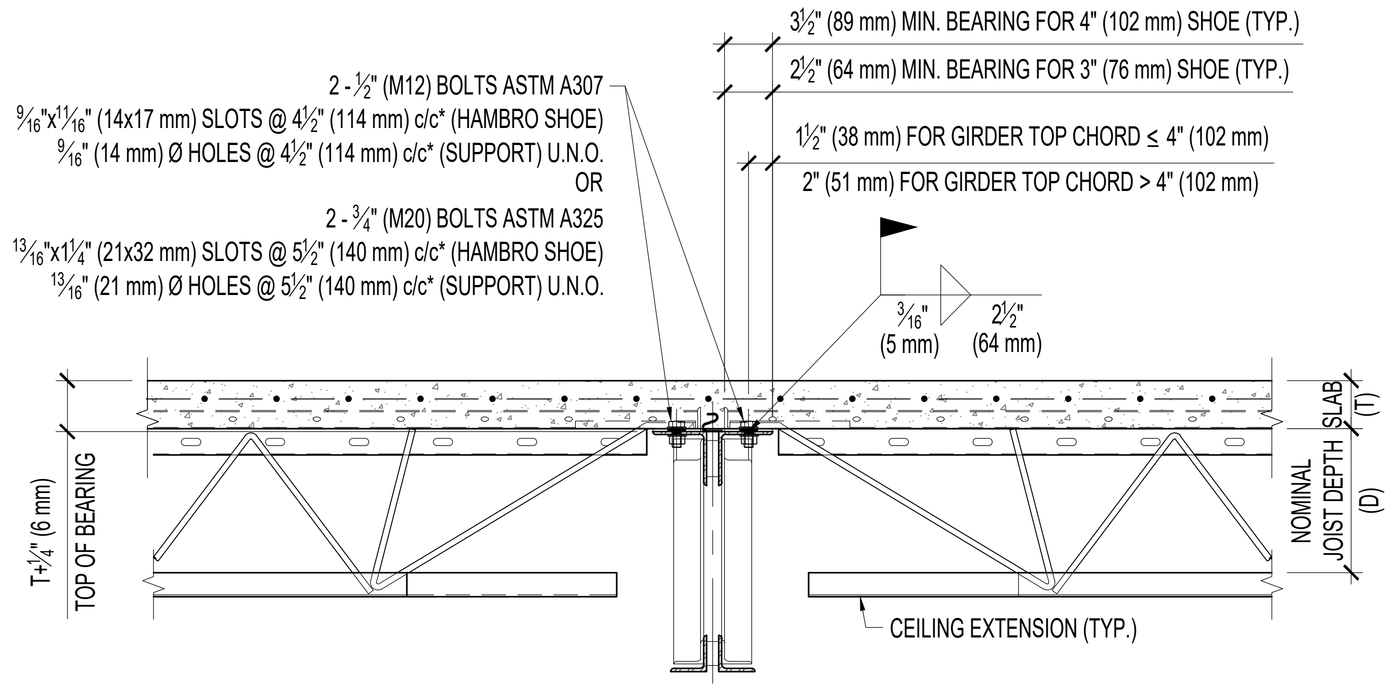


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

NOTE:
KNEE BRACING, IF REQUIRED, SEE ——— ON DRAWING. SIZE TO BE DETERMINED.

DETAIL 37

BOLTED JOIST ON GIRDER

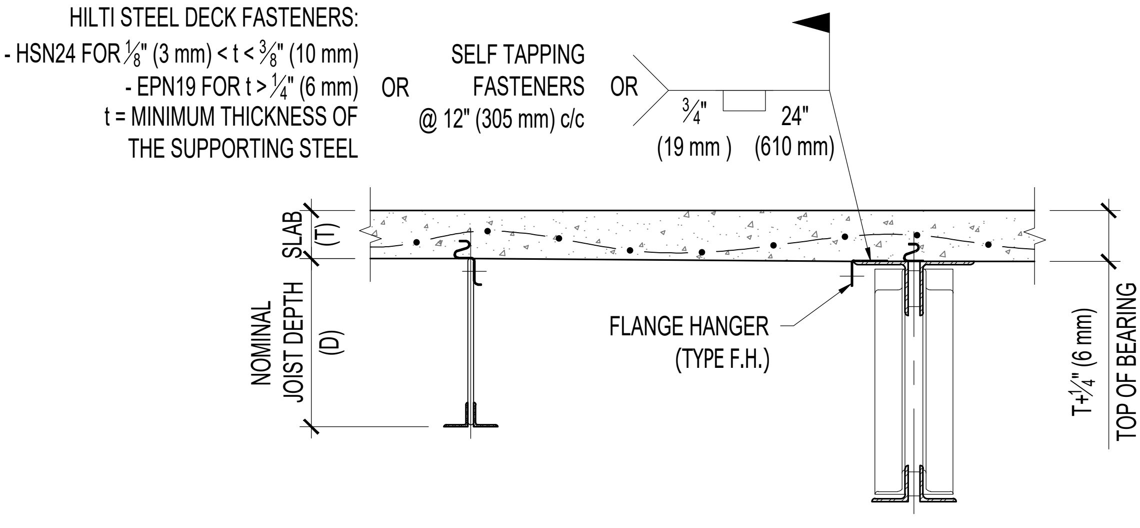


T+¼" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

* WHEN DEEP SHOE, THE c/c OF HOLE IS DIFFERENT, CONSULT THE APPROPRIATE DETAILS ON PLAN.

DETAIL 38

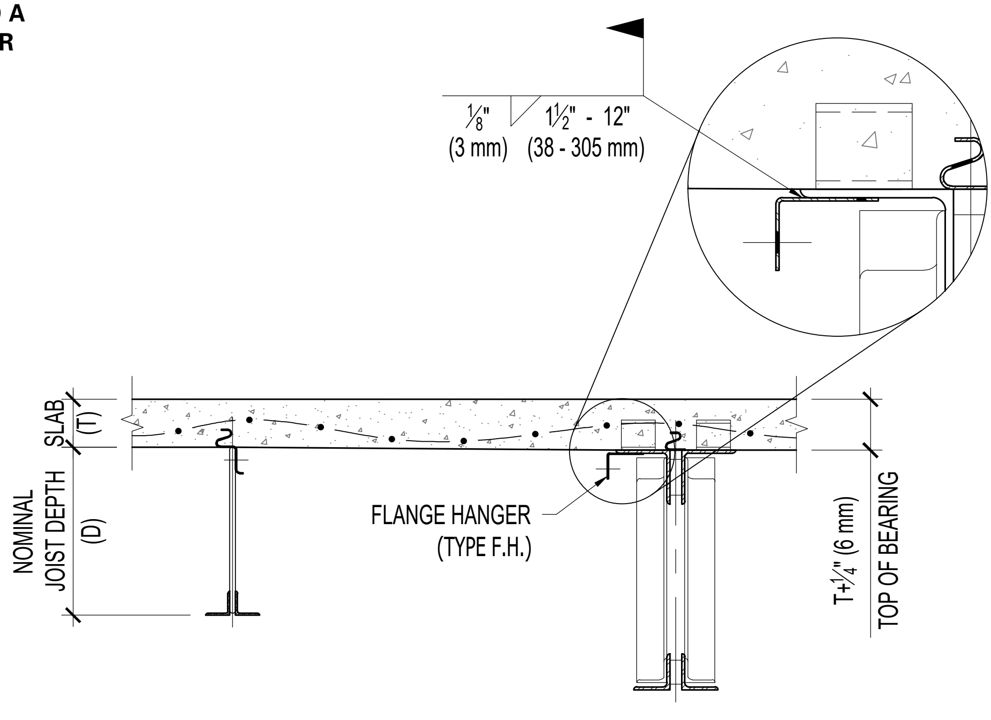
JOIST PARALLEL TO A GIRDER WITHOUT SHEAR CONNECTORS



T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

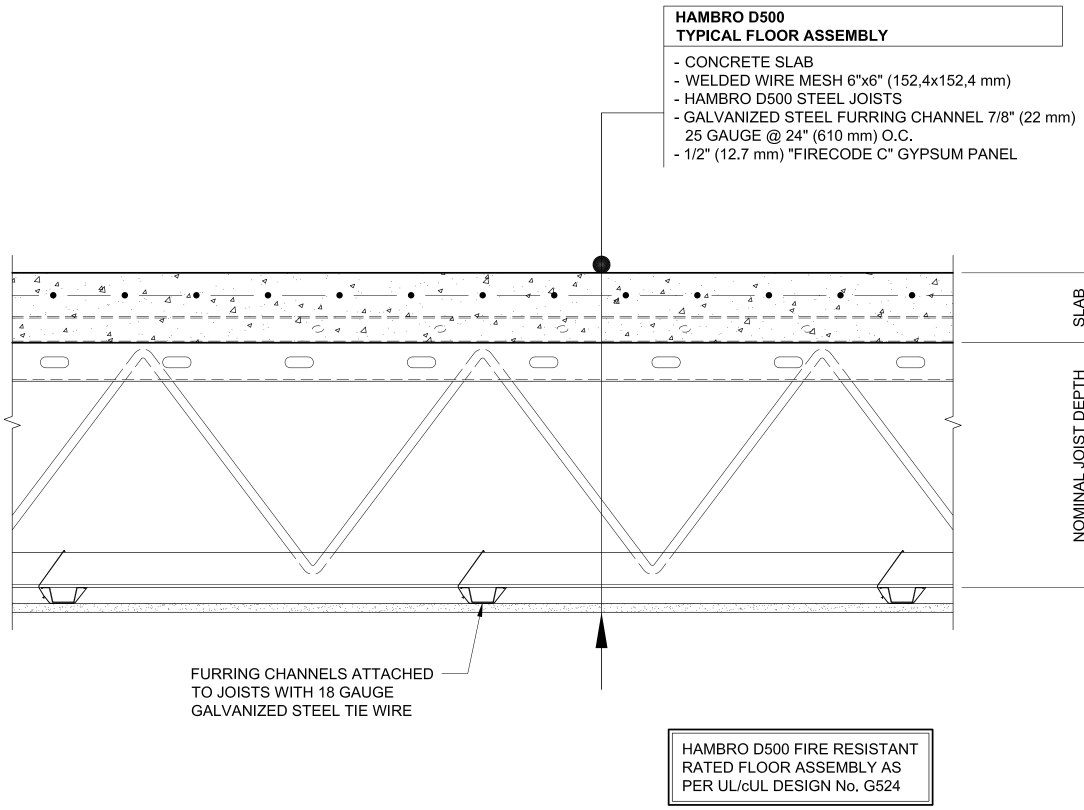
DETAIL 39

JOIST PARALLEL TO A GIRDER WITH SHEAR CONNECTORS

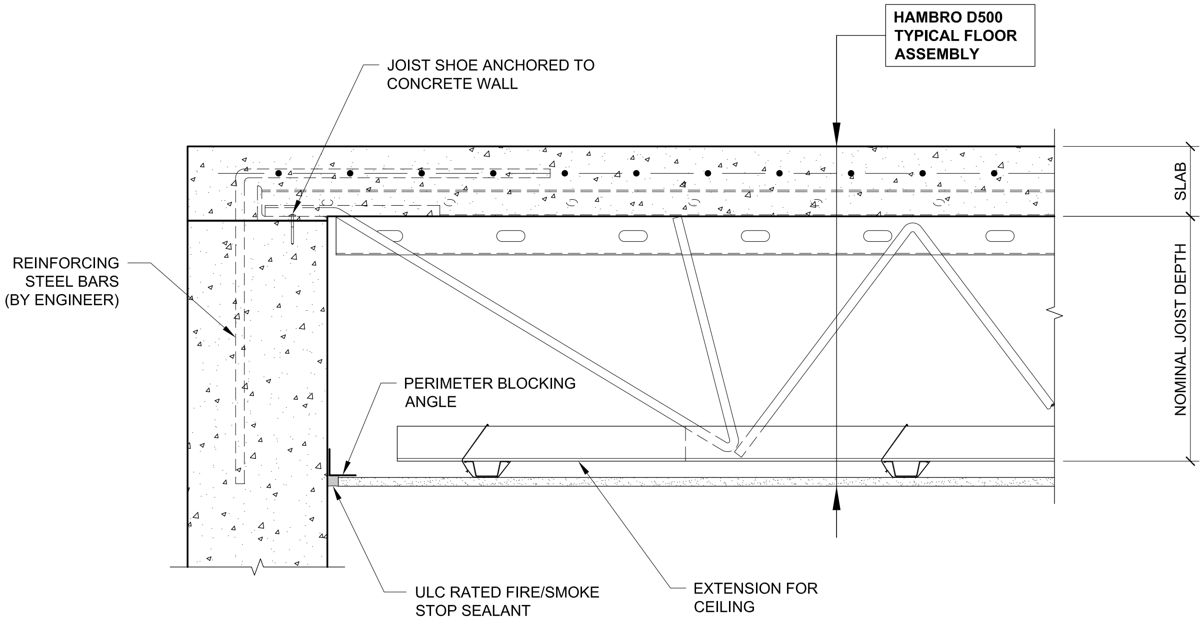


T+1/4" (6 mm) = SLAB THICKNESS + SHOE THICKNESS

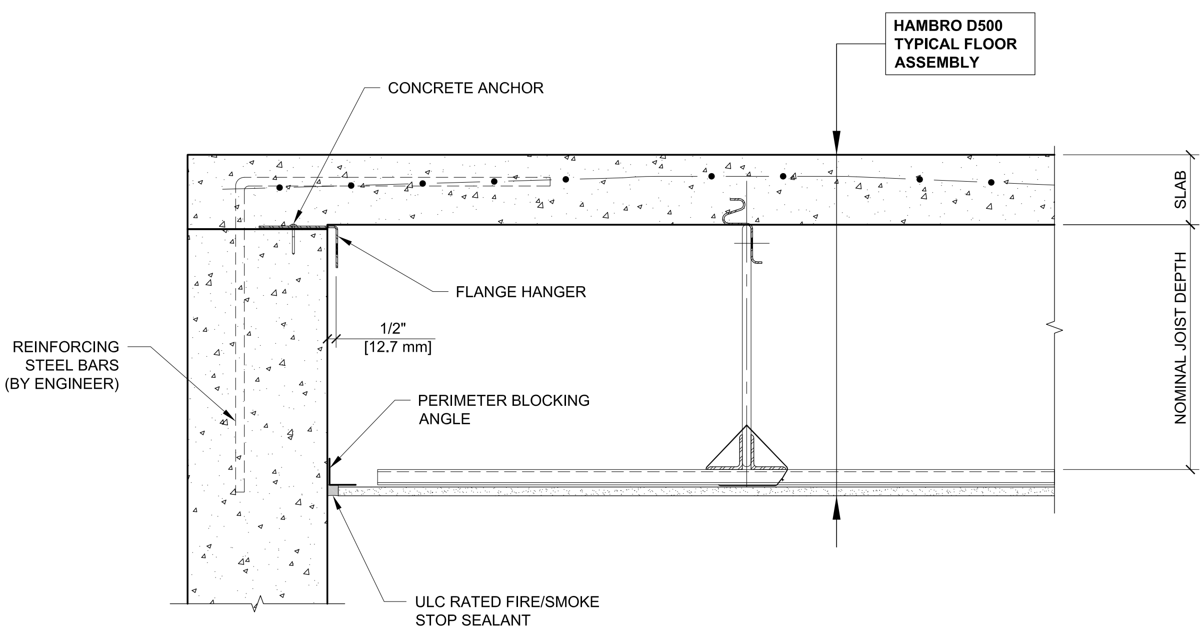
ARCHITECTURAL TYPICAL DETAILS – HAMBRO D500 (H SERIES)



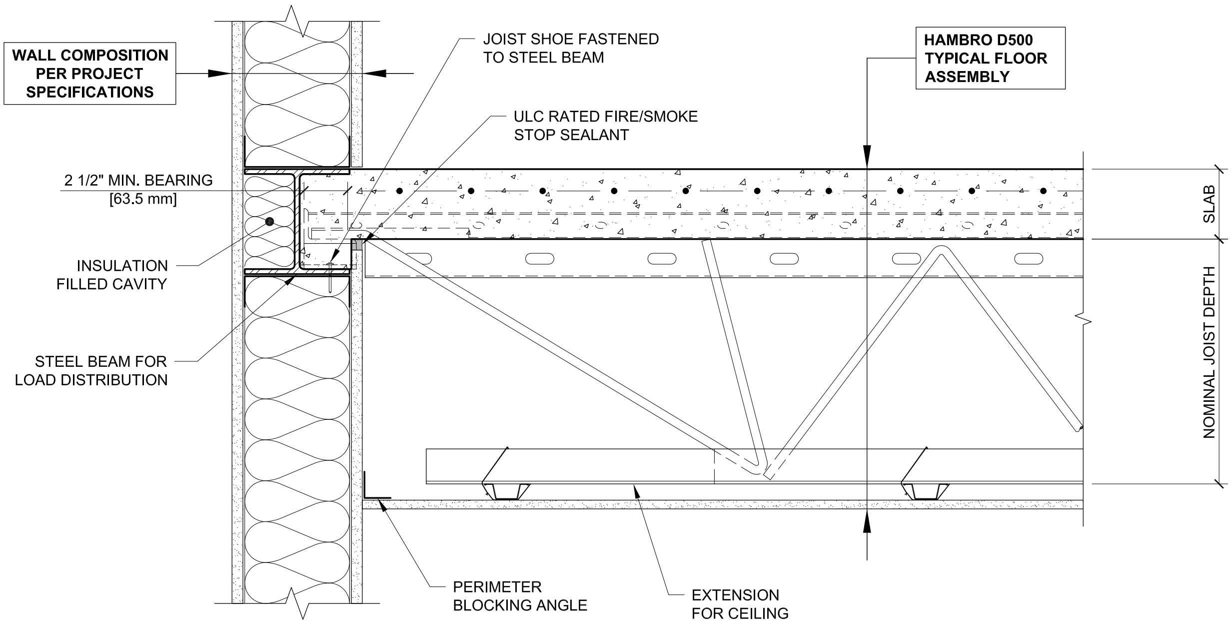
SECTION - TYPICAL FLOOR



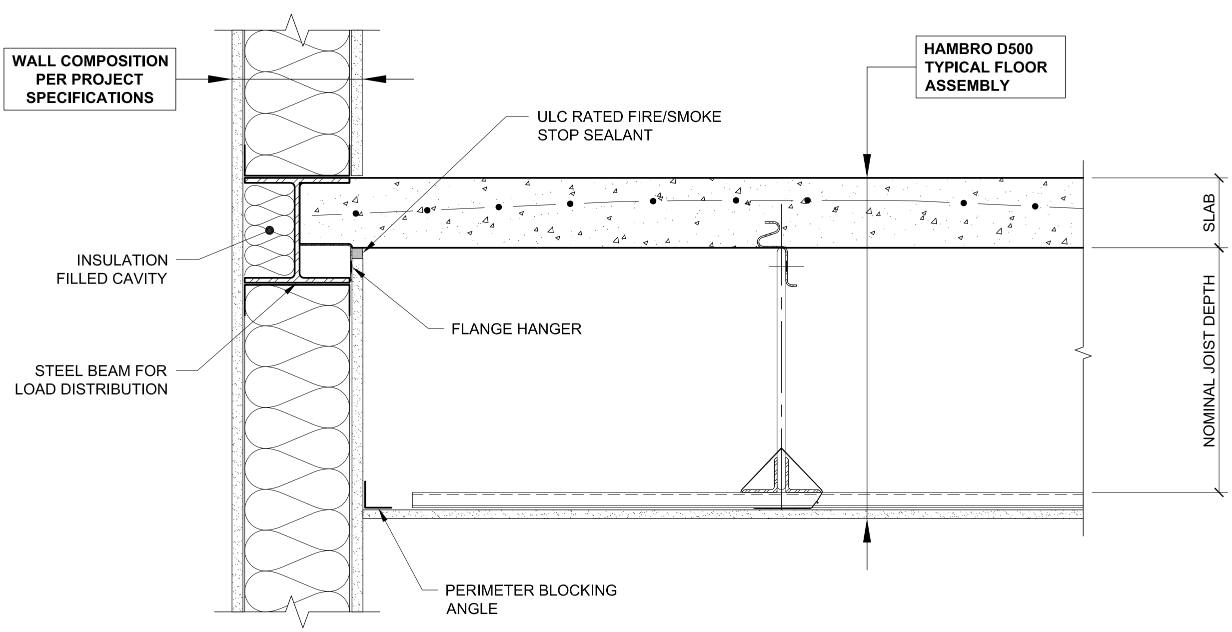
CONCRETE WALL (PERPENDICULAR)



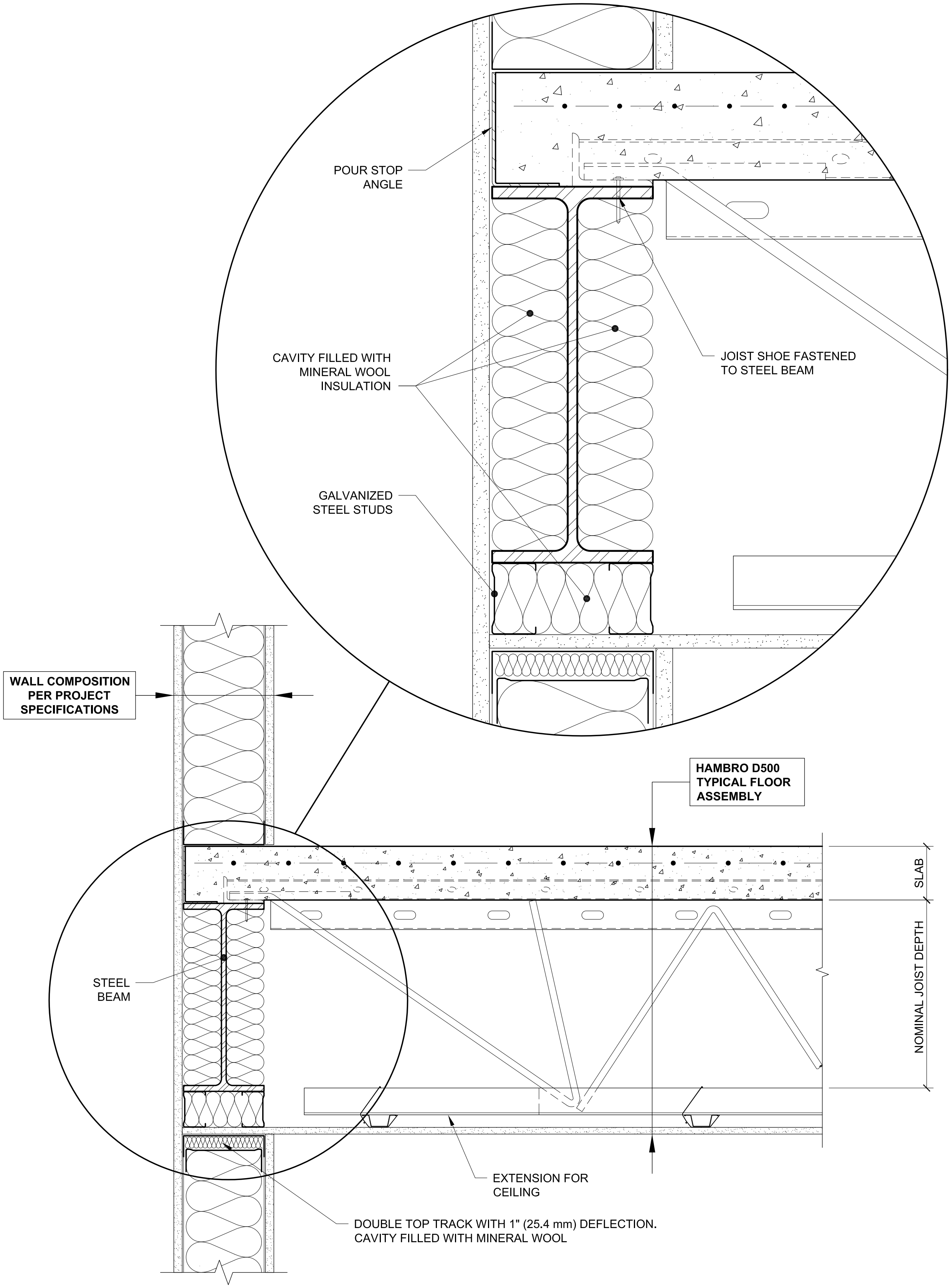
CONCRETE WALL (PARALLEL)



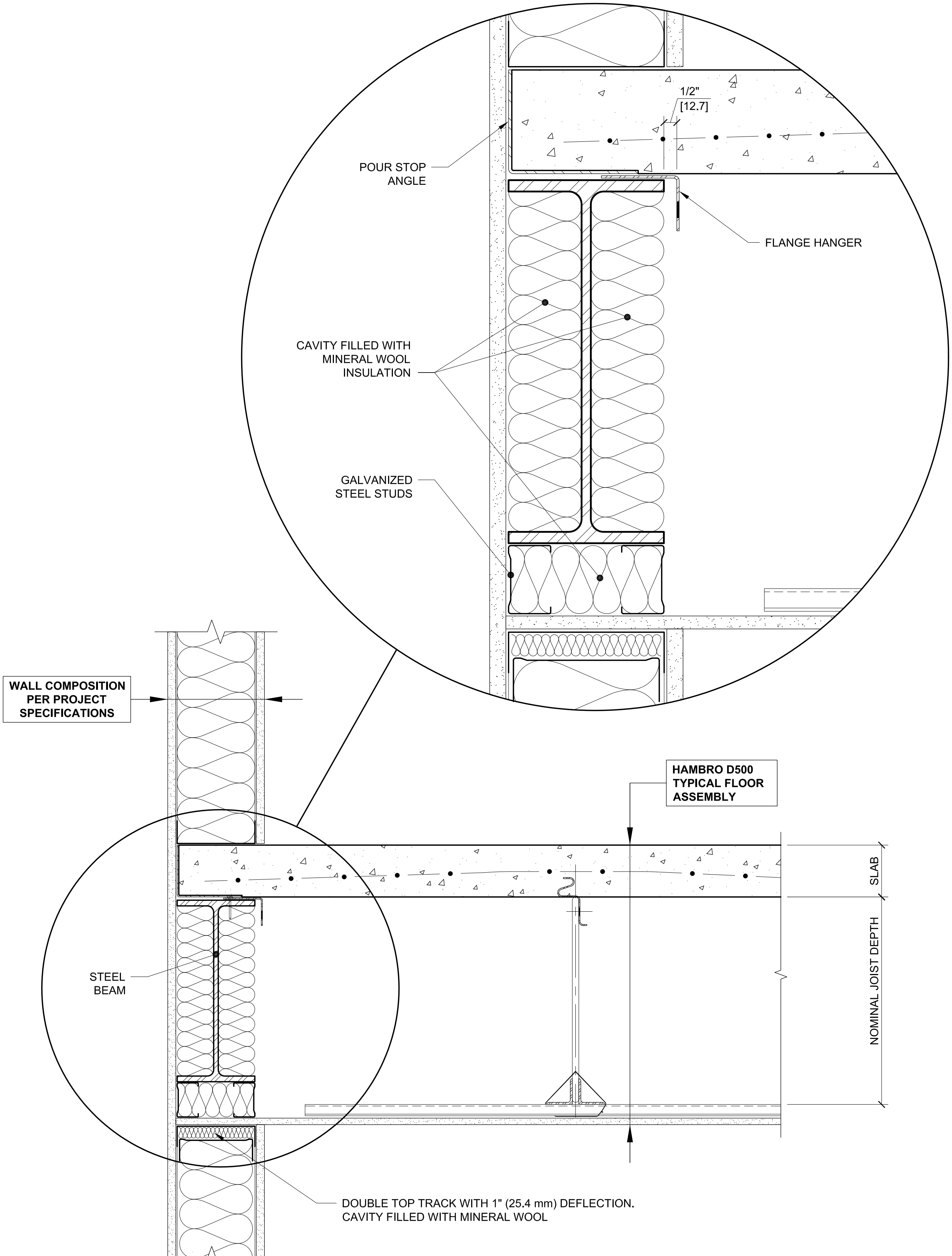
LOAD BEARING STEEL STUD WALL (PERPENDICULAR)



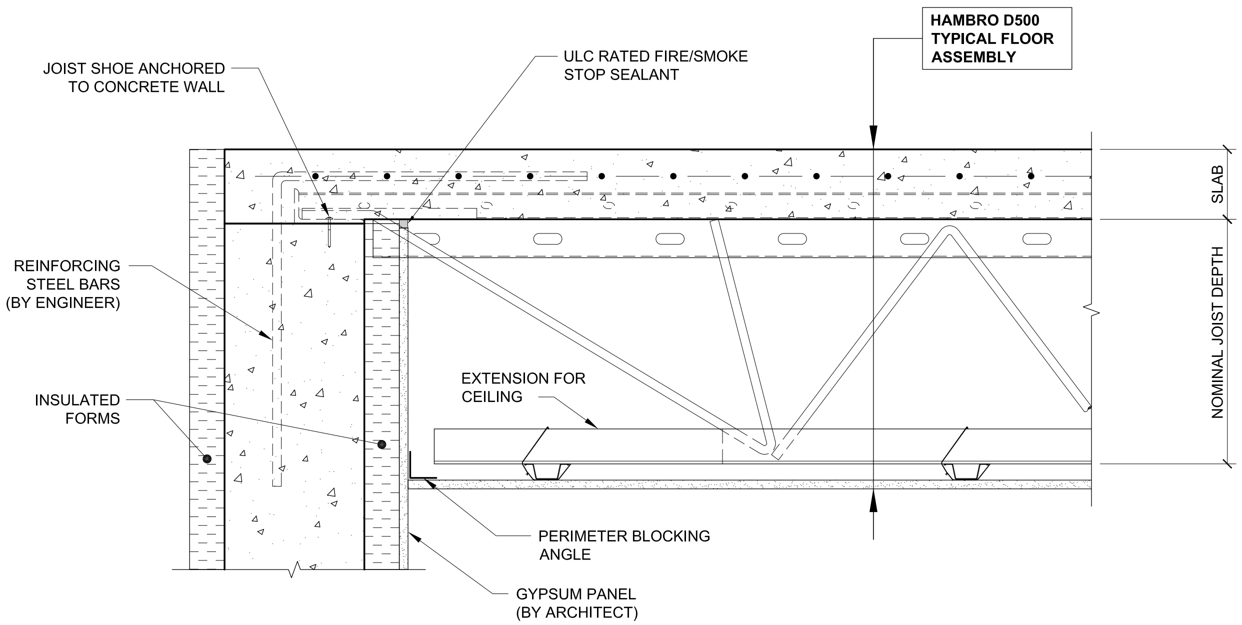
LOAD BEARING STEEL STUD WALL (PARALLEL)



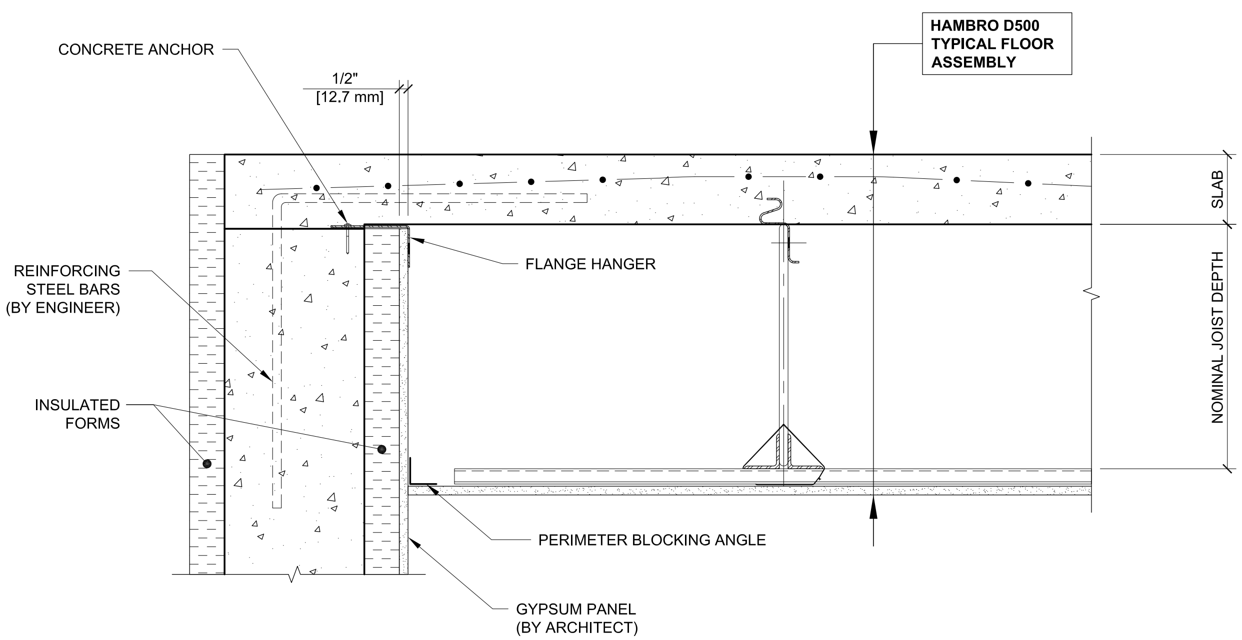
STRUCTURAL STEEL (PERPENDICULAR)



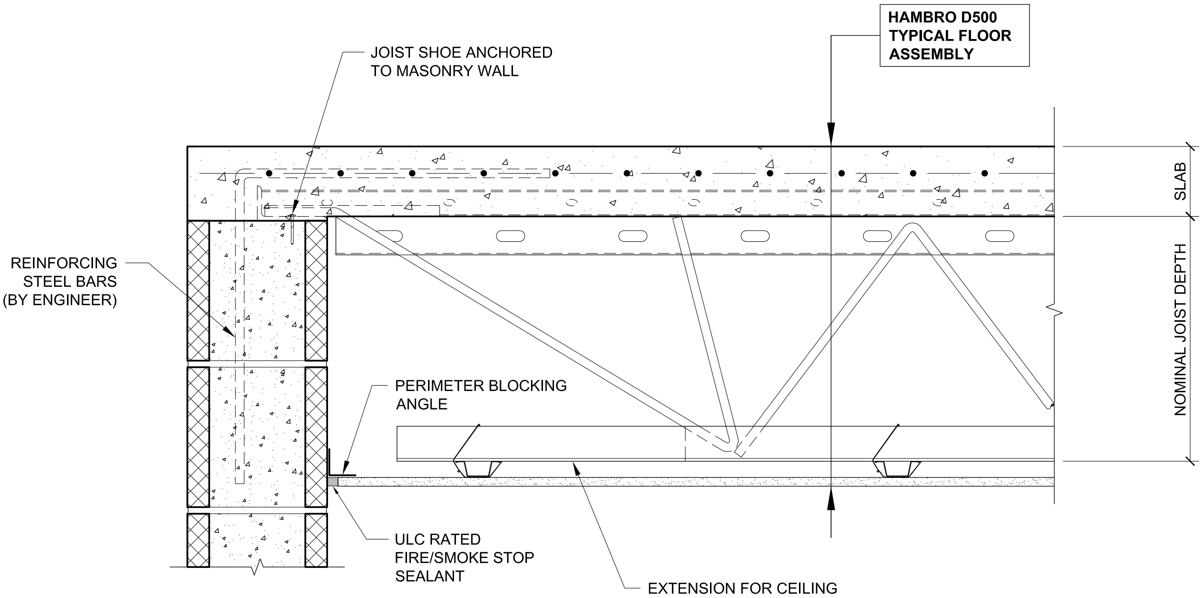
STRUCTURAL STEEL (PARALLEL)



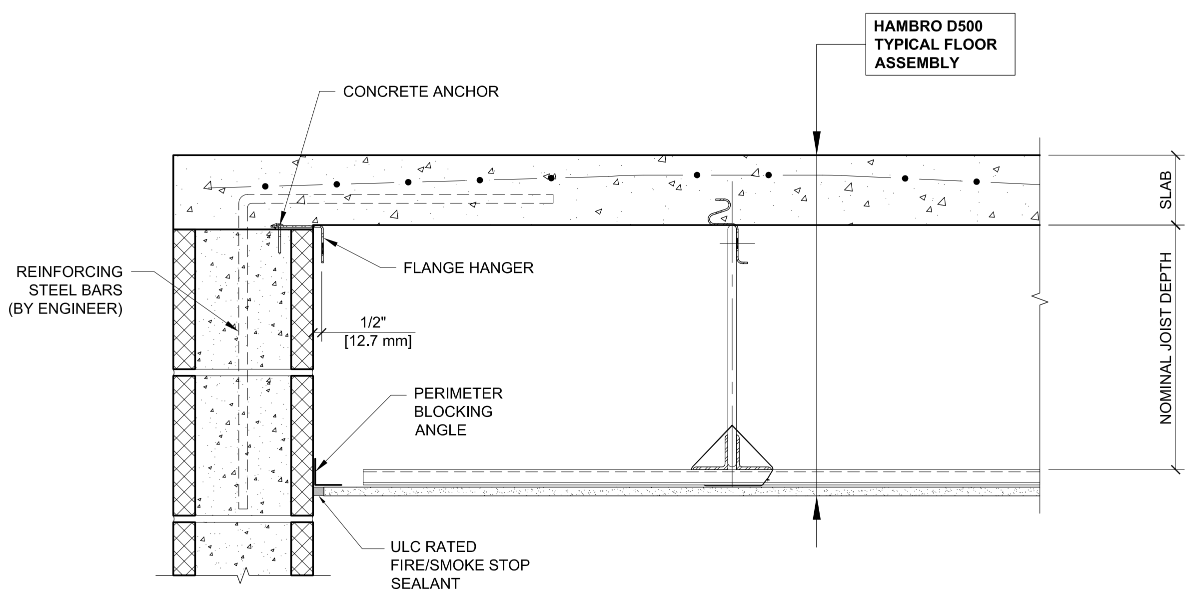
INSULATED CONCRETE FORMS WALL (PERPENDICULAR)



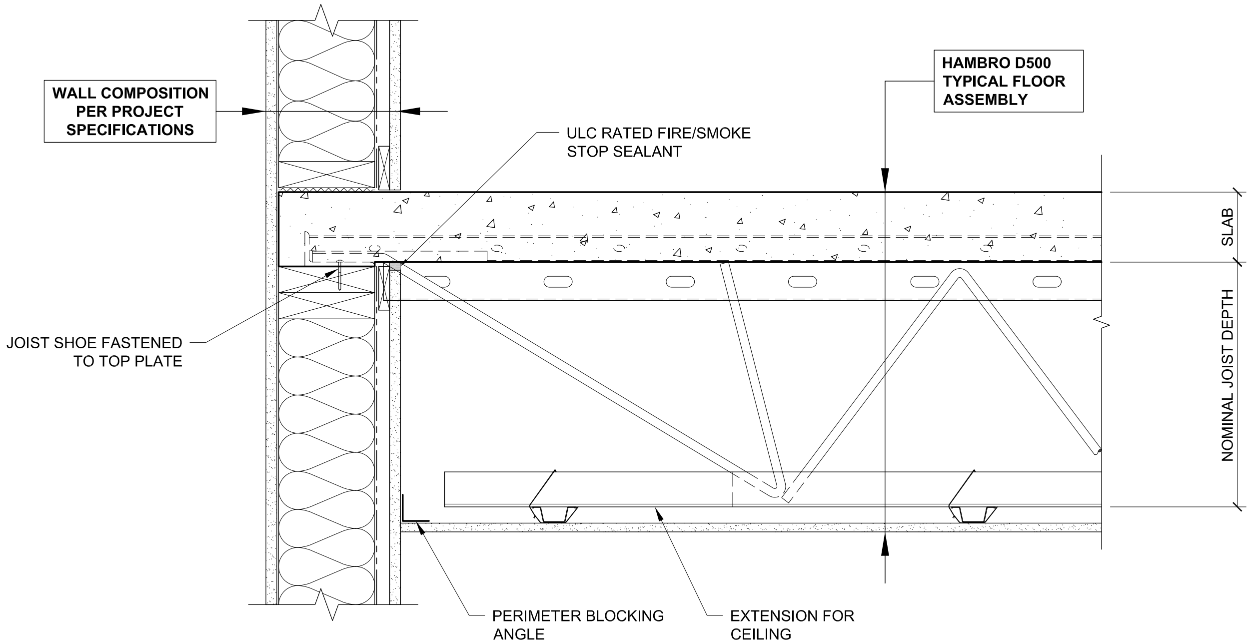
INSULATED CONCRETE FORMS WALL (PARALLEL)



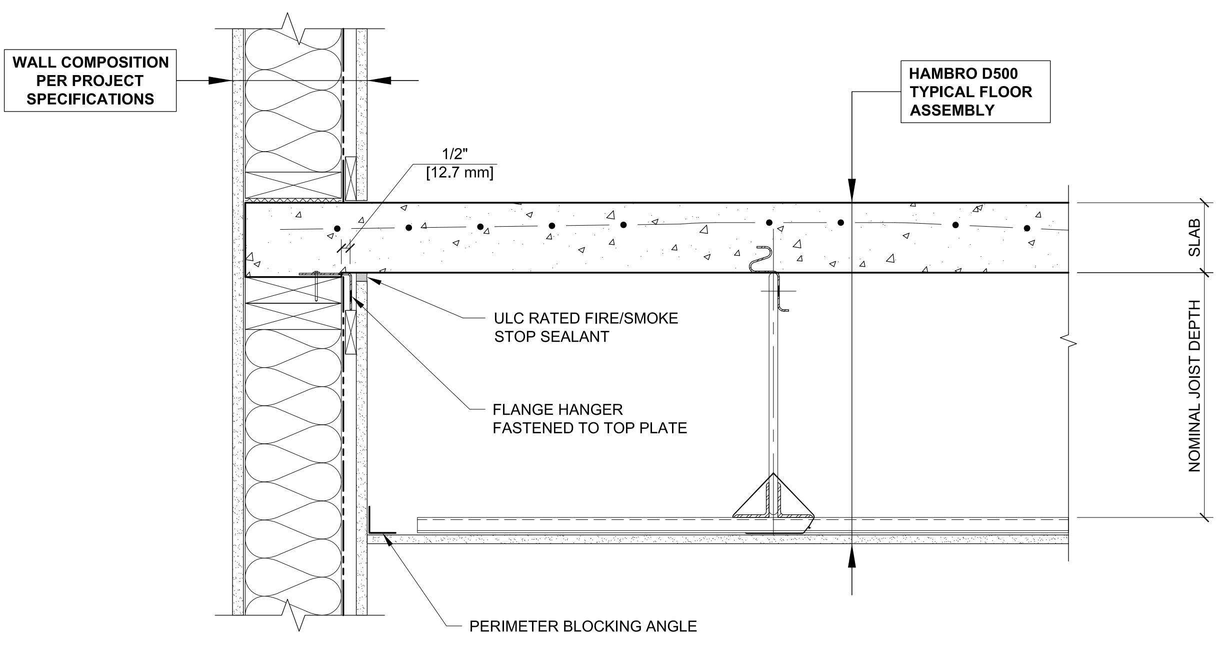
LOAD BEARING MASONRY WALL (PERPENDICULAR)



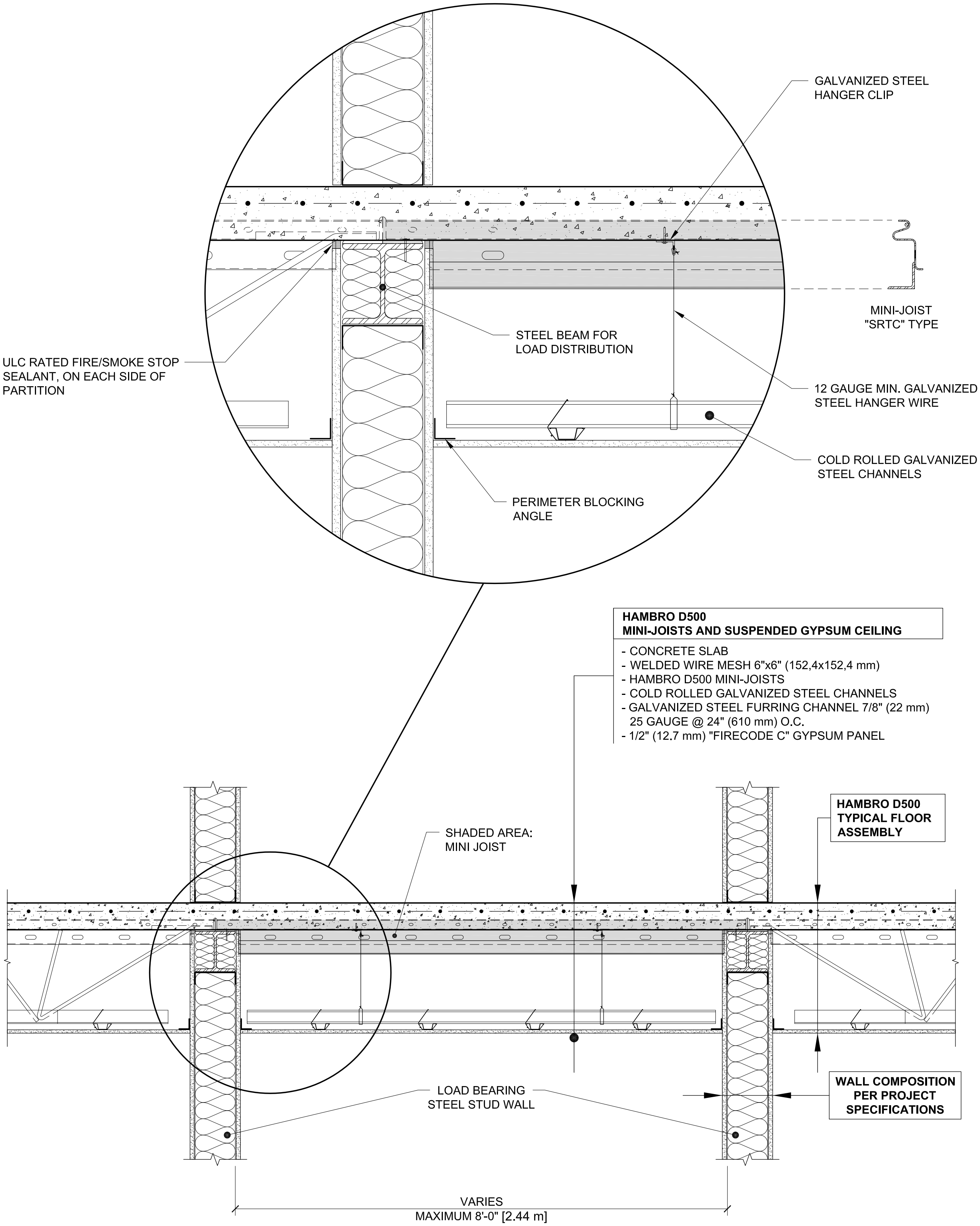
LOAD BEARING MASONRY WALL (PARALLEL)



LOAD BEARING WOOD STUD WALL (PERPENDICULAR)



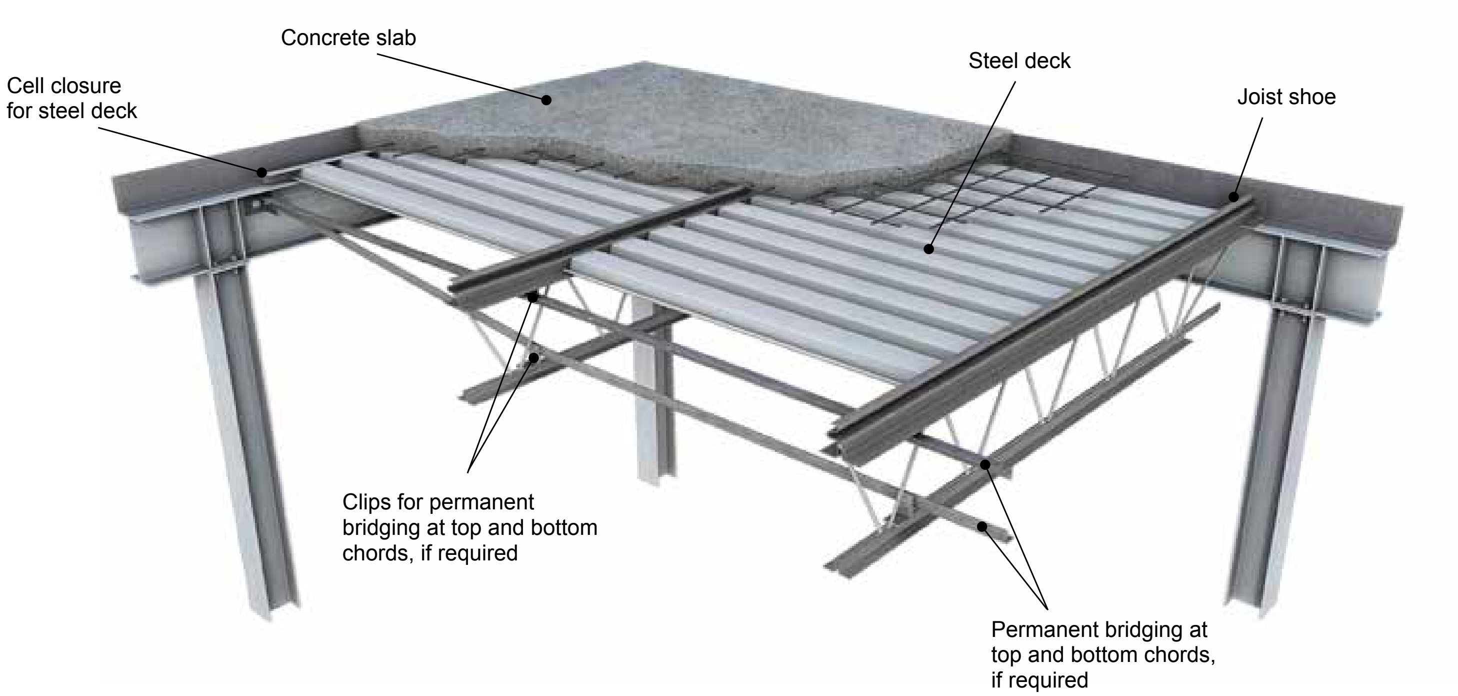
LOAD BEARING WOOD STUD WALL (PARALLEL)


GALVANIZED STEEL
HANGER CLIP
MINI-JOIST
"SRTC" TYPE
STEEL BEAM FOR
LOAD DISTRIBUTION
ULC RATED FIRE/SMOKE STOP
SEALANT, ON EACH SIDE OF
PARTITION
12 GAUGE MIN. GALVANIZED
STEEL HANGER WIRE
COLD ROLLED GALVANIZED
STEEL CHANNELS
PERIMETER BLOCKING
ANGLE
HAMBRO D500
MINI-JOISTS AND SUSPENDED GYPSUM CEILING
- CONCRETE SLAB
- WELDED WIRE MESH 6"x6" (152,4x152,4 mm)
- HAMBRO D500 MINI-JOISTS
- COLD ROLLED GALVANIZED STEEL CHANNELS
- GALVANIZED STEEL FURRING CHANNEL 7/8" (22 mm)
25 GAUGE @ 24" (610 mm) O.C.
- 1/2" (12,7 mm) "FIRECODE C" GYPSUM PANEL
HAMBRO D500
TYPICAL FLOOR
ASSEMBLY
SHADED AREA:
MINI JOIST
LOAD BEARING
STEEL STUD WALL
WALL COMPOSITION
PER PROJECT
SPECIFICATIONS
VARIES
MAXIMUM 8'-0" [2.44 m]

MINI-JOISTS

JOIST MEMBERS

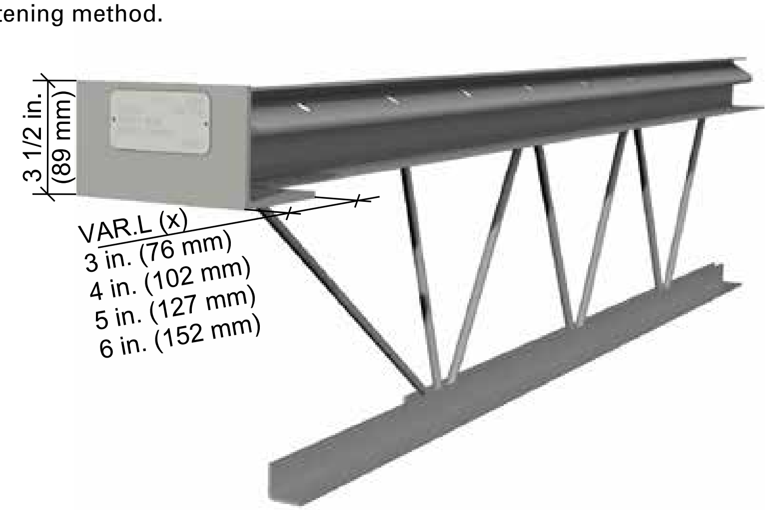
The MD2000 joist system (MDH series) features a top chord made of a cold formed "S" shaped section, an open web of bent steel rods and a wide range of two angles back-to-back (hot rolled and cold formed) as bottom chord.



MD2000 Hambro joist system

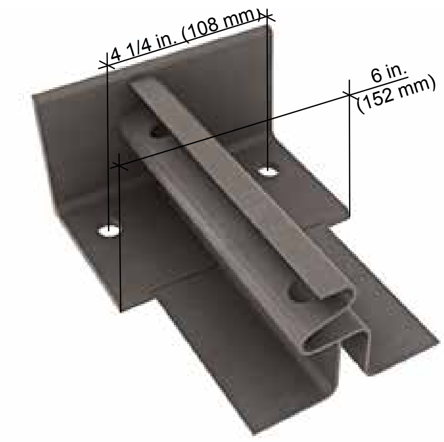
JOIST SHOE

The Hambro joist shoe consists of an angle with a vertical leg of 3½ in. (89 mm), a horizontal leg of variable lengths between 3 in. (76 mm), 4 in. (102 mm), 5 in. (127 mm) or 6 in. (152 mm), a thickness of ¼ in. (6 mm) and a variable width depending on the fastening method.

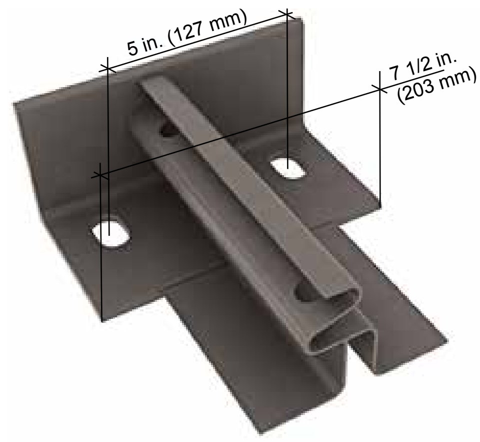


General MD2000 shoe configuration

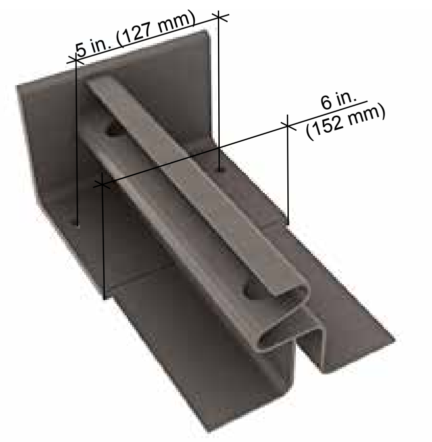
Shoe configuration is adapted according to the fastening method, options are shown in the following figure.



Bolted shoe - Option 1
Bolts ½ in. (13 mm)



Bolted shoe - Option 2
Bolts ¾ in. (19 mm)



Welded or mechanically anchored shoe

SPAN AND DEPTH

Span: up to 43 ft. (13,100 mm)
Depth: between 8 in. (200 mm) and 24 in. (600 mm)

JOIST SPACING

The standard joist spacing is 4 ft. (1,220 mm), unless noted otherwise on Canam drawings.

MAXIMUM END REACTION

The maximum factored end reaction of the MD2000 joist is 23.29 kip (103.6 kN) at the composite stage.

FORMWORK

Formwork is made of permanent P-3606 steel deck installed as single span sheet between joists.

MD2000 formwork

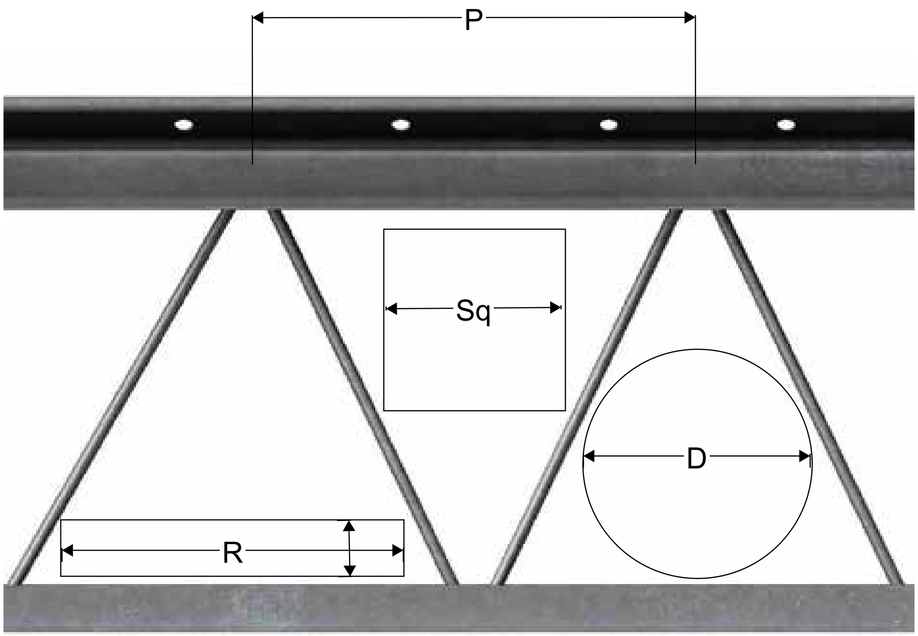
LATERAL STABILITY

At the non-composite stage, joists are braced at the top and bottom chords with steel bridging in order to prevent lateral buckling and hold the joist in the vertical plane during construction. These bridging lines must be continuous. At the end of the bay, the bridging must be firmly secured to a wall or steel beam that must be designed to carry the loads transferred by the bridging lines. If there is no wall or beam at the end of the bay, then the bottom chord can be braced temporarily to the floor below.

MD2000 bridging

MAXIMUM DUCT OPENING

The following table is a guideline for the maximum duct sizes that can fit through the openings of the different joist depths.



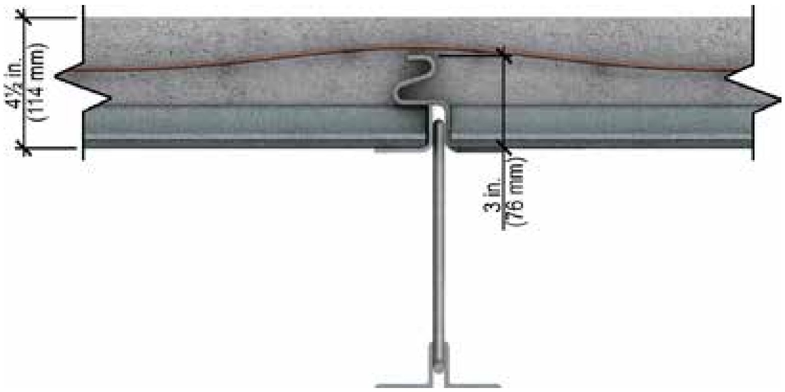
Duct opening for MD2000 joists

Maximum duct opening (in.)				
Joist depth	P	D	Sq	R
8	20	4	4	6 x 3
10	20	6	5	7 x 4
12	24	8	6	9 x 5
14	24	9	7	9½ x 6
16	24	10	8	10½ x 6½
18	24	11	8½	11 x 7
20	24	11½	9	12 x 7
22	24	12	9½	12 x 8
24	24	12½	10	13 x 8

Maximum duct opening (mm)				
Joist depth	P	D	Sq	R
200	508	100	100	150 x 75
250	508	150	125	175 x 100
300	610	200	150	225 x 125
350	610	225	175	240 x 150
400	610	250	200	265 x 165
450	610	280	216	280 x 175
500	610	292	225	310 x 175
550	610	300	240	310 x 200
600	610	315	250	330 x 200

SLAB

The minimum slab thickness is 4½ in. (114 mm) and the slab capacity chart tables on pages 86 and 87, show the total allowable load (including the dead load of the slab) based on a 3 ksi (20 MPa) concrete.



ACCESSORIES

Accessories are used to accommodate special cases.

1. Deep shoe: for height variation of joist bearing

MD2000 deep shoes

MINI-JOIST

The Hambro MD2000 top chord section, being 3⅛ in. (79 mm), possesses sufficient capacity to become the major steel component of the MD2000 mini-joist series. The two available types are illustrated in the figure below. The first type is called MD and has no reinforcement. The second one is the RMD with a rod reinforcement into the top chord. These two types have a steel angle shoe, same as the MD2000 joist.

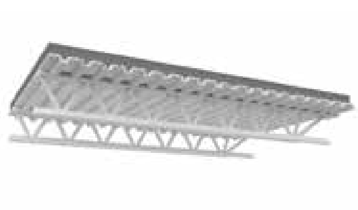
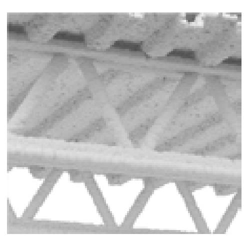
MD **RMD**

MD2000 mini-joist types

FIRE RATING

Fire protection floor/ceiling assemblies using Hambro have been tested by independent laboratories. Fire resistance ratings have been issued by Underwriters Laboratories Inc. (UL) and by Underwriters Laboratories of Canada (ULC). These tests cover gypsum board, acoustical tile and spray on protection systems.

Reference to these published listings should be made in the detailing of the ceiling construction. The following table is for information only, the original publication of these standards should be consulted before specifying it. The latest update of these listings is available on the UL directory or its website at www.ul.com or ULC website at www.ulc.ca.

<table>
<tr><th>Assembly</th><th>Assembly detail</th><th>Ceiling description</th><th>Design No.</th><th>Slab</th><th>Fire rating (h)</th><th>Beam rating (h)</th></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">Gypsum board
½ in. (12.7 mm)
Type C
or
*⅝ in. (16 mm)
Type X</td><td>I522</td><td>4½ in. (115 mm)</td><td>2</td><td>1.5</td></tr>
<tr><td>G524</td><td>Varies</td><td>1 to 3</td><td>1 to 3</td></tr>
<tr><td rowspan="6"></td><td rowspan="6"></td><td rowspan="6">Suspended
or ceiling tile</td><td>G203</td><td>4¼ in. (105 mm)</td><td>2</td><td>2</td></tr>
<tr><td rowspan="2">G213</td><td>4 in. (100 mm)</td><td>2</td><td>2</td></tr>
<tr><td>4¾ in. (120 mm)</td><td>3</td><td>3</td></tr>
<tr><td>G227</td><td>4 in. (100 mm)</td><td>2</td><td>2</td></tr>
<tr><td>G228</td><td>4 in. (100 mm)</td><td>1.5 to 2</td><td>1.5 to 2</td></tr>
<tr><td>G229</td><td>4 in. (100 mm)</td><td>3</td><td>3</td></tr>
<tr><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">Spray on</td><td>G702</td><td>Varies</td><td>1 to 3</td><td>-</td></tr>
<tr><td>I800</td><td>4 to 5 in.
(100 to 125 mm)</td><td>1 to 2</td><td>1</td></tr>
<tr><td>G802</td><td>Varies</td><td>1 to 3</td><td>-</td></tr>
</table>

*⅝ in. (16 mm) type X applicable only in G524 for 1 hour fire rating.

Please contact your Canam sales representative for any questions regarding the system's fire rating.

ACOUSTICAL PROPERTIES

SOUND TRANSMISSION CLASS (STC)

The STC is a rating that assigns a numerical value to the sound insulation provided by a partition separating rooms or areas. The rating is designed to match subjective impressions of the sound insulation provided against the sounds of speech, music, television, office machines and similar sources of airborne noise that are characteristic of offices and dwellings.

Here are the guidelines for a sample of STC ratings:

STC Rating	Practical guidelines
25	Normal speech easily understood
30	Normal speech audible, but not intelligible
35	Loud speech audible, fairly understandable
40	Loud speech audible, but not intelligible
45	Loud speech barely audible
50	Shouting barely audible
55	Shouting inaudible

IMPACT INSULATION CLASS (IIC)

The Impact Insulation Class (IIC) is a rating designed to measure the impact sound insulation provided by the floor/ceiling construction. The IIC of any assembly is strongly affected by and dependent upon the type of floor finish for its resistance to impact noise transmission.

ACOUSTICAL PERFORMANCES

The result in the following table have been obtained following laboratory testing. Field testing may vary depending on the quality of the assembly and the various materials used. Note that the minimum design slab thickness for Hambro MD2000 system is 4½ in. (114 mm).

Hambro assemblies					STC	IIC	Laboratory
Assembly	Total slab thickness in. (mm)	Steel deck	Gypsum thickness in. (mm)	# of gypsum layer			
	4 (102)	P-3606 gage 22	½ (12.7)	1	52	27	NGC Testing Services Buffalo, NY, USA www.ngctestingservices.com

Since the assemblies can have a wide range of components and performances, please contact a Canam representative for further information on the STC and IIC scores.

ACOUSTICAL ASSOCIATIONS AND CONSULTANTS

Because sound transmission and impact insulation depends upon a number of variables relating to the installation and materials used, Canam makes no assessments about the sound transmission performance of its products as installed. You should consult with a qualified acoustical consultant if you would like information about the final sound performance on the project.

The following is a list of acoustical associations that may be found on the Internet:

1. National Council of Acoustical Consultants - www.ncac.com;
2. Canadian Acoustical Association – www.caa-aca.ca;
3. Acoustical Society of America – www.asa.aip.org;
4. Institute of Noise Control Engineering – www.inceusa.org.

As a convenience, Canam is providing the following list of vendors who have worked with the Hambro product. This list is not an endorsement. Canam has no affiliation with these providers, and makes no representations concerning their abilities.

Sieben Associates, Inc.
625 NW 60th Street, Suite C
Gainesville, FL
32607
United States

Acousti-Lab
Robert Ducharme
C.P. 5028
Ste-Anne-des-Plaines, QC
J0N 1H0
Canada

Octave Acoustique, Inc.
Christian Martel, M. Sc. Arch.
963, chemin Royal
Saint-Laurent-de-l'île-d'Orléans, QC
G0A 4N0
Canada

Acousti-Tech
Vincent Moreau
150, rue Léon-Vachon
Saint-Lambert-de-Lauzon, QC
G0S 2N0
Canada

SELECTION TABLES

MD2000 JOIST SPAN TABLES

The joist span tables are provided to assist engineers in selecting the most optimal depth of joist for a particular slab thickness and a specific loading. The engineer must specify the joist depth, slab thickness, the design loads, special point loads and linear loads where applicable. Canam will provide composite joists designed to meet these requirements.

The following load tables are guidelines and give the optimized depth for specific span, slab thickness and loads. The optimal situation is represented by the value 1.00 in the tables. Values greater than 1.00 represent the additional weight percentage at the optimum value. The first depth recorded per table indicate the minimum that could be used for the length specified.

Other types of loading and slab thickness than the ones shown in this section can be used for the Hambro MD2000 system. If the criteria for your project are different from those contained in the tables, please contact a Canam representative for assistance.

Note:

The validation of the optimal depth must be done in conjunction with the validation of the concrete slab capacity.

Joist spacing and concrete strength table

Values indicated are calculated with a regular spacing of 4 ft. (1,220 mm) and a concrete strength of 3 ksi (20 MPa).

Loads

Live load

The tables have been prepared for four categories of loading depending on the usage of the floor:

Use	Uniform load	or	Point load
Residential	40 psf (1.92 kPa)		1.01 kip (4.5 kN)
Office	50 psf (2.4 kPa)		2.02 kip (9 kN)
Corridor/lobby	100 psf (4.8 kPa)		1.01 kip (4.5 kN) or 2.02 kip (9 kN)
Garage	50 psf (2.4 kPa)		4.05 kip (18 kN)

Dead load

The tables have been prepared for different slab thicknesses, therefore different dead loads:

Total slab thickness	Dead load
4½ in. (115 mm)	73 psf (3.50 kPa)
5 in. (125 mm)	79 psf (3.78 kPa)
5½ in. (140 mm)	85 psf (4.07 kPa)
6 in. (150 mm)	91 psf (4.36 kPa)
6½ in. (165 mm)	97 psf (4.64 kPa)

Note:
The total slab thickness includes the steel deck.

MD2000 slab thickness

Deflection criteria

For all cases presented in the tables, deflection for live load does not exceed $L/360$.

Vibration criteria

Maximum peak acceleration in full height partition: 0.5% a/g
Damping: 5%

Joist designation

MD2000 joists are designated MDHXX (MDHXXX) on drawings. For example, MDH14 (MDH350) means that the joist is 14 in. (350 mm) depth. The depth of a joist is measured from the underside of the plain slab thickness (top of steel deck) to the extremity of the bottom chord.

Example

Find the optimal depth and the minimum depth for the following office project with Hambro MD2000 joists (MDH series).

	Imperial	Metric
Span	32 ft.	(9,755 mm)
Slab thickness	5½ in.	(140 mm)
Joists spacing	4 ft.	(1,220 mm)
Concrete strength	3 ksi	(20 MPa)
Concrete density	150 pcf	(2,400 kg/m^3)
Live load	50 psf	(2.4 kPa)
Dead load	85 psf	(4.07 kPa)
- Joist	3.15 psf	(0.15 kN/m^2)
- Concrete	54 psf	(2.59 kN/m^2)
- Mechanical	2.5 psf	(0.12 kN/m^2)
- Ceiling	3.15 psf	(0.15 kN/m^2)
- Partition	20 psf	(0.96 kN/m^2)
- Steel deck	2 psf	(0.10 kN/m^2)

Using this information, you can find in the tables that:

1. The optimal joist depth is: 20 in. (500 mm).
2. The minimum joist depth is: 14 in. (350 mm).

MD2000 span tables

- 1.xx Most optimal situation of the live load category
- 1.xx Most optimal depth according to slab thickness
- End joist reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity

		Residential					Office					Corridor/lobby					Garage
Live loads		40 psf (1.92 kPa)					50 psf (2.4 kPa)					100 psf (4.8 kPa)					50 psf (2.4 kPa)
Slab thickness (in.)		4½	5	5½	6	6½	4½	5	5½	6	6½	4½	5	5½	6	6½	6½
Slab thickness (mm)		115	125	140	150	165	115	125	140	150	165	115	125	140	150	165	165
Length (ft. / mm)	Depth (in. / mm)																
12 ft. / 3,660 mm	8 in. / 200 mm	1.04	1.04	1.04	1.06	1.06	1.04	1.04	1.06	1.06	1.08	1.06	1.06	1.08	1.08	1.08	1.07
	10 in. / 250 mm	1.06	1.08	1.08	1.08	1.08	1.09	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.07
	12 in. / 300 mm	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.06
	14 in. / 350 mm	1.00	1.01	1.01	1.01	1.01	1.00	1.01	1.01	1.01	1.01	1.00	1.01	1.01	1.01	1.01	1.00
	16 in. / 400 mm	1.03	1.03	1.03	1.06	1.06	1.03	1.03	1.03	1.03	1.07	1.03	1.03	1.03	1.03	1.07	1.02
	18 in. / 450 mm	1.09	1.09	1.13	1.13	1.13	1.10	1.10	1.14	1.14	1.14	1.10	1.10	1.14	1.14	1.14	1.12
	20 in. / 500 mm	1.15	1.15	1.15	1.15	1.15	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.19
14 ft. / 4,270 mm	8 in. / 200 mm	1.02	1.03	1.03	1.03	1.03	1.03	1.03	1.05	1.05	1.05	1.02	1.04	1.07	1.07	1.07	1.04
	10 in. / 250 mm	1.05	1.05	1.05	1.05	1.08	1.07	1.07	1.07	1.07	1.10	1.07	1.07	1.10	1.10	1.09	1.09
	12 in. / 300 mm	1.02	1.02	1.06	1.06	1.06	1.02	1.02	1.02	1.06	1.06	1.04	1.04	1.04	1.04	1.04	1.06
	14 in. / 350 mm	1.00	1.00	1.03	1.03	1.03	1.00	1.00	1.00	1.03	1.03	1.00	1.00	1.00	1.00	1.00	1.00
	16 in. / 400 mm	1.04	1.04	1.04	1.06	1.06	1.05	1.05	1.05	1.05	1.07	1.02	1.02	1.04	1.04	1.04	1.04
	18 in. / 450 mm	1.10	1.12	1.12	1.12	1.12	1.11	1.13	1.13	1.13	1.13	1.10	1.10	1.10	1.10	1.14	1.15
	20 in. / 500 mm	1.15	1.15	1.15	1.15	1.19	1.16	1.16	1.16	1.16	1.16	1.13	1.17	1.17	1.17	1.17	1.18
16 ft. / 4,880 mm	8 in. / 200 mm	1.00	1.02	1.02	1.02	1.02	1.01	1.01	1.01	1.06	1.06	1.09	1.07	1.08	1.08	1.08	1.06
	10 in. / 250 mm	1.02	1.05	1.05	1.06	1.06	1.03	1.06	1.06	1.09	1.09	1.05	1.08	1.08	1.08	1.08	1.08
	12 in. / 300 mm	1.02	1.02	1.02	1.02	1.02	1.04	1.03	1.03	1.03	1.03	1.04	1.04	1.04	1.04	1.08	1.03
	14 in. / 350 mm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.02	1.02	1.02	1.00	1.00	1.00	1.03	1.03	1.00
	16 in. / 400 mm	1.02	1.02	1.02	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.05	1.05	1.05	1.05	1.05	1.05
	18 in. / 450 mm	1.08	1.08	1.11	1.11	1.11	1.10	1.10	1.10	1.10	1.14	1.11	1.11	1.14	1.14	1.14	1.13
	20 in. / 500 mm	1.13	1.13	1.16	1.16	1.16	1.13	1.16	1.16	1.16	1.19	1.17	1.17	1.17	1.17	1.20	1.18
18 ft. / 5,490 mm	8 in. / 200 mm	1.07	1.00	1.01	1.02	1.03	1.04	1.01	1.01	1.02	1.03	1.08	1.08	1.10	1.12	1.12	1.09
	10 in. / 250 mm	1.03	1.03	1.03	1.03	1.03	1.00	1.03	1.03	1.03	1.02	1.05	1.05	1.08	1.08	1.08	1.08
	12 in. / 300 mm	1.02	1.02	1.05	1.04	1.04	1.01	1.01	1.01	1.01	1.01	1.03	1.03	1.03	1.03	1.03	1.04
	14 in. / 350 mm	1.00	1.00	1.02	1.02	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	16 in. / 400 mm	1.04	1.04	1.05	1.05	1.05	1.02	1.02	1.02	1.04	1.04	1.03	1.03	1.03	1.03	1.05	1.04
	18 in. / 450 mm	1.10	1.10	1.10	1.10	1.10	1.07	1.10	1.10	1.11	1.11	1.09	1.09	1.11	1.11	1.11	1.10
	20 in. / 500 mm	1.13	1.13	1.13	1.14	1.16	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.16	1.16	1.17
20 ft. / 6,100 mm	8 in. / 200 mm	1.22	1.05	1.05	1.12	1.16	1.25	1.14	1.16	1.12	1.17	1.16	1.19	1.20	1.20	1.18	1.15
	10 in. / 250 mm	1.09	1.02	1.02	1.05	1.06	1.12	1.05	1.07	1.06	1.11	1.11	1.12	1.09	1.13	1.14	1.11
	12 in. / 300 mm	1.03	1.01	1.01	1.03	1.03	1.03	1.03	1.03	1.06	1.08	1.06	1.07	1.07	1.10	1.10	1.07
	14 in. / 350 mm	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.02	1.05	1.00	1.00	1.02	1.02	1.02	1.00
	16 in. / 400 mm	1.02	1.02	1.02	1.02	1.04	1.02	1.04	1.07	1.07	1.07	1.02	1.02	1.02	1.04	1.04	1.00
	18 in. / 450 mm	1.07	1.07	1.10	1.10	1.13	1.13	1.13	1.13	1.16	1.16	1.07	1.09	1.09	1.09	1.09	1.12
	20 in. / 500 mm	1.12	1.12	1.16	1.16	1.16	1.16	1.16	1.18	1.18	1.21	1.12	1.12	1.12	1.17	1.17	1.17

MD2000 span tables

1.xx	Most optimal situation of the live load category
1.xx	Most optimal depth according to slab thickness
	End joist reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity

		Residential					Office					Corridor/lobby					Garage
Live loads		40 psf (1.92 kPa)					50 psf (2.4 kPa)					100 psf (4.8 kPa)					50 psf (2.4 kPa)
Slab thickness (in.)		4½	5	5½	6	6½	4½	5	5½	6	6½	4½	5	5½	6	6½	6½
Slab thickness (mm)		115	125	140	150	165	115	125	140	150	165	115	125	140	150	165	165
Length (ft. / mm)	Depth (in. / mm)																
22 ft. / 6,710 mm	10 in. / 250 mm	1.23	1.12	1.13	1.14	1.14	1.23	1.15	1.18	1.22	1.24	1.15	1.15	1.15	1.16	1.18	1.12
	12 in. / 300 mm	1.08	1.03	1.03	1.06	1.10	1.08	1.08	1.10	1.11	1.12	1.06	1.06	1.06	1.07	1.08	1.07
	14 in. / 350 mm	1.00	1.00	1.00	1.02	1.05	1.00	1.04	1.07	1.07	1.07	1.02	1.02	1.02	1.02	1.02	1.00
	16 in. / 400 mm	1.00	1.02	1.05	1.05	1.07	1.05	1.05	1.07	1.07	1.07	1.00	1.04	1.04	1.04	1.06	1.01
	18 in. / 450 mm	1.11	1.11	1.11	1.13	1.13	1.10	1.13	1.13	1.13	1.15	1.03	1.07	1.07	1.07	1.07	1.09
	20 in. / 500 mm	1.13	1.13	1.16	1.16	1.18	1.16	1.16	1.18	1.19	1.19	1.08	1.12	1.12	1.12	1.12	1.10
	22 in. / 550 mm	1.17	1.19	1.21	1.23	1.23	1.21	1.23	1.23	1.23	1.25	1.15	1.15	1.15	1.15	1.18	1.18
24 ft. / 7,315 mm	10 in. / 250 mm	1.30	1.13	1.15	1.20	1.20	1.24	1.16	1.18	1.19	1.21	1.18	1.20	1.22	1.24	1.24	1.15
	12 in. / 300 mm	1.15	1.07	1.10	1.10	1.14	1.11	1.06	1.08	1.08	1.11	1.09	1.11	1.12	1.18	1.19	1.09
	14 in. / 350 mm	1.00	1.02	1.05	1.05	1.07	1.00	1.00	1.02	1.03	1.04	1.03	1.03	1.04	1.06	1.07	1.00
	16 in. / 400 mm	1.02	1.02	1.02	1.05	1.05	1.00	1.00	1.00	1.04	1.04	1.00	1.02	1.05	1.07	1.07	1.02
	18 in. / 450 mm	1.08	1.08	1.08	1.09	1.11	1.03	1.05	1.06	1.08	1.08	1.10	1.10	1.11	1.11	1.11	1.05
	20 in. / 500 mm	1.10	1.12	1.13	1.13	1.16	1.09	1.09	1.11	1.11	1.11	1.11	1.11	1.11	1.13	1.17	1.06
	22 in. / 550 mm	1.17	1.17	1.17	1.19	1.19	1.12	1.14	1.14	1.19	1.19	1.14	1.14	1.14	1.19	1.19	1.15
26 ft. / 7,925 mm	12 in. / 300 mm	1.18	1.07	1.10	1.12	1.13	1.15	1.09	1.12	1.13	1.15	1.12	1.13	1.14	1.15	1.16	1.09
	14 in. / 350 mm	1.02	1.04	1.05	1.06	1.06	1.00	1.01	1.04	1.08	1.08	1.00	1.05	1.06	1.07	1.08	1.01
	16 in. / 400 mm	1.00	1.00	1.00	1.05	1.07	1.00	1.02	1.03	1.06	1.09	1.04	1.04	1.04	1.05	1.06	1.00
	18 in. / 450 mm	1.03	1.04	1.05	1.05	1.07	1.05	1.05	1.05	1.05	1.07	1.04	1.04	1.06	1.06	1.06	1.00
	20 in. / 500 mm	1.06	1.08	1.08	1.08	1.08	1.06	1.06	1.06	1.11	1.17	1.07	1.07	1.13	1.13	1.13	1.05
	22 in. / 550 mm	1.09	1.11	1.11	1.16	1.21	1.09	1.14	1.18	1.18	1.18	1.13	1.13	1.13	1.13	1.14	1.08
	24 in. / 600 mm	1.14	1.19	1.22	1.24	1.24	1.20	1.22	1.22	1.22	1.22	1.13	1.13	1.14	1.18	1.23	1.10
28 ft. / 8,535 mm	12 in. / 300 mm	1.18	1.13	1.15	1.19	1.20	1.14	1.12	1.14	1.18	1.20	1.12	1.14	1.15	1.19	1.21	1.15
	14 in. / 350 mm	1.05	1.03	1.04	1.08	1.12	1.01	1.04	1.05	1.06	1.10	1.03	1.03	1.04	1.05	1.07	1.04
	16 in. / 400 mm	1.00	1.04	1.05	1.05	1.07	1.00	1.01	1.04	1.04	1.05	1.00	1.01	1.03	1.03	1.07	1.00
	18 in. / 450 mm	1.02	1.04	1.04	1.06	1.08	1.03	1.04	1.05	1.10	1.13	1.02	1.05	1.05	1.06	1.07	1.03
	20 in. / 500 mm	1.03	1.05	1.06	1.10	1.14	1.02	1.08	1.12	1.12	1.12	1.06	1.06	1.06	1.06	1.08	1.08
	22 in. / 550 mm	1.07	1.08	1.10	1.10	1.10	1.06	1.08	1.08	1.08	1.09	1.02	1.06	1.06	1.08	1.09	1.05
	24 in. / 600 mm	1.11	1.13	1.13	1.14	1.14	1.09	1.10	1.10	1.12	1.18	1.05	1.07	1.13	1.13	1.13	1.06
30 ft. / 9,145 mm	12 in. / 300 mm	1.18	1.13	1.18	1.21		1.16	1.14	1.18	1.21		1.18	1.18	1.19	1.21		
	14 in. / 350 mm	1.02	1.06	1.07	1.08	1.17	1.04	1.06	1.06	1.10	1.17	1.04	1.06	1.10	1.10	1.15	1.06
	16 in. / 400 mm	1.00	1.01	1.04	1.05	1.07	1.00	1.04	1.04	1.08	1.13	1.00	1.04	1.04	1.09	1.12	1.00
	18 in. / 450 mm	1.00	1.02	1.04	1.08	1.13	1.01	1.05	1.09	1.13	1.13	1.01	1.03	1.04	1.07	1.08	1.02
	20 in. / 500 mm	1.01	1.02	1.06	1.08	1.10	1.03	1.03	1.05	1.07	1.08	1.00	1.01	1.02	1.02	1.04	1.01
	22 in. / 550 mm	1.05	1.05	1.06	1.07	1.08	1.05	1.05	1.08	1.10	1.15	1.02	1.03	1.03	1.03	1.05	1.04
	24 in. / 600 mm	1.06	1.06	1.08	1.10	1.14	1.05	1.07	1.13	1.13	1.13	1.04	1.04	1.04	1.06	1.08	1.04

MD2000 span tables

1.xx (dark grey)	Most optimal situation of the live load category
1.xx (light grey)	Most optimal depth according to slab thickness
(pale grey)	End joist reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity

		Residential					Office					Corridor/lobby					Garage
Live loads		40 psf (1.92 kPa)					50 psf (2.4 kPa)					100 psf (4.8 kPa)					50 psf (2.4 kPa)
Slab thickness (in.)		4½	5	5½	6	6½	4½	5	5½	6	6½	4½	5	5½	6	6½	6½
Slab thickness (mm)		115	125	140	150	165	115	125	140	150	165	115	125	140	150	165	165
Length (ft. / mm)	Depth (in. / mm)																
32 ft. / 9,755 mm	14 in. / 350 mm	1.08	1.08	1.12	1.15	1.18	1.05	1.06	1.10	1.19	1.22	1.08	1.10	1.16	1.16	1.20	1.06
	16 in. / 400 mm	1.02	1.03	1.06	1.10	1.19	1.01	1.02	1.12	1.13	1.16	1.04	1.06	1.08	1.10	1.14	1.05
	18 in. / 450 mm	1.00	1.04	1.07	1.09	1.13	1.03	1.04	1.05	1.07	1.10	1.01	1.02	1.02	1.05	1.08	1.02
	20 in. / 500 mm	1.01	1.04	1.05	1.07	1.07	1.00	1.04	1.04	1.07	1.10	1.00	1.02	1.03	1.03	1.04	1.00
	22 in. / 550 mm	1.05	1.06	1.07	1.10	1.14	1.02	1.03	1.09	1.12	1.15	1.04	1.04	1.07	1.08	1.11	1.03
	24 in. / 600 mm	1.03	1.07	1.10	1.15	1.19	1.09	1.09	1.12	1.13	1.16	1.03	1.03	1.05	1.07	1.07	1.08
34 ft. / 10,365 mm	14 in. / 350 mm	1.05	1.13	1.15			1.06	1.16	1.18			1.18	1.16	1.18			
	16 in. / 400 mm	1.04	1.05	1.08	1.14	1.16	1.03	1.05	1.08	1.12	1.14	1.07	1.07	1.11	1.14	1.17	1.05
	18 in. / 450 mm	1.02	1.04	1.08	1.09	1.13	1.01	1.04	1.06	1.08	1.17	1.01	1.03	1.05	1.06	1.11	1.02
	20 in. / 500 mm	1.02	1.03	1.04	1.09	1.14	1.00	1.02	1.08	1.09	1.13	1.01	1.04	1.04	1.05	1.06	1.00
	22 in. / 550 mm	1.00	1.04	1.08	1.11	1.15	1.03	1.05	1.10	1.11	1.13	1.00	1.03	1.04	1.05	1.06	1.03
	24 in. / 600 mm	1.08	1.08	1.12	1.13	1.18	1.07	1.09	1.12	1.12	1.14	1.04	1.06	1.07	1.10	1.13	1.02
36 ft. / 10,975 mm	16 in. / 400 mm	1.04	1.11	1.12	1.14		1.04	1.08	1.08	1.11		1.10	1.14	1.15	1.15		
	18 in. / 450 mm	1.04	1.05	1.06	1.14	1.17	1.00	1.03	1.09	1.13	1.15	1.02	1.06	1.06	1.13	1.14	1.02
	20 in. / 500 mm	1.00	1.03	1.09	1.10	1.18	1.03	1.04	1.08	1.11	1.14	1.01	1.01	1.03	1.05	1.08	1.03
	22 in. / 550 mm	1.04	1.10	1.10	1.11	1.15	1.03	1.06	1.07	1.09	1.13	1.00	1.00	1.01	1.07	1.08	1.00
	24 in. / 600 mm	1.06	1.10	1.10	1.12	1.17	1.02	1.07	1.09	1.12	1.16	1.02	1.03	1.06	1.07	1.08	1.00
38 ft. / 11,585 mm	16 in. / 400 mm	1.06	1.07				1.04	1.06				1.16	1.12				
	18 in. / 450 mm	1.00	1.05	1.10	1.14		1.00	1.05	1.09	1.12		1.04	1.10	1.11	1.14		
	20 in. / 500 mm	1.00	1.04	1.10	1.13	1.14	1.00	1.04	1.05	1.09	1.13	1.00	1.01	1.02	1.07	1.14	1.02
	22 in. / 550 mm	1.05	1.05	1.07	1.10	1.16	1.00	1.03	1.06	1.09	1.16	1.00	1.01	1.06	1.08	1.10	1.01
	24 in. / 600 mm	1.04	1.06	1.08	1.15	1.15	1.02	1.06	1.08	1.09	1.10	1.01	1.01	1.01	1.03	1.03	1.00
40 ft. / 12,190 mm	18 in. / 450 mm	1.00	1.06	1.12			1.05	1.08	1.09			1.11	1.12	1.13			
	20 in. / 500 mm	1.01	1.04	1.09	1.12		1.01	1.01	1.08	1.10		1.03	1.04	1.10	1.10		
	22 in. / 550 mm	1.00	1.04	1.05	1.10	1.17	1.00	1.05	1.06	1.12		1.00	1.01	1.02	1.07	1.13	1.00
	24 in. / 600 mm	1.01	1.02	1.09	1.10	1.19	1.02	1.04	1.08	1.09	1.13	1.02	1.02	1.04	1.07	1.10	1.05
43 ft. / 13,110 mm	20 in. / 500 mm	1.07	1.07	1.11			1.02	1.04	1.07			1.10	1.11				
	22 in. / 550 mm	1.00	1.04	1.11	1.14		1.01	1.02	1.07	1.08		1.06	1.08	1.09	1.09		
	24 in. / 600 mm	1.03	1.07	1.08	1.11	1.14	1.00	1.01	1.02	1.11	1.12	1.00	1.06	1.09	1.10		1.00

MD2000 MINI-JOIST SPAN TABLES

The following tables show the maximum total length of the two types of MD2000 mini-joist, considering a spacing of 4 ft. (1,220 mm) and the uniform loads presented. The minimum length for the MD2000 mini-joist is 4 ft. (1,220 mm).

Maximum total span for MD2000 mini-joist					
Slab thickness (in.)	**4½**	**5**	**5½**	**6**	**6½**
Dead load (psf)	**73**	**79**	**85**	**91**	**97**
Live load (psf)	up to 50				
MD	5'-9''	5'-6''	5'-3''	5'-1''	4'-11''
RMD	8'-0''	7'-8''	7'-4''	7'-1''	6'-10''
Live load (psf)	up to 100				
MD	5'-2''	5'-1''	5'-0''	4'-11''	4'-10''
RMD	7'-2''	7'-1''	6'-11''	6'-10''	6'-9''

Maximum total span for MD2000 mini-joist					
Slab thickness (mm)	**115**	**125**	**140**	**150**	**165**
Dead load (kPa)	**3.5**	**3.8**	**4.1**	**4.4**	**4.6**
Live load (kPa)	up to 2.4				
MD	1,753	1,676	1,600	1,549	1,499
RMD	2,438	2,337	2,235	2,159	2,083
Live load (kPa)	up to 4.8				
MD	1,575	1,549	1,524	1,499	1,473
RMD	2,184	2,159	2,108	2,083	2,057

Notes:
The total spans indicated in these tables are considered to be out to out, meaning they take into account a joist seat of normally 4 in. (102 mm) long at each end, therefore the maximum clear span (without the joist seats) is 8 ft. (2,438 mm).

SLAB TABLES FOR MD2000 PRODUCT

Mesh size

The typical wire mesh used has a yield strength of 65,000 psi minimum. The typical sizes used are indicated in the following table:

Metric	Imperial	Diameter		Area	
		in.	mm	in.²/lin. ft.	mm²/lin. m
152 x 152 MW18.7 x MW18.7	6 x 6 W2.9 / W2.9 (6x6-6/6)	0.192	4.88	0.059	123
152 x 152 MW25.7 x MW25.7	6 x 6 W4 / W4 (6x6-4/4)	0.226	5.74	0.081	170

Hambro MD2000 Composite Floor System

Slab capacity under uniform load

MD2000 - Maximum unshored deck for single spans

f'_c = 3,000 psi, ρ = 145 pcf, Fy = 40,000 psi

Effective slab thickness[1] (total slab)	Deck gage 22	Deck gage 20
3 in. (4½ in.)	5'-7"	6'-5"
3½ in. (5 in.)	5'-4"	6'-1"
4 in. (5½ in.)	5'-2"	5'-11"
4½ in. (6 in.)	5'-0"	5'-8"
5 in. (6½ in.)	4'-10"	5'-6"

MD2000 - Maximum unshored deck for single spans

f'_c = 20 MPa, ρ = 2,400 kg/m³, Fy = 275 MPa

Effective slab thickness[1] (total slab)	Deck gage 22	Deck gage 20
75 mm (115 mm)	1,710	1,955
90 mm (125 mm)	1,640	1,870
100 mm (140 mm)	1,580	1,800
115 mm (150 mm)	1,525	1,740
125 mm (165 mm)	1,480	1,685

(1) Only slab portion over the deck is considered for effective slab thickness.

Notes:

In non-composite stage, deck supports self-weight, weight of concrete and construction load.
Maximum unshored deck span considers the deflection under wet concrete to be less than the span over 180 (L/180).
The web crippling resistance is calculated assuming the end bearing length equals to 1.5 in. (40 mm).

MD2000 - Slab capacity chart for uniform loading in composite stage (total factored load in psf)*

f'_c = 3,000 psi, ρ = 145 pcf, F_y = 65,000 psi

Effective slab thickness[1] (total slab)	Chair	Mesh size[2] (6 in. X 6 in.)	Composite – Joist spacing 4'-0" Exterior	4'-0" Interior	4'-6" Exterior	4'-6" Interior	5'-0" Exterior	5'-0" Interior	5'-6" Exterior	5'-6" Interior	6'-0" Exterior	6'-0" Interior
3 in. (4½ in.)	N/A	W6 /W 6	240	275	190	217	153	176	-	-	-	-
		W4 / W4	319	376	252	297	204	240	168	199	-	167
3½ in. (5 in.)	N/A	W4 / W4	342	376	270	297	218	240	180	199	-	167
4 in. (5½ in.)	N/A	W4 / W4	342	376	270	297	218	240	180	199	-	167
		2 layers W6 / W6	536	590	424	466	342	377	283	312	238	262
		2 layers W4 / W4	734	808	580	638	470	517	388	427	326	359
4½ in. (6 in.)	N/A	2 layers W6 / W6	536	590	424	466	343	377	283	312	238	262
		2 layers W4 / W4	734	808	580	638	470	517	388	427	326	359
5 in. (6½ in.)	3 in.	2 layers W6 / W6[3]	720	792	568	625	460	506	380	418	320	352
		2 layers W4 / W4[3]	972	1,069	768	844	622	684	514	565	432	475

MD2000 - Slab capacity chart for uniform loading in composite stage (total factored load in kPa)*

f'_c = 20 MPa, ρ = 2,400 kg/m³, F_y = 450 MPa

Effective slab thickness[1] (total slab)	Chair	Mesh size[2] (152 mm x 152 mm)	Composite – Joist spacing 1,220 mm Exterior	1,220 mm Interior	1,372 mm Exterior	1,372 mm Interior	1,524 mm Exterior	1,524 mm Interior	1,676 mm Exterior	1,676 mm Interior	1,829 mm Exterior	1,829 mm Interior
76 mm (114 mm)	N/A	MW18.7 x MW18.7	11	13	9	10	7	8	-	-	-	-
		MW25.7 x MW25.7	15	18	12	14	9	11	8	9	-	8
90 mm (128 mm)	N/A	MW25.7 x MW25.7	16	18	12	14	10	11	8	9	-	8
102 mm (140 mm)	N/A	MW25.7 x MW25.7	16	18	12	14	10	11	8	9	-	8
		2 layers MW18.7 x MW18.7	25	28	20	22	16	18	13	14	11	12
		2 layers MW25.7 x MW25.7	35	38	27	30	22	24	18	20	15	17
115 mm (153 mm)	N/A	2 layers MW18.7 x MW18.7	25	28	20	22	16	18	13	14	11	12
		2 layers MW25.7 x MW25.7	35	38	27	30	22	24	18	20	15	17
127 mm (165 mm)	76 mm	2 layers MW18.7 x MW18.7[3]	34	37	27	29	22	24	18	20	15	16
		2 layers MW25.7 x MW25.7[3]	46	51	36	40	29	32	24	27	20	22

* Total factored load is taken as 1.25D +1.5L
Where D = dead load
L = live load

(1) Only slab portion over the deck is considered for effective slab thickness, concrete in deck flute cannot be considered due to UL ratings.
(2) Mesh size is only a recommendation. A Canam engineer will determine the mesh size.
(3) One layer of wire mesh on top chord and one layer on high chair.

Slab capacity under concentrated load

MD2000 - Slab capacity chart for unfactored dead load (psf) with concentrated live load

f'$_c$ = 3,000 psi, ρ = 145 pcf, Fy = 65,000 psi

	Concentrated load	Effective slab thickness(1) (total slab)	Mesh size(2) (6 in. x 6 in.)	Joist spacing									
				4'-0"		4'-6"		5'-0"		5'-6"		6'-0"	
				Exterior	Interior	Exterior	Interior	Exterior	Interior	Exterior	Interior	Exterior	Interior
f'$_c$ = 3,000 psi	Classroom/ Residential 1 kip on 30 in. x 30 in.	3 in. (4½ in.)	W6 /W 6	-	134	-	93	-	-	-	-	-	-
			W4 / W4	118	203	81	157	-	124	-	101	-	83
		3½ in. (5 in.)	W4 / W4	191	204	147	158	115	125	93	101	-	84
		4 in. (5½ in.)	W4 / W4	192	205	148	158	116	126	94	102	-	-
			2 layers W6 / W6	338	350	263	273	209	219	171	179	141	149
			2 layers W4 / W4	476	476	379	390	304	314	249	257	207	215
		4½ in. (6 in.)	2 layers W6 / W6	339	351	263	274	210	220	171	180	141	149
			2 layers W4 / W4	542	542	380	391	305	314	250	258	208	215
	Office 2 kip on 30 in. x 30 in.	3½ in. (5 in.)	W4 / W4	-	152	-	113	-	85	-	-	-	-
		4 in. (5½ in.)	W4 / W4	129	154	93	115	-	88	-	-	-	-
			2 layers W6 / W6	274	299	208	230	162	181	129	146	105	119
			2 layers W4 / W4	401	401	325	347	257	276	207	224	170	185
		4½ in. (6 in.)	2 layers W6 / W6	276	301	210	231	164	182	130	147	106	120
			2 layers W4 / W4	428	449	327	348	258	277	209	225	171	186
f'$_c$ = 5,075 psi	Garage 4 kip on 4¾ in. x 4¾ in.	5½ in. + 3 in. High chair (7 in. + 3 in. High chair)	2 layers W6 / W6 (3)	-	-	-	-	-	-	-	-	-	-
			2 layers W4 / W4 (3)	233	356	129	312	-	241	-	-	-	-

MD2000 - Slab capacity chart for unfactored dead load (kPa) with concentrated live load

f'$_c$ = 20 MPa, ρ = 2,400 kg/m³, F_y = 450 MPa

	Concentrated load	Effective slab thickness(1) (total slab)	Mesh size(2) (152 mm x 152 mm)	Joist spacing									
				1,220 mm		1,372 mm		1,524 mm		1,676 mm		1,829 mm	
				Exterior	Interior	Exterior	Interior	Exterior	Interior	Exterior	Interior	Exterior	Interior
f'$_c$ = 20 MPa	Classroom/ Residential 4.5 kN on 750 mm x 750 mm	76 mm (115 mm)	MW18.7 x MW18.7	-	6	-	4	-	-	-	-	-	-
			MW25.7 x MW25.7	5	9	3	7	-	5	-	4	-	3
		90 mm (127 mm)	MW25.7 x MW25.7	9	9	7	7	5	6	4	4	-	4
		102 mm (140 mm)	MW25.7 x MW25.7	9	9	7	7	5	6	4	4	-	-
			2 layers MW18.7 x MW18.7	16	16	12	13	10	10	8	8	6	7
			2 layers MW25.7 x MW25.7	22	22	18	18	14	15	11	12	9	10
		115 mm (153 mm)	2 layers MW18.7 x MW18.7	16	16	12	13	10	10	8	8	6	7
			2 layers MW25.7 x MW25.7	25	25	18	18	14	15	11	12	9	10
	Office 9 kN on 750 mm x 750 mm	90 mm (127 mm)	MW25.7 x MW25.7	-	7	-	5	-	4	-	-	-	-
		102 mm (140 mm)	MW25.7 x MW25.7	6	7	4	5	-	4	-	-	-	-
			2 layers MW18.7 x MW18.7	13	14	10	11	7	8	6	7	5	5
			2 layers MW25.7 x MW25.7	19	19	15	16	12	13	9	10	8	8
		115 mm (153 mm)	2 layers MW18.7 x MW18.7	13	14	10	11	7	8	6	7	5	5
			2 layers MW25.7 x MW25.7	20	21	15	16	12	13	10	10	8	8
f'$_c$ = 35 MPa	Garage 18 kN on 120 mm x 120 mm	140 mm + 76 mm High chair (178 mm + 76 mm High chair)	2 layers MW18.7 x MW18.7 (3)	-	-	-	-	-	-	-	-	-	-
			2 layers MW25.7 x MW25.7 (3)	11	17	6	14	-	11	-	-	-	-

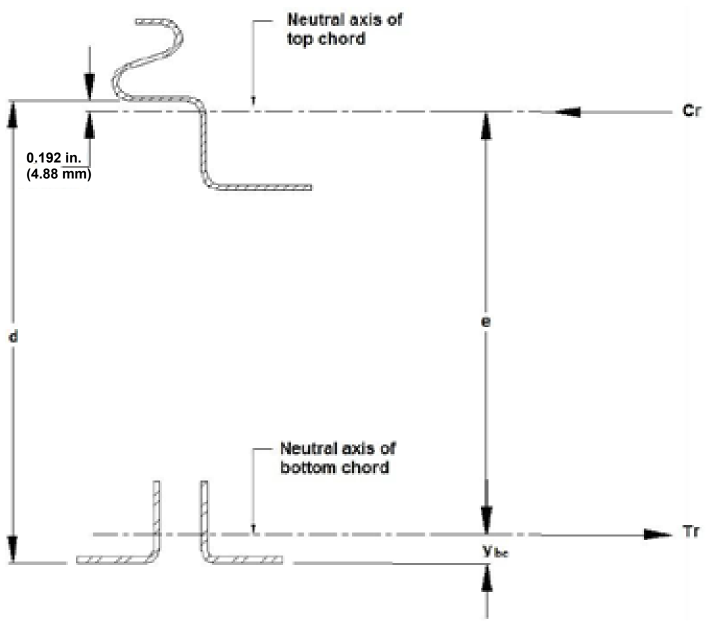
Note:
Needs to be used in conjuncture with uniform load table.

(1) Only slab portion over the deck is considered for effective slab thickness, concrete in deck flute cannot be considered due to UL ratings.
(2) Mesh size is only a recommendation. A Canam engineer will determine the mesh size.
(3) One layer of wire mesh on top chord and one layer on high chair.

DESIGN PRINCIPLES

NON-COMPOSITE DESIGN

During the formwork installation and pouring process, Hambro joists are considered non-composite. At this stage, the top chord capacity controls the design of the joist.



MD2000 non-composite neutral axis

Load distribution

At this stage, joist members behave in distinct ways:

1. The bottom chord, composed of two angles back-to-back, acts as a tension member.
2. The web, made of bent steel rods, acts as a tension or compression member.
3. The "S" top chord, acts as a compression member.

Non-composite loads

1. Non-composite dead load
   The dead loads considered at the non-composite stage are from the concrete, formwork (deck) and joist selfweight.

   Concrete: *slab thickness over the steel deck x concrete density*
   + 0.33* *x steel deck thickness x concrete density*

   *0.33 comes from the fact that the steel deck ribs are filled with concrete by 33% of the sheet thickness.

   Example for a 4½ in. (114 mm) total slab thickness:
   $\left(\frac{3\text{ in.}}{12}\right) x\ 145\ lb./ft.^3 + 0.33\left(\frac{1.5\text{ in.}}{12}\right) x\ 145\ lb./ft^3 = 42.23\ psf$
   $(0.114 - 0.038)\ m\ x\ 22.78\ kN/m^3 + 0.33\ x\ 0.038\ m\ x\ 22.78\ kN/m^3 = 2.02\ kN/m^2$

   Formwork and joist: $5\ psf\ (0.24\ kN/m^2)$

   Total factored dead load: $1.25\ x\ (concrete + formwork + joist)$
   Example: $1.25\ x\ (42.23 + 5) = 59.04\ psf$
   $(1.25\ x\ (2.02 + 0.24) = 2.83\ kN/m^2)$

2. Non-composite live load

   Construction live load: $20\ psf\ (0.96\ kN/m^2)$

   Total factored live load: $1.5\ x\ (construction\ live\ load)$
   Example: $1.5\ x\ 20\ psf = 30\ psf$
   $(1.5\ x\ 0.96\ kN/m^2 = 1.44\ kN/m^2)$

3. Total factored load

   Example: $59.04 + 30 = 89.04\ psf$
   $(2.83 + 1.44 = 4.27\ kN/m^2)$

Factored moment resistance

$$M_{r\,nc} = C_r e \text{ or } T_r e \quad i.e.$$

$$\frac{W_{nc}L^2}{8} = C_r e \text{ or } T_r e \text{ whichever the lesser}$$

Where:

$$W_{nc} = 89.04\ psf\left(\frac{4.27\ kN}{m^2}\right)\ x\ joist\ spacing\ (plf\ or\ kN/m)$$

$$L = joist\ length\ (ft.\ or\ m)$$

$$C_r = area\ of\ top\ chord\ x\ factored\ compressive\ resistance\ (kip\ or\ kN)$$

$$T_r = area\ of\ bottom\ chord\ x\ factored\ tensile\ resistance\ (kip\ or\ kN)$$

$$e = effective\ lever\ arm\ at\ non-composite\ stage$$

$$= (d - 0.192\ in.\ (4.88\ mm) - y_{bc})\ (in.\ or\ mm)$$

$$d = depth\ of\ joist\ (in.\ or\ mm)$$

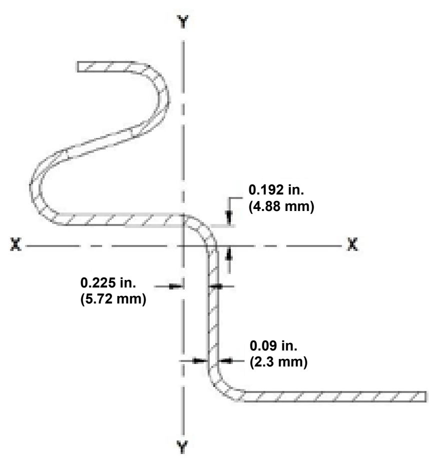
$$y_{bc} = neutral\ axis\ of\ bottom\ chord\ (in.\ or\ mm)$$

From the above formula, the maximum limiting span may be computed for the non-composite stage. For spans beyond this value, the top chord must be strengthened. Strengthening of the top chord, when required, is usually accomplished by installing one or two rods in the curvatures of the “S” part of the top chord.

As for the bottom chord, it is sized for the total factored load which is more critical than the construction load, the design method is explained in the Composite design section.

Top chord properties

The information below present the Hambro MD2000 top chord properties.



MD2000 top chord geometry

$$t = 0.09\ in.\ (2.3\ mm)$$

$$A_{gross} = 0.690\ in.^2\ (445.16\ mm^2)$$
$$A_{net} = 0.634\ in.^2\ (409.03\ mm^2)$$
$$A_{effective} = 0.565\ in.^2\ (364.52\ mm^2)$$

$$I_{x\ gross} = 0.761\ in.^4\ (3.168\ x\ 10^5\ mm^4)$$
$$I_{y\ gross} = 0.575\ in.^4\ (2.393\ x\ 10^5\ mm^4)$$

$$I_{x\ net} = 0.707\ in.^4\ (2.943\ x\ 10^5\ mm^4)$$
$$I_{y\ net} = 0.537\ in.^4\ (2.235\ x\ 10^5\ mm^4)$$

$$F_{y\ top\ chord} = 65\ ksi\ (450\ MPa)$$

Steel deck

It is possible to consider the steel deck acting as a diaphragm at the non-composite stage, i.e. during assembly of the structure. The engineer of records is responsible for calculating the required fasteners (welds or screws).

COMPOSITE DESIGN

Joist composite design

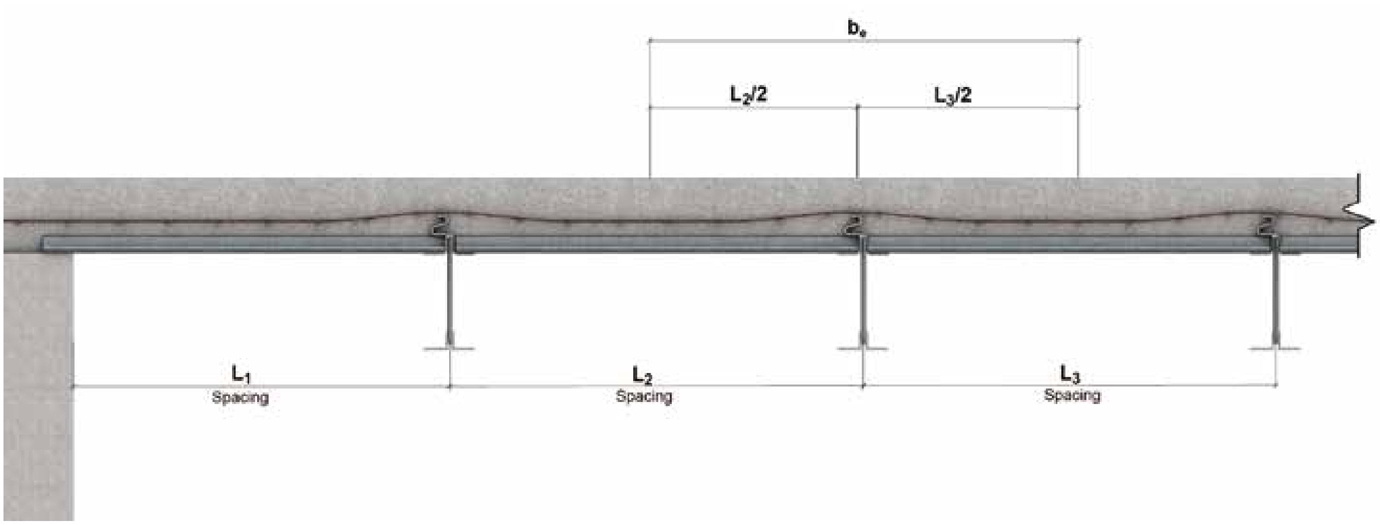
For the design of the composite action, the effective width of concrete slab of an interior joist is taken as the minimum between:

$$b_e = min.\left(L/4\ ;\frac{(L_2 + L_3)}{2}\right)$$

Where:

L = *span of joist*

L_2 *and* L_3 = *spacings adjacent to the joist*



Effective width of MD2000 interior joists

For the effective width of concrete slab for a perimeter joist:

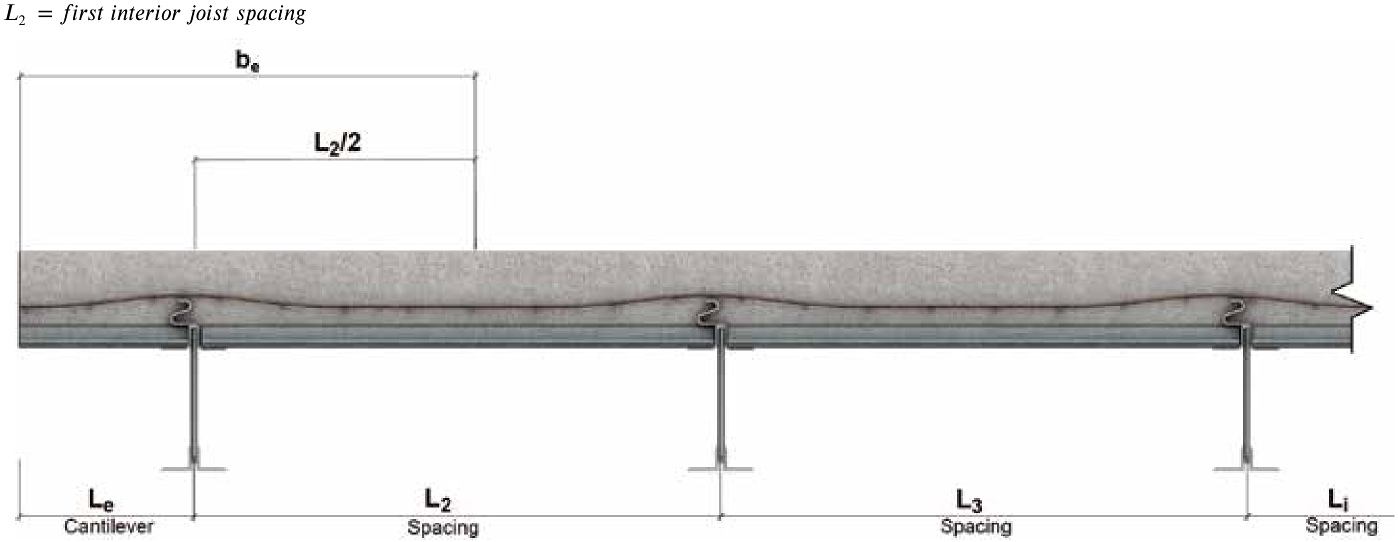
$$b_e = L_e + min.\ (L/10;\ L_2/2)$$

Where:

L = *span of joist*

L_e = *length of cantilever*

L_2 = *first interior joist spacing*



Effective width of MD2000 perimeter joists

Flexure design

The flexure design is calculated with the ultimate strength approach which is based on the actual failure strengths of the component materials. This method is initially used for composite beam or joist with stud connectors but is applicable to the Hambro MD2000 joist.

Load capacity calculations involve the equilibrium of internal factored forces $C'_r = T_r$. In order to use this method, some assumptions need to be made:

1. The plastic neutral axis is strictly in the slab so that the whole steel section of the system works in tension.
2. The wire mesh reinforcement in the slab has been neglected in compression.
3. $\propto_1 = 0.85$ since $f'_c \leq 4.35\ ksi\ (30\ MPa)$[2].
4. Composite action is considered at 100%.

The simplified concrete stress block, as shown above is universally used to find the ultimate tension. According to CAN/CSA-S16, clause 17.9.3, and CAN/CSA A23.3, clause 10.1.7, the factored resisting moment of the composite section is given by:

$$M_{rc} = \varnothing_s A_b F_y e' = T_r e'$$

Where :

$e' = lever\ arm$ at composite stage $= d + slab\ thickness - a/2 - y_{bc}$, $in.\ (mm)$

$d = joist\ depth,\ in.\ (mm)$

$y_{bc} = neutral\ axis\ of\ bottom\ chord,\ in.\ (mm)$

$a = depth\ of\ compression\ block = \dfrac{\varnothing_s A_b F_y}{\alpha_1 \varnothing_c f_c' b_e},\ in.\ (mm)$

$\varnothing_s = 0.9$

$A_b = area\ of\ bottom\ chord,\ in.^2\ (mm^2)$

$F_y = yield\ stress\ of\ steel,\ ksi\ (MPa)$

$\alpha_1 = 0.85$

$\varnothing_c = 0.65$

$f_c' = concrete\ compressive\ strength,\ ksi\ (MPa)$

$b_e = effective\ width\ of\ concrete,\ in.\ (mm)$

The factored resisting moment can then be compared to the factored moment:

$$M_f = \frac{W_f L^2}{8}$$

Where:

$W_f = total\ factored\ uniform\ load,\ plf\ (kN/m)$

$L = span\ of\ joist,\ ft.\ (m)$

Web design

Vertical shear

The web of the steel joist is designed according to CAN/CSA-S16, clause 17.3.2, requires the web system to be proportioned to carry the total vertical shear V_f.

According to clause 16.5.1, the loading applied to the joist is as follows:

1. The total factored dead and live loads specified by the building designer.
2. The total dead load and an unbalanced load of 100% of the live load on any continuous portion of the joist and 0% of the live load on the remainder to produce the most critical effect on any component.
3. Factored dead load plus the appropriate factored concentrated load from the NBCC applied at any panel point to produce the most critical effect on any web members.

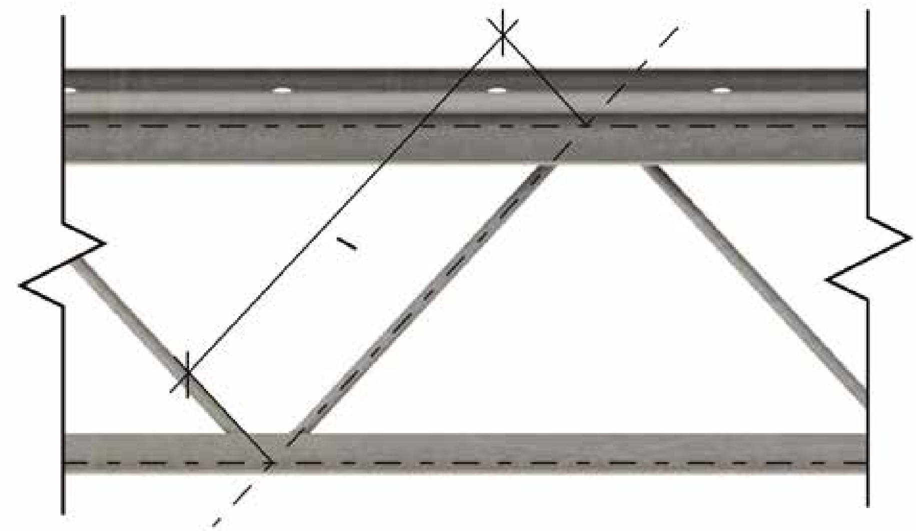
The above loadings do not need to be applied simultaneously.

[2] Denis BEAULIEU and André PICARD. Calcul des charpentes d'acier : Tome II, Chapitre IX – Poutres mixtes. Markham, Ontario, Institut canadien de la construction en acier (ICCA), 2010. (French only)

Tension and compression diagonal

The web members are sized for the specified loading including concentrated loads where applicable.

The effective length of web member Kl is taken from the chord neutral axis to the bottom chord neutral axis.



Length "l" of MD2000 web member

For webs in tension, the slenderness ratio is not limited (clause 16.5.8.5), they are dimensioned using clause 13.2; generally this formula controls:

$$T_r = \varnothing A_g F_y$$

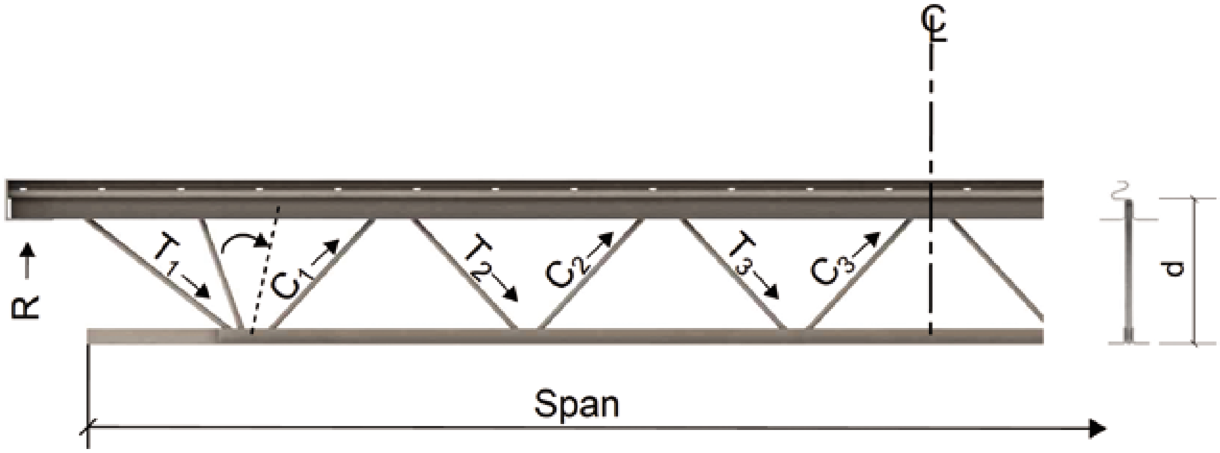
For webs in compression, the slenderness ratio shall not exceed 200 (clause 16.5.8.6); they are dimensioned using clause 13.3. Rods are used, therefore this equation applies:

$$C_r = \varnothing A F_y (1+\lambda^{2n})^{-1/n}$$

Where:

$$\lambda = \sqrt{\frac{F_y}{F_e}}$$

$$F_e = \frac{\pi^2 E}{\left(\frac{K\,l}{r}\right)^2},\ ksi\ (MPa)$$

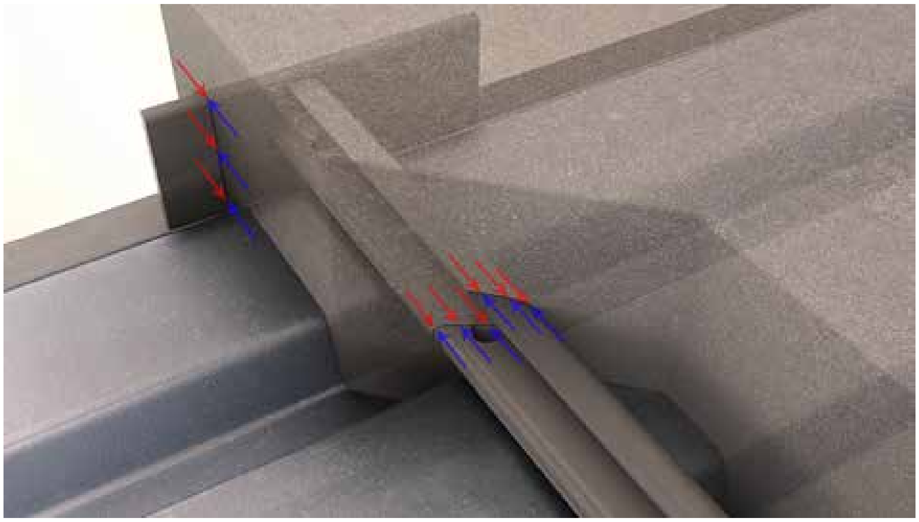


Efforts in MD2000 web members

Interface shear

The Hambro joist comprises a composite concrete slab-steel joist system with composite action achieved by the shear connection developed by two mechanisms:

1. Horizontal bearing forces
   The bearing shoes of the joist consist of angles that are embedded in the concrete. They act as anchorage for the first diagonal member producing a horizontal bearing force when the joist is loaded.
2. Steel/concrete interface
   Once embedded in the slab, the top chord bonds with the concrete in order to provide a shear-friction resistance. There are also holes in the “S” part of the top chord, which help reinforce the bond between the steel/concrete interface.



MD2000 horizontal bearing force and friction at the steel/concrete interface

Shear resistance of the steel/concrete interface can be evaluated by either elastic or ultimate strength procedures; both methods have shown good correlation with the test results. The interface shear force resulting from superimposed loads on the composite joist may be computed, using the “elastic approach” by the equation:

$$q = VQ/I_c$$

Where :

q = *horizontal shear flow, lb./in. (N/mm)*

V = *vertical shear force due to superimposed loads, lb. (N)*

I_c = *moment of inertia of the composite joist, in.*^{4} *(mm*^{4}*)*

Q = *statical moment of the effective concrete in compression (hatched area) about the elastic neutral axis of the composite section, in.*^{3} *(mm*^{3}*)*

$= (by/n)\,(Y_c - y/2)$ *and* $y = y_c \leq t$

b_e = *concrete width, in. (mm)*

n = *modular ratio*

$= E_s/E_c = 9.4$ *(for* $f'_c = 3$ ksi (20 *MPa*))

t = *slab thickness, in. (mm)*

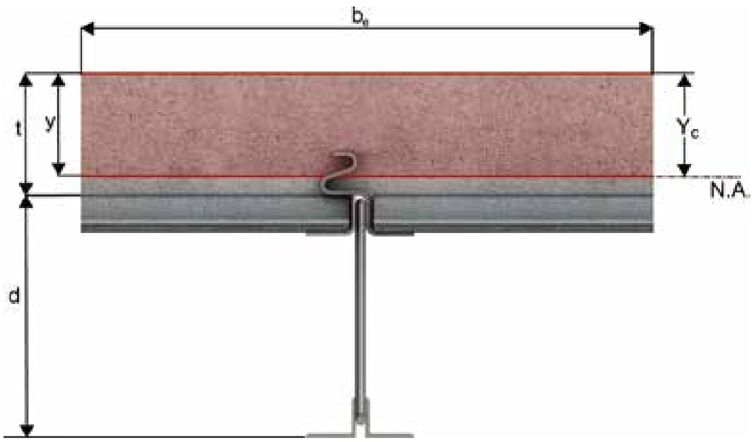
Y_c = *depth of neutral axis from top of concrete slab, in. (mm)*

y = *neutral axis of composite joist, in. (mm)*

$= Y_c \rightarrow$ *when* elastic *neutral axis lies within slab*

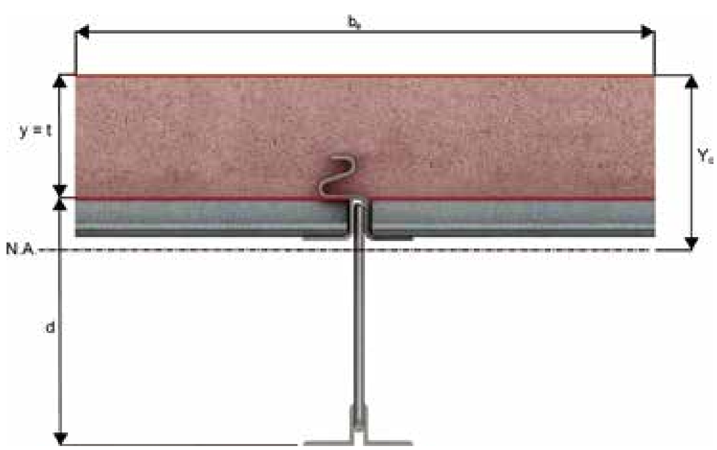
$= t \rightarrow$ *when* elastic *neutral axis lies outside slab*

Case 1: N.A. within the slab ($y = Y_c$)



Case 1

Case 2: N.A. outside the slab ($y = t$)



Case 2

The most recent full testing programs have consistently established a failure value for the horizontal bearing forces and the friction between steel and concrete. An additional contributing factor is a hole in the section at each 7 in. (178 mm) on the length.

1. Horizontal bearing forces
   The test has defined an ultimate value for the end bearing shoe equal to 50 kip (222 kN) for a concrete strength of 3 ksi (20 MPa).
2. Friction between concrete and top chord
   The failure value for the interface shear is 255 lb./in. (44.7 N/mm).

Slab Design

Note: The calculations attached to slab design are metric only.

The slab component of the MD2000 Hambro composite floor system behaves as a oneway slab carrying loads transversely to the joists. The slab design is based on CAN/CSA-A23.3, Design of Concrete Structures. This standard stipulates that in order to provide adequate safety level, the factored effects shall be less than the factored resistance.

Note:

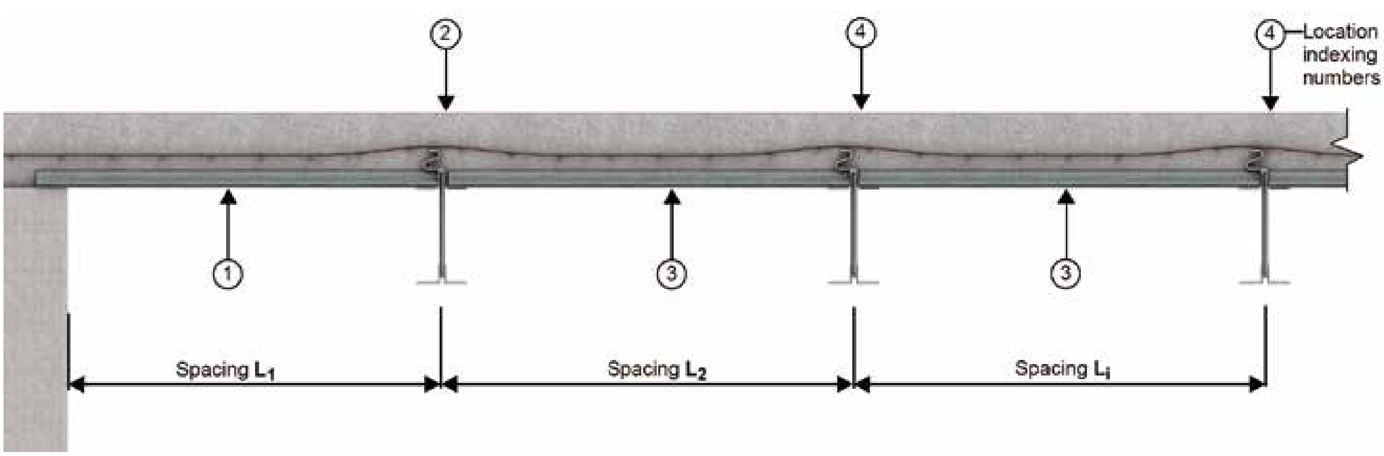
For the MD2000 product, it is not possible to consider the steel deck and concrete within the steel deck's ribs in the calculation of the slab capacity due to fire rating restrictions.

Uniform load – load distribution

Continuous span
The standard CAN/CSA-A23.3, clause 9.2.3.1, requires that factored dead load to act simultaneously with the factored live load apply on:

- Adjacent spans (maximum negative moment at support); or
- Alternate spans (maximum positive moment at mid-span).

If criteria (a) to (e) of clause 9.3.3 are satisfied, the following approximate value may be used in the design of one-way slabs. Refer to the figure below for location of moments and shear efforts.



MD2000 continuous span slab design

1. Positive moment
   Exterior span (location 1): $M_f = W_f L_1^2/11$
   Interior span (location 3): $M_f = W_f L_i^2/16$
2. Negative moment
   First interior support (location 2): $M_f = W_f L_a{}^2/10$
   Other interior support (location 4): $M_f = W_f L_a{}^2/11$
3. Shear
   Face of first interior support (location 2): $V_f = 1.15\ W_f L_1/2$
   Other interior support (location 4): $V_f = W_f L_i/2$

   Where :
   W_f = total factored design load (kN/m)
   L_1 = first span (exterior span) (m)
   L_i = interior spans → joist spacing (m)
   L_a = average of two adjacent spans (m)

Single span
However, if at least one of the criteria of CAN/CSA-A23.3, clause 9.3.3, is not met, the slab must be considered as simply supported and the distribution of forces will be as follow (refer to the figure on page 95 for location of moment and shear):

1. Positive moment
   All spans (locations 1 and 3): $M_f = W_f L_i{}^2/8$
2. Shear
   All supports: $V_f = W_f L_i/2$

<u>Concentrated load – load distribution</u>

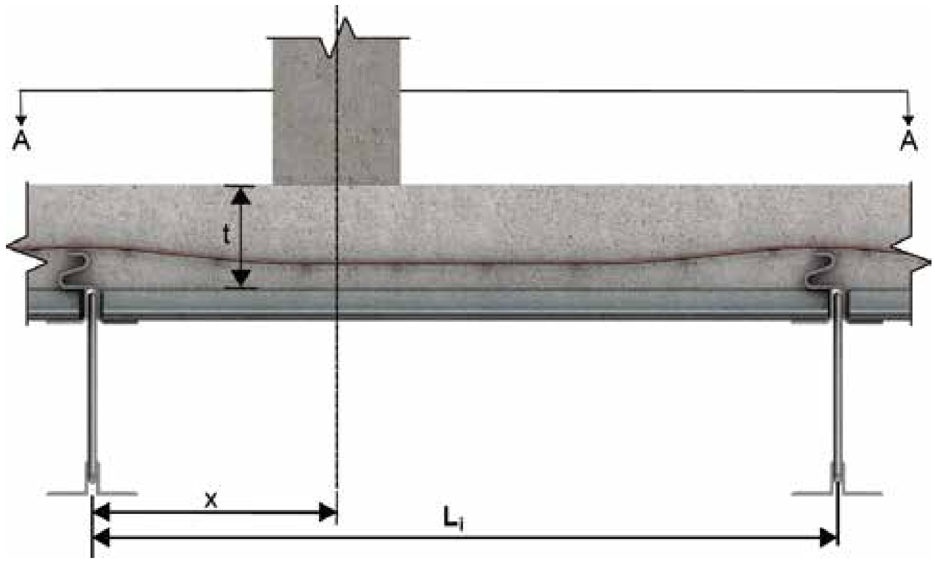
In addition to the previous verification, the Division B of the National Building Code of Canada (NBCC), clause 4.1.5.9 1), requires consideration for a minimum concentrated live load to be applied over a specified area. The magnitude of the load depends on the occupancy. This loading does not need to be considered to act simultaneously with the specified uniform live load.

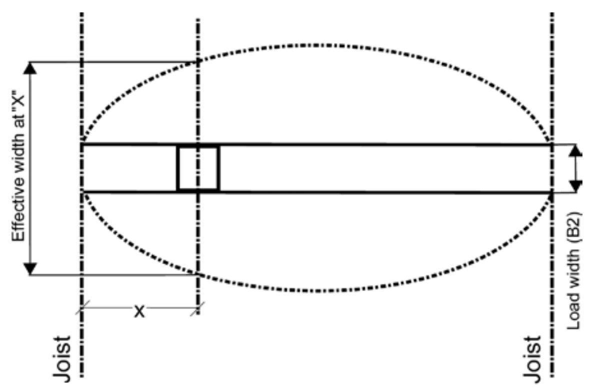
The area of an applied concentrated load on the slab can be distributed laterally to reduce its intensity. Since the Canadian codes and standards do not provide a precise method, the following calculations for the effective widths of concentrated load, b_e, are based on the SDI approach. CSSBI standard 12M-15 states that for special cases not covered, it is possible to refer to other standards.

1. For moment calculation:
   $b_e = b_m + (4/3)\ (1 - x/L)x \leq 106.8\ (t_c/h)$
2. For shear calculation:
   $b_e = b_m + (1 - x/L_i)x$

   Where :

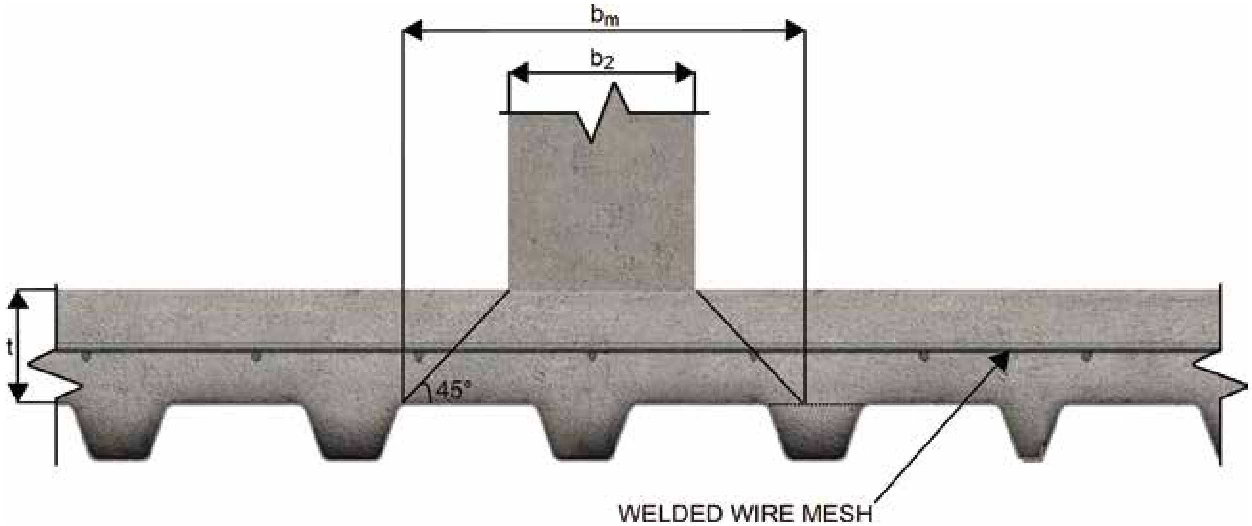
   $b_m = b_2 + 2\ t_c\ (mm)$
   b_2 = load width (mm)
   t_c = slab thickness (mm)





Section A-A

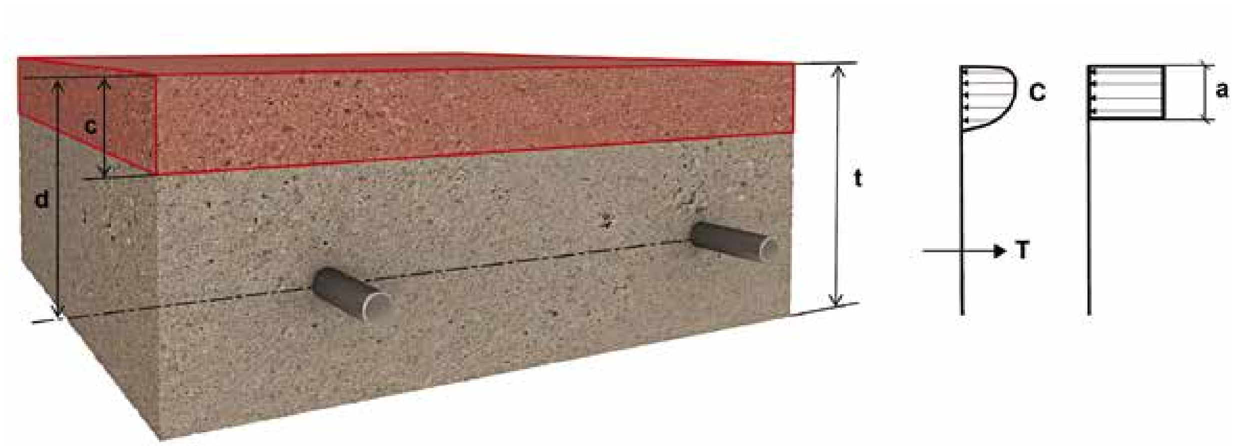
Concentrated load distribution for effective width



Projected width of concentrated load

Moment Capacity

The factored moment resistance (M_r) of a reinforced concrete section, using an equivalent rectangular concrete stress distribution is given by (CAN/CSA-A23.3, clause 10.1.7):



Moment capacity block

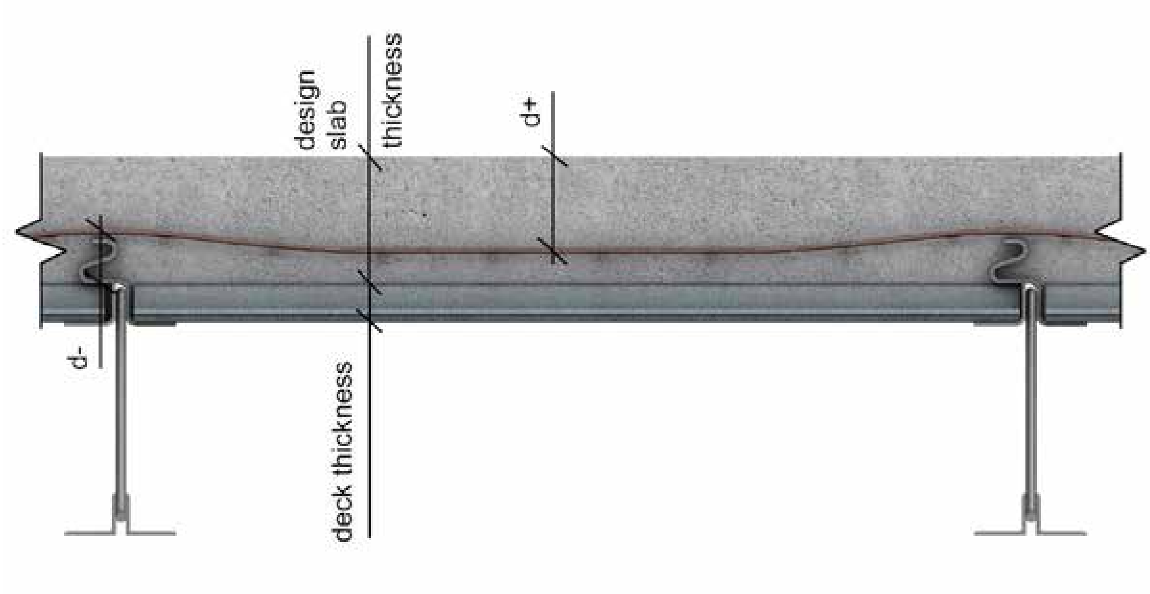
$$M_r = \varnothing_s A_s F_y \,(d - a/2)$$

$$a = \frac{\varnothing_s A_s F_y}{\alpha_1 \varnothing_c f'_c b}$$

$$\alpha_1 = 0.85 - 0.0015\, f'_c \geq 0.67$$

Where:

- a = *depth of the equivalent concrete stress block* (*mm*)
- F_y = *yield strength of reinforcing steel* (450 *MPa min.*)
- f'_c = *compressive strength of concrete* (20 *MPa min.*)
- A_s = *area of reinforcing steel in the direction ofanalysis* (mm^2/m *width*)
- b = *unit slab width* (*mm*)
- d^+ *or* d^- = *distance from extreme compression fiber to centroïd of tension reinforcement* (*mm*)
- t = *thickness of the slab* (*mm*)
- $\varnothing_s$ = *performance factor of reinforcing steel* (0.85)
- $\varnothing_c$ = *performance factor of concrete* (0.65)



MD2000 wire mesh position (d+, d-)

Shear Capacity

The shear stress capacity (V_r), which is a measure of diagonal tension, is unaffected by the embedment of the top chord section as this principal tensile crack would be angled and radiate away from the top chord. The factored shear capacity is given by CAN/CSAA23.3, clause 11.3.4:

$$V_r = V_c = \varnothing_c \lambda \beta \sqrt{f'_c} b_w d_v$$

Where:

$$\lambda = 1 \ (for\ normal\ density\ concrete)$$

$$\beta = \frac{230}{(1{,}000 + d_v)}$$

$$d_v = 0.9\ d^+ or\ 0.9\ d^- \geq 0.72\ t\ (mm)$$

$$d^+ \ or\ d^- = distance\ from\ extreme\ compression\ fiber\ to\ centroïd\ of\ tension\ reinforcement\ (mm)$$

$$b_w = b = width\ of\ the\ slab\ (mm)$$

Serviceability limit states

Crack control parameter

When the specified yield strength, F_y, for tension reinforcement exceeds 300 MPa, cross sections of maximum positive and negative moments shall be so proportioned that the quantity Z does not exceed 30,000 N/mm for interior exposure and 25,000 N/mm for exterior exposure. Refer to CSA A23.3, clause 10.6.1.

The quantity Z limiting distribution of flexural reinforcement is given by:

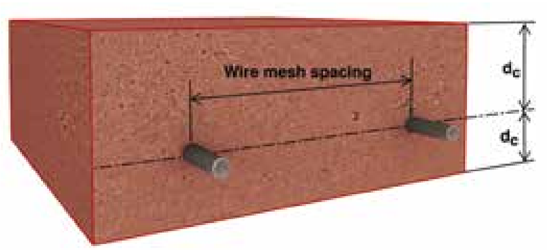
$$Z = f_s \sqrt[3]{d_c A}$$

Where:

f_s = *stress in reinforcement at specified loads taken as* $0{,}6F_y$ (MPa)

d_c = *thickness of concrete cover measure from extreme tension fibre to the center of the reinforcing bar located closest thereto* ≤ 50 *mm*

A = $2d_c$ *x wire mesh spacing,* (mm^2)



Crack control parameter

Deflection control

For one-way slabs not supporting or attached to partitions of other construction likely to be damaged by large deflections, deflection criteria are considered to be satisfied if the following span/depth ratio are met (CAN/CSA-A23.3, Table 9.2):

Exterior span: $t \geq L_i/24$
Interior span: $t \geq L_i/28$

Where:

L_i = *spacing between joists* (mm)

Slab design example

Verify the standard Hambro slab under various limit states (strength and serviceability) for residential loading.

	Metric
Dead load	3.5 kPa
Live load	1.9 kPa
Concentrated load	4.5 kN on 750 mm x 750 mm everywhere
Total slab thickness	115 mm
Slab thickness (t)	76 mm
Joists spacing (L_i)	1,220 mm
Concrete strength (f'_c)	20 MPa
Wire mesh	152 x 152 MW25.7 x MW25.7
Area of steel (A_s)	170 mm²/mm
Wire mesh diameter	5.74 mm

1. Loads and efforts per meter of slab

Factored load

$W_f = 1.25 \; x \; 3.5 + 1.5 \; x \; 1.9 = 7.23 \; kN/m^2$

Maximum positive moment at location 1

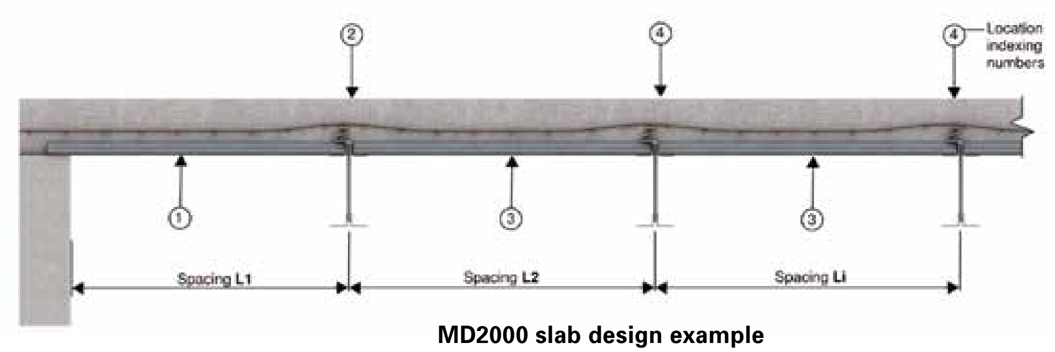
$$M_f^+ = \frac{7.23 \; x \; 1.22^2}{11} \; x \; 1 \; m = 0.98 \; kNm$$

Maximum negative moment at location 2

$$M_f^- = \frac{7.23 \; x \; 1.22^2}{10} \; x \; 1 \; m = 1.08 \; kNm$$

Maximum shear

$$V_f = \frac{1.15 \; x \; 7.23 \; x \; 1.22}{2} = 5.07 \; kN$$



MD2000 slab design example

2. Resistance under uniform load

Positive moment capacity

$$d^+ = t - 38.1 \; mm - \varnothing_{mesh}/2$$

$$d^+ = 76 - 38.1 - \frac{5.74}{2} = 35.03 \; mm$$

$$\alpha_1 = 0.85 - 0.0015 \; x \; 20 = 0.82 \geq 0.67 \rightarrow OK$$

$$a = \frac{\varnothing_s A_s F_y}{\alpha_1 \varnothing_c f'_c b} = \frac{0.85 \; x \; 170 \; x \; 450}{0.82 \; x \; 0.65 \; x \; 20 \; x \; 1{,}000} = 6.1 \; mm$$

$$M_r^+ = \varnothing_s A_s F_y \, (d^+ - a/2) = 0.85 \; x \; 170 \; x \; 450 \; (35.03 - 6.1/2) = 2.08 \; kNm > M_f^+ = 0.98 \; kNm \rightarrow OK$$

Negative moment capacity

$$d^- = t - d^+$$

$$d^- = 76 - 35.03 = 40.97 \; mm$$

$$\alpha_1 = 0.85 - 0.0015 \; x \; 20 = 0.82 \geq 0.67 \rightarrow OK$$

$$a = \frac{\varnothing_s A_s F_y}{\alpha_1 \varnothing_c f'_c b} = \frac{0.85 \; x \; 170 \; x \; 450}{0.82 \; x \; 0.65 \; x \; 20 \; x \; 1{,}000} = 6.1 \; mm$$

$$M_r^- = \varnothing_s A_s F_y \, (d^- - a/2) = 0.85 \; x \; 170 \; x \; 450 \; (40.97 - 6.1/2) = 2.47 \; kNm > M_f^- = 1.08 \; kNm \rightarrow OK$$

Shear capacity

$$d_v = 0.9 \; d^- \geq 0.72 \; t$$

$$d_v = 0.9 \; x \; 40.97 \geq 0.72 \; x \; 76 \rightarrow 36.87 \; mm \geq 54.72 \; mm \rightarrow d_v = 54.72 \; mm$$

$$\beta = \frac{230}{(1{,}000 + d_v)}$$

$$\beta = \frac{230}{(1{,}000 + 54.72)} = 0.218$$

$$V_r = \varnothing_c \lambda \beta \sqrt{f'_c} b_w d_v$$

$$V_r = 0.65 \; x \; 1 \; x \; 0.218\sqrt{20} \; x \; 1{,}000 \; x \; 54.72 = 34.68 \; kN > V_f = 5.07 \; kN$$

3. Resistance under concentrated load

Refer to table Slab capacity under concentrated load on page 87.

The slab can carry a dead load of 5 kPa which is higher than the specified loads of 3.5 kPa. Then, the reinforcement is ok.

4. Serviceability

Crack control

$d_c = max\ [t - 38.1 - \varnothing_{mesh}/2;\ 38.1 + \varnothing_{mesh}/2]$
$d_c = max\ [76 - 38.1 - 5.74/2;\ 38.1 + 5.74/2] = max\ [35.03;\ 40.97] = 40.97\ mm$

$A = 2\ d_c\ x\ wire\ mesh\ spacing$
$A = 2\ x\ 40.97\ x\ 152 = 12{,}454.88\ mm^2$

$f_s = 0.6\ F_y$
$f_s = 0.6\ x\ 450 = 270\ MPa$

$Z = f_s \sqrt[3]{d_c A}$
$Z = 270 \sqrt[3]{40.97\ x\ 12{,}454.88} = \dfrac{21{,}576\ N}{mm} < \dfrac{30{,}000\ N}{mm} \rightarrow OK$

Deflection control

$$\frac{span}{depth} = \frac{1{,}220}{76} = 16.05$$

$$\text{Exterior span: } t \geq L_i/24 \rightarrow t \geq \frac{1{,}220}{24} = 50.83 > 16.05 \rightarrow OK$$

$$\text{Interior span: } t \geq L_i/28 \rightarrow t \geq \frac{1{,}220}{28} = 43.57 > 16.05 \rightarrow OK$$

DIAPHRAGM

Note: The calculations attached to diaphragm design are metric only.

THE HAMBRO SLAB AS A DIAPHRAGM

With the increasing use of the Hambro system for floor-building in earthquake or in hurricane prone areas as well as for multi-story buildings where shear transfer could occur at some level of the building due to the reduction of the floor plan, it is important to develop an understanding of how the slabs will be able to transmit horizontal loads while being part of the Hambro floor system. Note that the deck cannot be used structurally for the diaphragm at the composite stage, it is used only for the formwork or for the diaphragm during the erection of the structure.

The floor slab, part of the Hambro system, must be designed by the project structural engineer as a diaphragm to resist horizontal loads and transmit them to the vertical resisting system. Take note that the Hambro joist doesn't transfer lateral loads and that drag struts or connectors should be designed in order to transfer these loads to the perimeter elements. The Canam engineering team is available for technical support for diaphragm design.

A diaphragm works as the web of a beam spanning between or extending beyond the supports. In the case of a floor slab, the slab is the web of the beam spanning between or extending beyond the vertical elements designed to transmit to the foundations the horizontal loads produced by earthquake or wind.

Any diaphragm has the following limit states:

1. Shear strength between the supports;
2. Out of plane buckling;
3. In plane deflection of the diaphragm;
4. Shear transmission at the supports.

We will use a simple example of wind load acting on a diaphragm part of a horizontal beam forming a single span between end walls. The structural engineer responsible for the design of the building shall establish the horizontal loads that must be resisted at each floor of the building for the wind and earthquake conditions prevailing at the building location. The structural engineer must also identify the vertical elements that will transmit the horizontal loads to the foundations in order to calculate the shear that must be resisted by the floor slab.

Shear strength between supports

A series of fourteen specimens of concrete slabs, part of a Hambro D500 floor system, were tested in the Carleton University's laboratories in Ottawa. Since MD2000 works on the same principles, these results are applicable as well. The purpose of the tests was to identify the variables affecting the in-plane shear strength of the concrete slab reinforced with welded wire mesh.

The specimens were made of slabs with a concrete thickness of 64 mm or 68 mm forming a beam with a span of 610 mm and a depth of 610 mm. This beam was loaded with two equal concentrated loads at 152 mm from the supports. The other variables were:

1. The size of the wire mesh;
2. The presence or absence of the Hambro joist's embedded top chord parallel to the load in the shear zone;
3. The concrete strength.

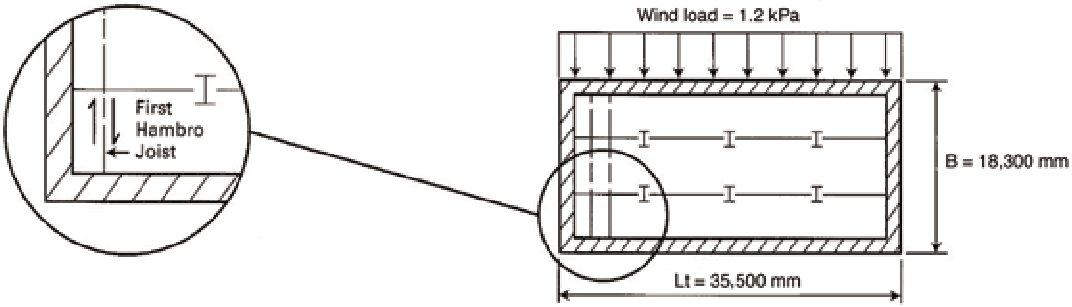
It was found that the shear resistance of the slab is minimized when the shear stress is parallel to the Hambro joist's embedded top chord. A conservative assumption could be made that the concrete confined **steel wire mesh is the only element that will transmit the shear load** over the embedded top chord. In other cases, the shear forces are taken up by the reinforced concrete slab and calculated by the structural engineer responsible for the design of the building.

As recommended in the report produced as a result of tests conducted at the Carleton University, in the following example of the design procedure, we will take into account that the steel wire mesh is already under tension stress produced by the continuity of the slab over the Hambro joist, and that the remaining capacity of the steel wire mesh will be the limiting factor for the shear strength of the slab over the Hambro joist.

Design example

The diaphragm example (see figure on page 104) illustrates a simple building with a slab in diaphragm. Hambro system values are taken from the slab design example on page 100. Other necessary values are listed below.

	Metric
Total wind pressure load from leeward and windward faces (*W*)	1.2 kPa
Story height (h_s)	3.7 m
Span of the beam with the floor slab acting as web (*Lt*)	35.5 m
Length of the walls parallel to the horizontal force (*B*)	18.3 m



Diaphragm example

1. Non-factored moments

   The ending moment over the embedded top chord is calculated for one-meter width. In using the data from the slab design example, the non-factored moments for a joist with a spacing of 1,220 mm is:

   Dead load: $Mf_d^- = \dfrac{3.5\ kPa\ x\ 1.22^2}{10}\ x\ 1\ m = 0.52\ kNm$

   Live load: $Mf_L^- = \dfrac{1.9\ kPa\ x\ 1.22^2}{10}\ x\ 1\ m = 0.28\ kNm$

2. Bending moment in the slab between joists due to gravity loads

   The lever arm between the compression concrete surface and the tension steel of the wire mesh at the top chord allows us to calculate the factored bending capacity of the slab to be $M_r^- = 2.47\ kNm.$

3. Horizontal shear

   We can establish the horizontal shear that the floor diaphragm will have to resist in order to transfer the horizontal load from the walls facing the wind to the perpendicular walls where a vertical lateral resisting system will bring that load down to the foundation.

   For the purpose of our example, the factored wind load is the maximum horizontal load calculated according to the provisions of the local building code, but earthquake load shall also be calculated by the structural design engineer of the project and the maximum of the two loads should be used in the calculation.

$$V_f = h_s W \frac{Lt}{2}$$
$$= 3.7\ x\ 1.2\ \frac{35.5}{2}$$
$$= 78.8\ kN$$

   In our example, the end reaction is distributed along the whole length (18.3 m) of the end wall used to transfer the load.

$$V_f = \frac{78.8}{18.3}$$
$$= 4.3\ kN/m$$

4. Steel shear capacity

   To establish the shear capacity of steel wire mesh for a slab unit width of one meter, we use the following formula adapted from CSA-A23.3, clause 11.5, and simplify it to calculate the resistance of the reinforcing steel only, considering a shear crack developing at a 45 degree angle and intersecting the wire mesh in both directions.

$$\begin{aligned} V_r &= \varnothing_s A_s F_y \cos 45° \\ &= (0.85 \; x \; 2 \; x \; 170 \; x \; 450 \cos 45°)/1{,}000 \\ &= 98.89 \; kN/\mathrm{m} \end{aligned}$$

   The steel area is multiplied by two since the crack is developing at a 45 degree angle, crossing both directions of the wire mesh.

5. Interaction formulas

   Considering the reduction factor from the NBCC for the simultaneity of gravity live load and horizontal wind load for our example, the structural engineer of the project needs to verify the diaphragm capacity of the floor slab and its reinforcement by verifying that the moment and shear interaction formulas used below are less than unity:

   Load Combination 1:

$$1.25 \frac{Mf^-_d}{M_r} + 1.5 \frac{Mf^-_L}{M_r} \leq 1$$

$$1.25 \frac{0.49}{2.47} + 1.5 \frac{0.30}{2.47} = 0.43 \leq 1 \rightarrow OK \text{ (Doesn't control)}$$

   Load Combination 2:

$$1.25 \frac{Mf^-_d}{M_r} + 1.5 \frac{Mf^-_L}{M_r} + 0.4 \frac{V_f}{V_r} \leq 1$$

$$1.25 \frac{0.52}{2.47} + 1.5 \frac{0.28}{2.47} + 0.4 \frac{4.3}{98.89} = 0.45 \leq 1 \rightarrow OK \text{ (Controls)}$$

   Load Combination 3:

$$1.25 \frac{Mf^-_d}{M_r} + 0.5 \frac{Mf^-_L}{M_r} + 1.4 \frac{V_f}{V_r} \leq 1$$

$$1.25 \frac{0.52}{2.47} + 0.5 \frac{0.28}{2.47} + 1.4 \frac{4.3}{98.89} = 0.38 \leq 1 \rightarrow OK \text{ (Doesn't control)}$$

These verifications indicate that the wire mesh embedded in the slab would provide enough shear strength to transfer those horizontal loads over the Hambro joist.

Out of plane buckling

The floor slab, when submitted to a horizontal shear load, may tend to buckle out of plane like a sheet of paper being twisted. The minimum thickness of Hambro concrete slab of 76 mm plus deck of 38 mm are properly held in place by the Hambro joists spaced at a maximum of 1,829 mm which are attached at their ends to prevent vertical movement. The buckling length of the slab itself will then be limited to the spacing of the joist and the buckling of a floor will normally not be a factor in the design of the slab as a diaphragm.

In plane deflection of the diaphragm

As for every slab used as a diaphragm, the deflection of the floor as a horizontal member between the supports provided by the vertical bracing system shall be investigated by the structural engineer of the building to verify that the horizontal deflection remains within the allowed limits.

Beam effect

The structural engineer of the project shall indicate the required steel reinforcement on his drawings according to the beam effect calculations.

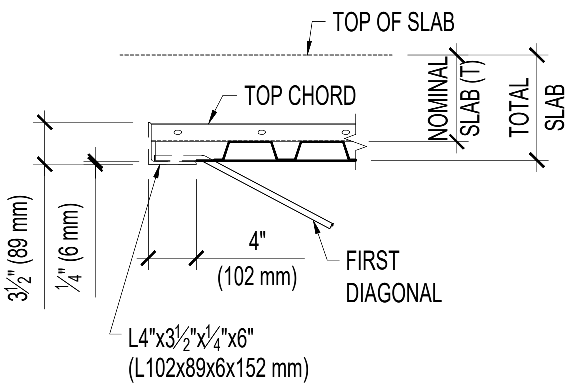
Shear transmission to the vertical bracing system

The structural engineer of the project shall design and indicate on his drawings proper methods and/or reinforcement to attach the slab to the vertical bracing system over such a length as to prevent local overstress of the slab capacity to transfer shear.

ENGINEERING TYPICAL DETAILS – HAMBRO MD2000 (MDH SERIES)

DETAIL 40

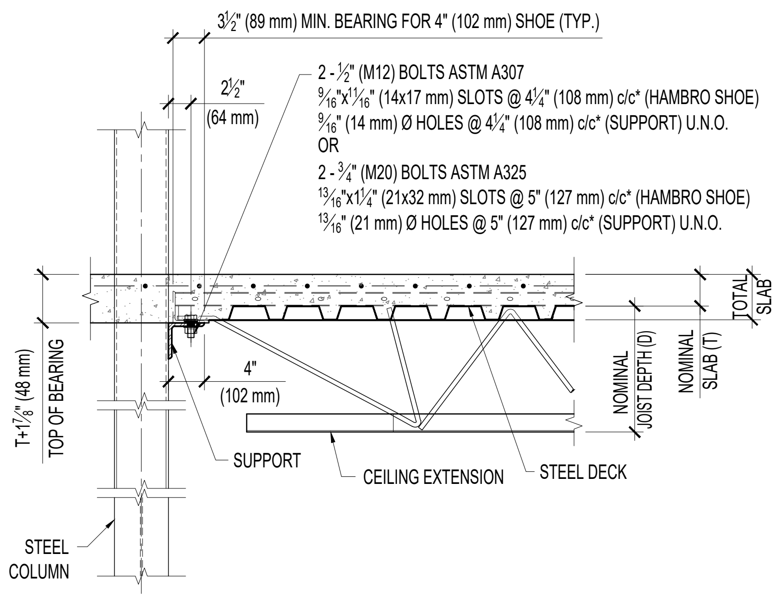
MD2000 STANDARD SHOE



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 41

BOLTED JOIST ON STEEL COLUMN (FLANGE, WEB)

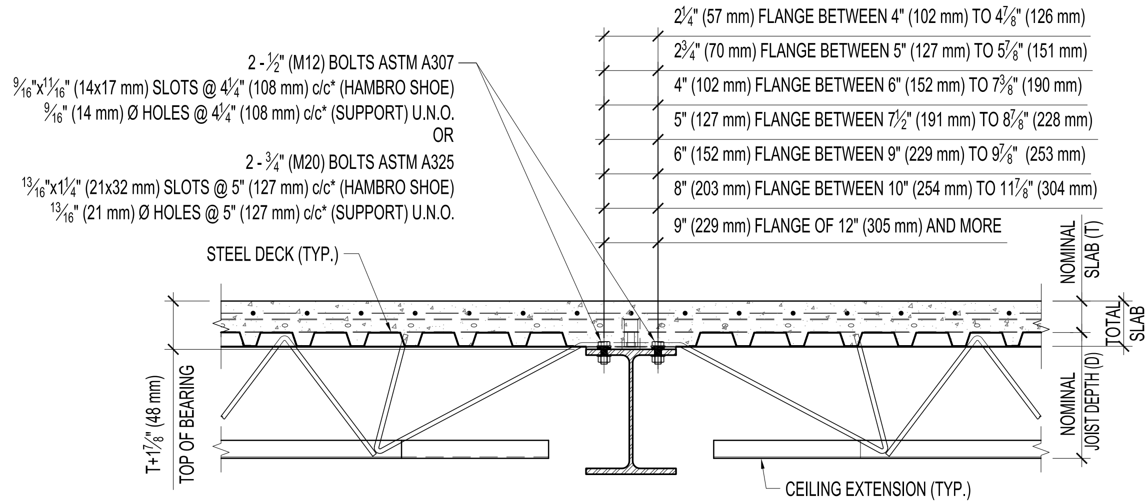


T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

* WHEN DEEP SHOE, THE C/C OF HOLE IS DIFFERENT, CONSULT THE APPROPRIATE DETAILS ON PLAN.

DETAIL 42

BOLTED JOIST ON INTERIOR STEEL BEAM

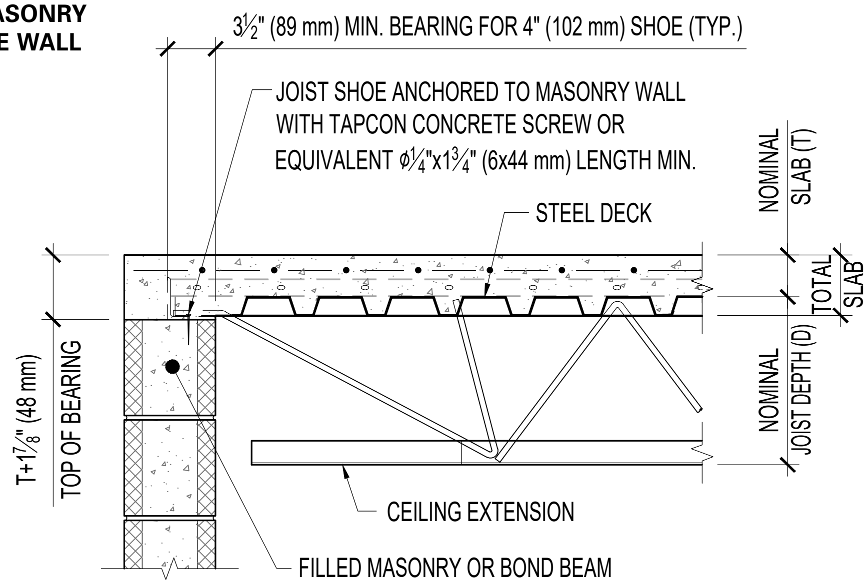


T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE FLANGE BEAM IS LESS THAN 8" (203 mm).
* WHEN DEEP SHOE, THE C/C OF HOLE IS DIFFERENT, CONSULT THE APPROPRIATE DETAILS ON PLAN.

DETAIL 43

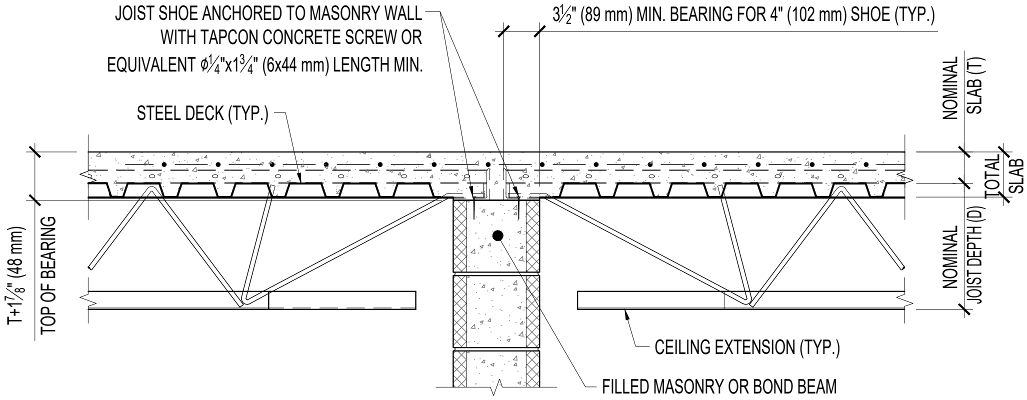
JOIST BEARING ON EXTERIOR MASONRY OR CONCRETE WALL



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 44

JOIST BEARING ON INTERIOR MASONRY OR CONCRETE WALL

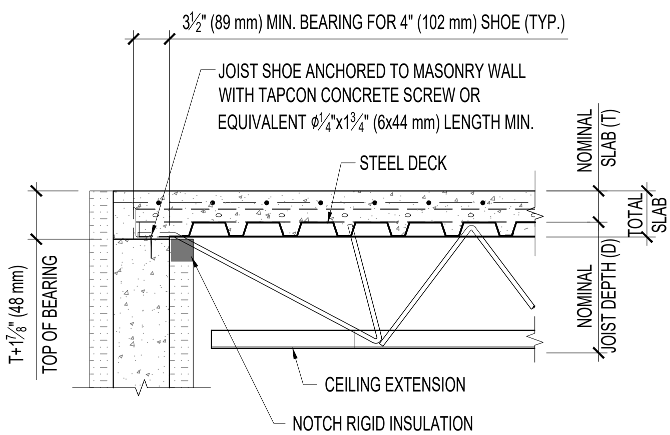


T+1 7/8" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 45

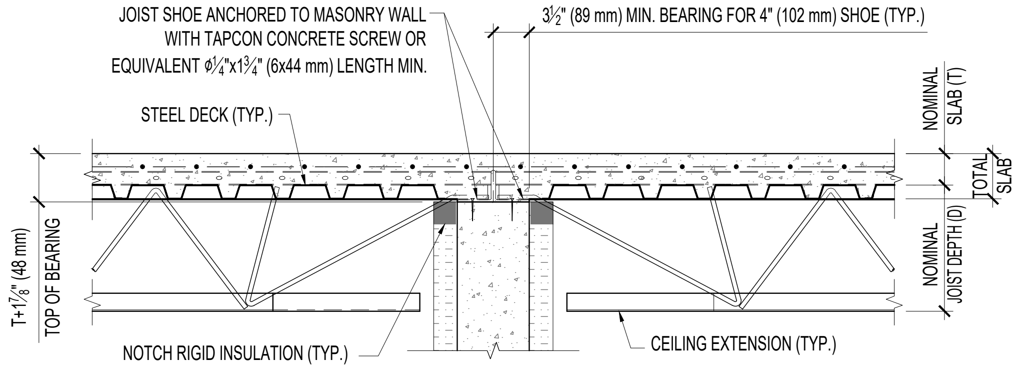
JOIST BEARING ON EXTERIOR INSULATED CONCRETE WALL



T+1 7/8" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 46

JOIST BEARING ON INTERIOR INSULATED CONCRETE WALL

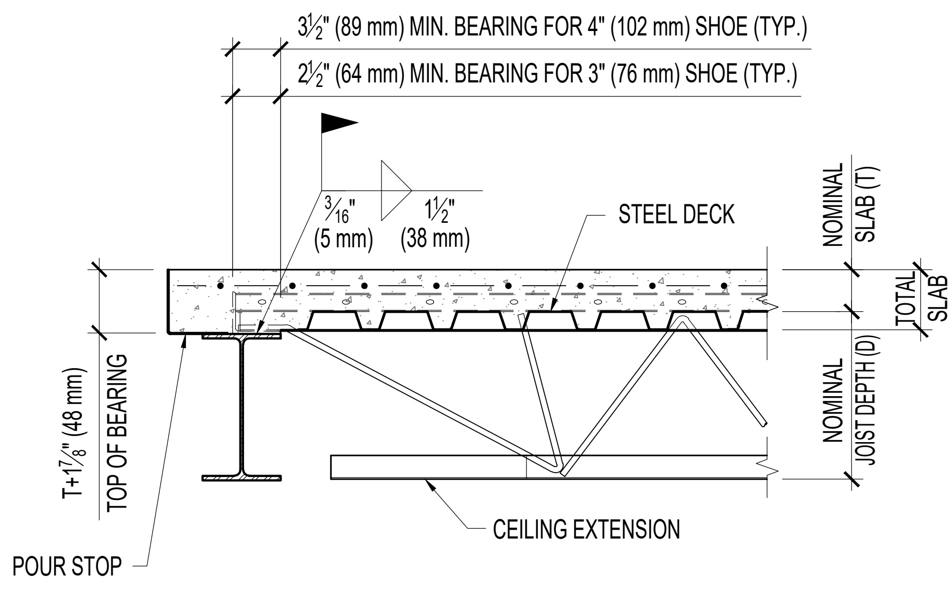


T+1 7/8" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 47

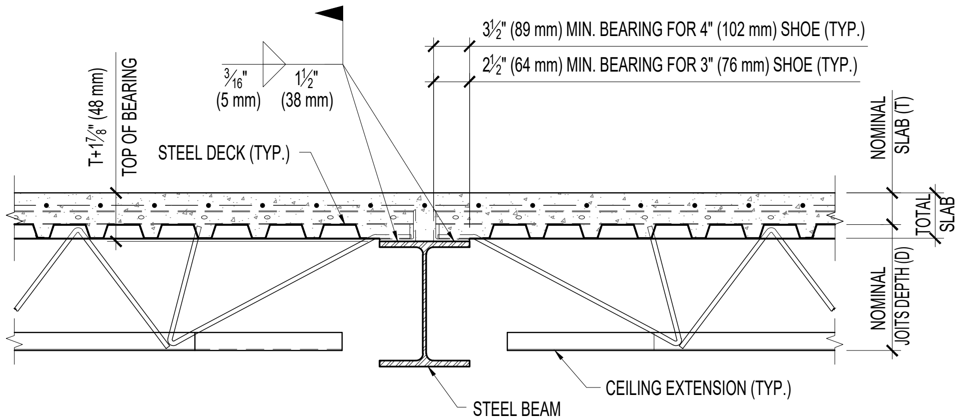
JOIST BEARING ON EXTERIOR STEEL BEAM



T+1 7/8" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 48

JOIST BEARING ON INTERIOR STEEL BEAM

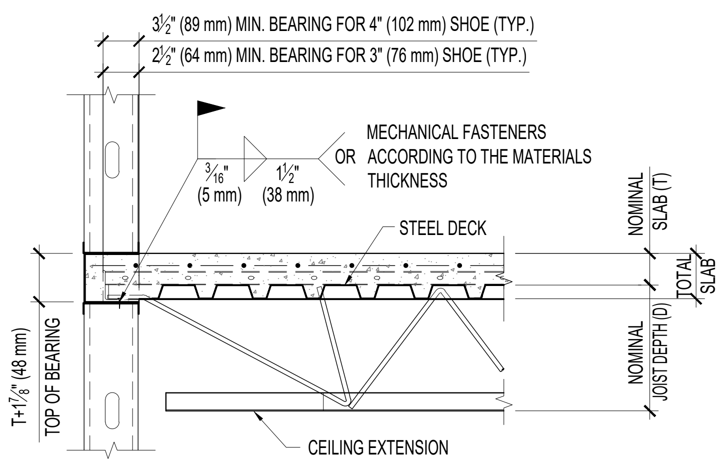


T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE FLANGE BEAM IS LESS THAN 8" (203 mm).

DETAIL 49

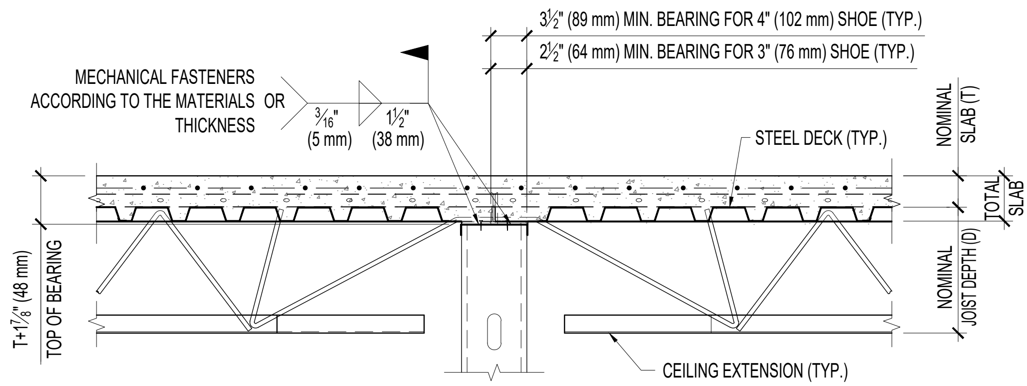
JOIST BEARING ON EXTERIOR STEEL STUD WALL



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 50

JOIST BEARING ON INTERIOR STEEL STUD WALL

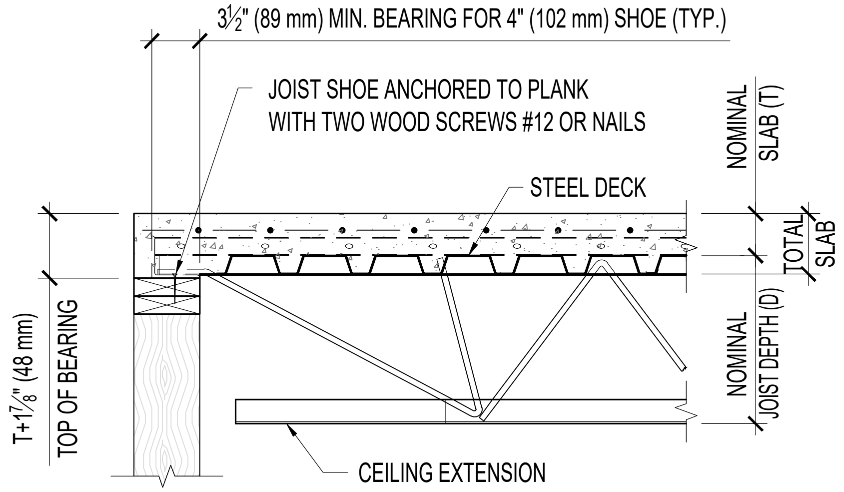


T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 51

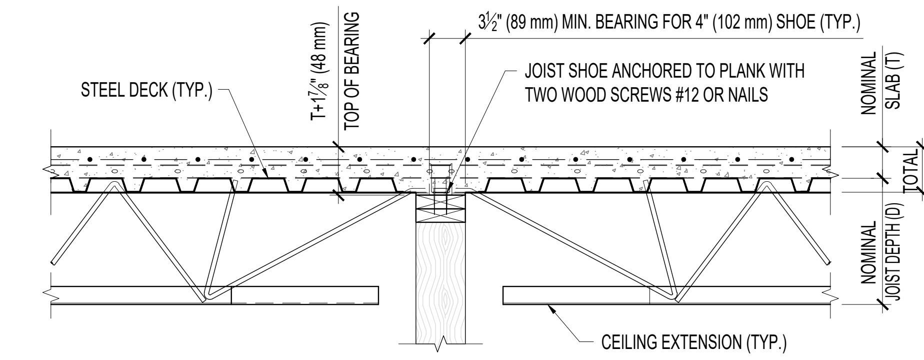
JOIST BEARING ON EXTERIOR WOOD STUD WALL



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 52

JOIST BEARING ON INTERIOR WOOD STUD WALL

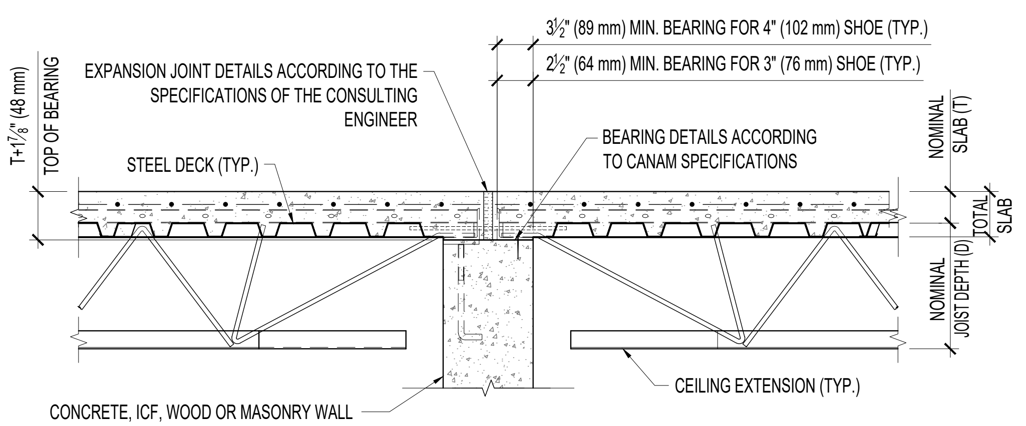


T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8" (203 mm).

DETAIL 53

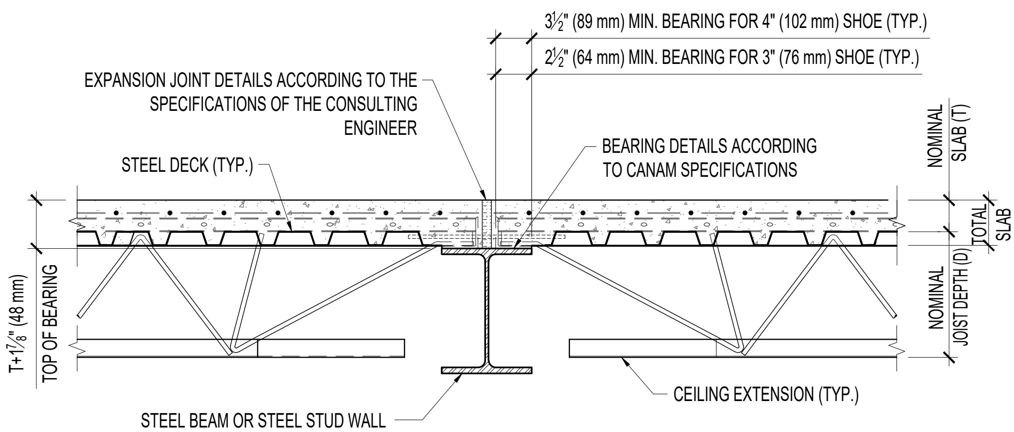
EXPANSION JOINT AT ROOF



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 54

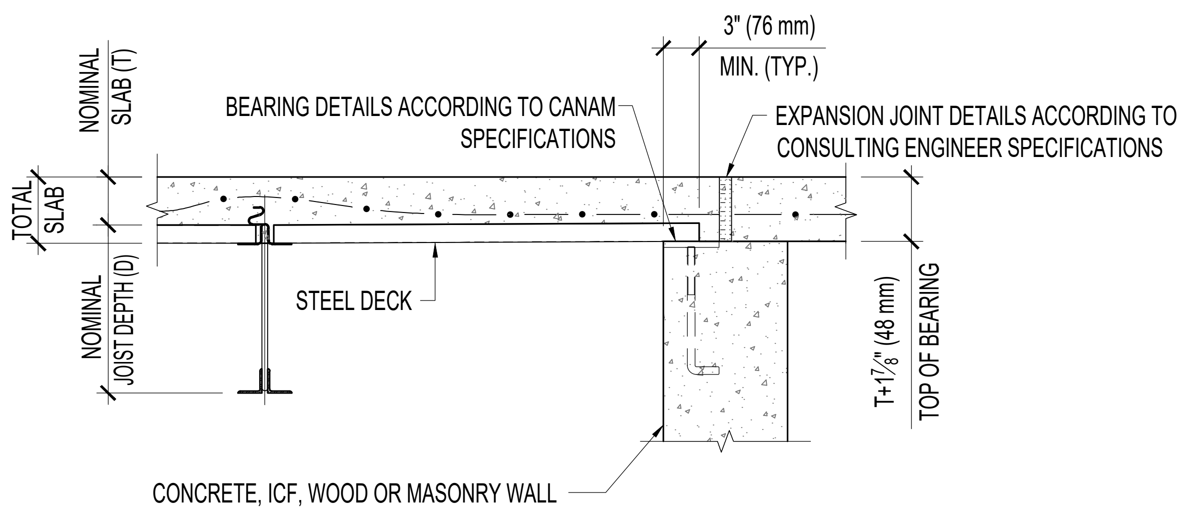
EXPANSION JOINT AT ROOF (STEEL BEAM)



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 55

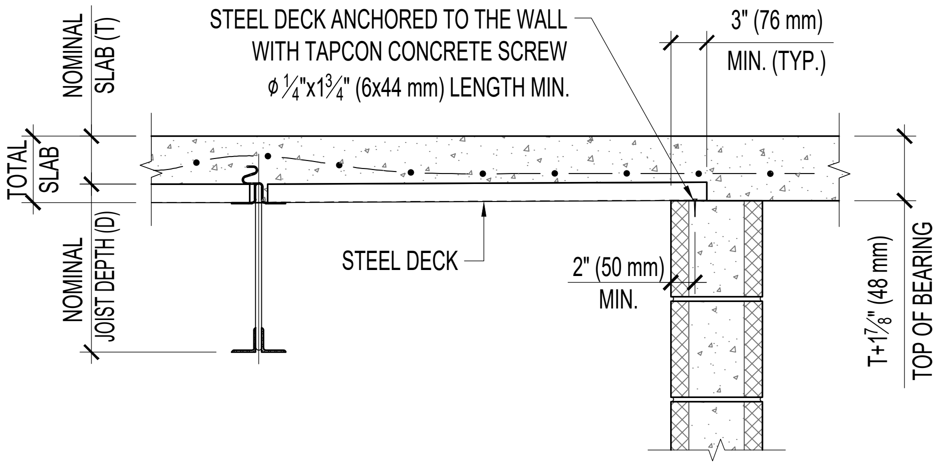
JOIST PARALLEL TO EXPANSION JOINT



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 56

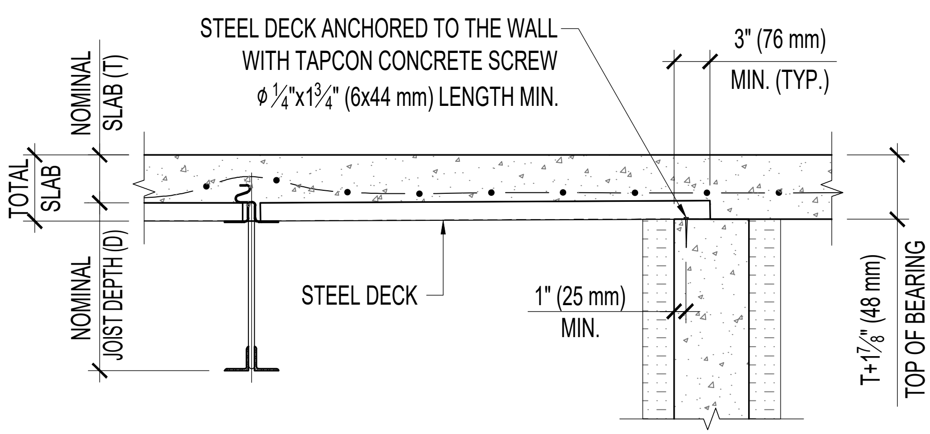
JOIST PARALLEL TO MASONRY OR CONCRETE WALL



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 57

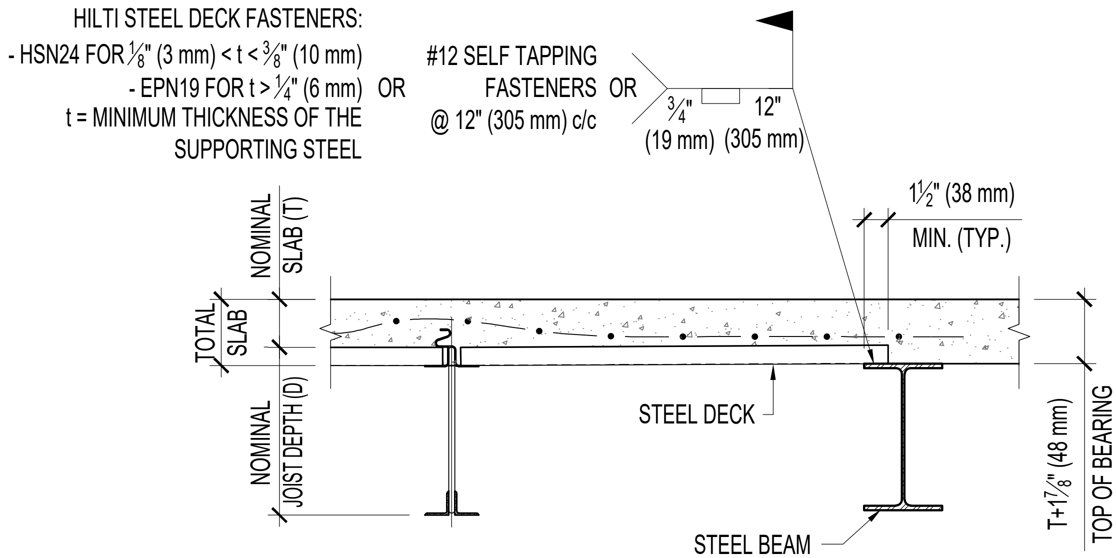
JOIST PARALLEL TO INSULATED CONCRETE WALL



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 58

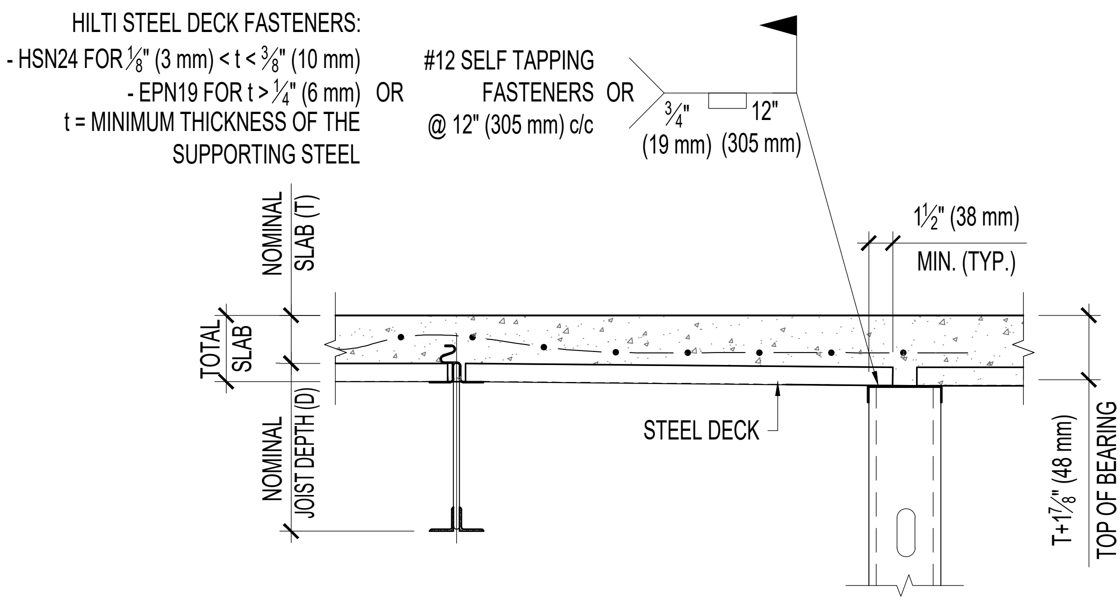
JOIST PARALLEL TO A STEEL BEAM



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 59

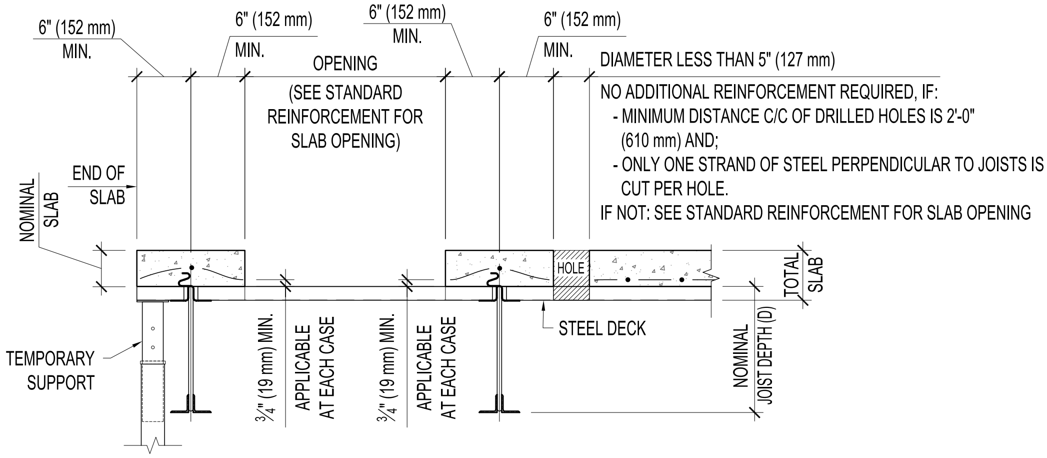
JOIST PARALLEL TO A STEEL STUD WALL

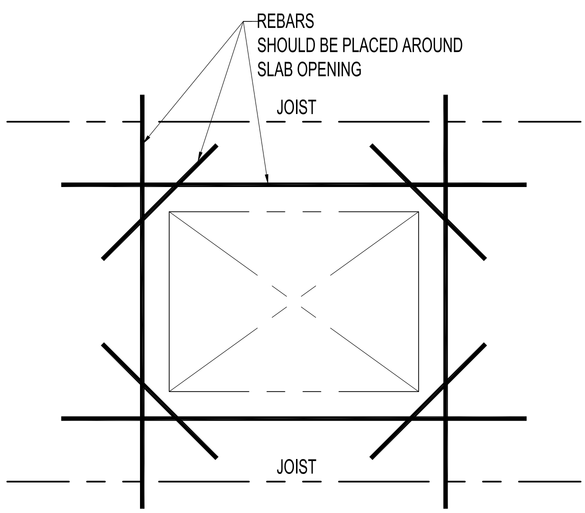


T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 60

MINIMUM CLEARANCE OPENING AND HOLE IN THE SLAB



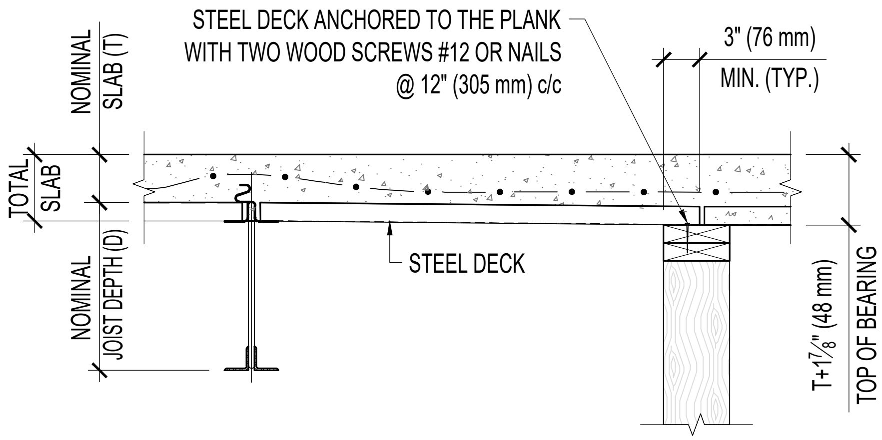


IF SLAB OPENING IS:
- LESS THAN 1'-5" (430 mm), REINFORCE THE AREA WITH AN ADDITIONAL LAYER OF WIRE MESH LAPPED 1'-0" (305 mm) ALL AROUND OPENING.
- 1'-5" (430 mm) OR MORE, FOLLOW THE ENGINEER OF RECORDS' DETAIL.

STANDARD REINFORCEMENT FOR SLAB OPENING

DETAIL 61

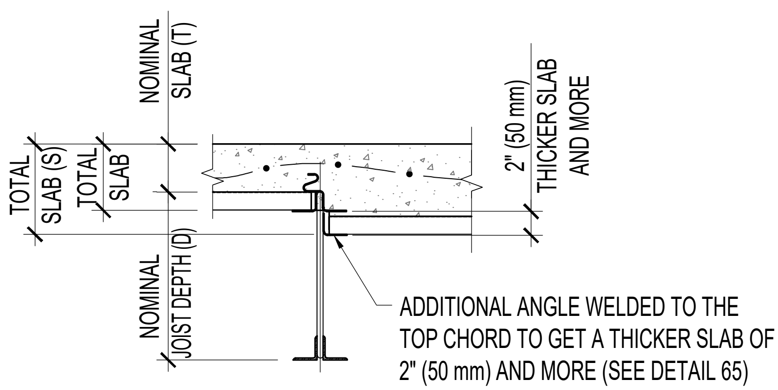
JOIST PARALLEL TO A WOOD WALL



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

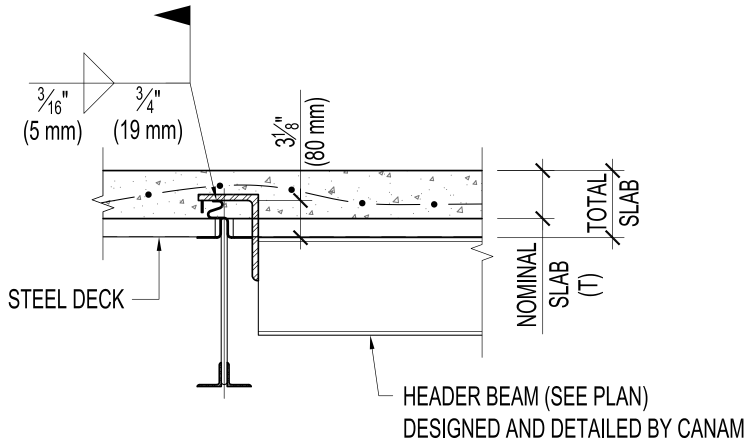
DETAIL 62

THICKER SLAB



DETAIL 63

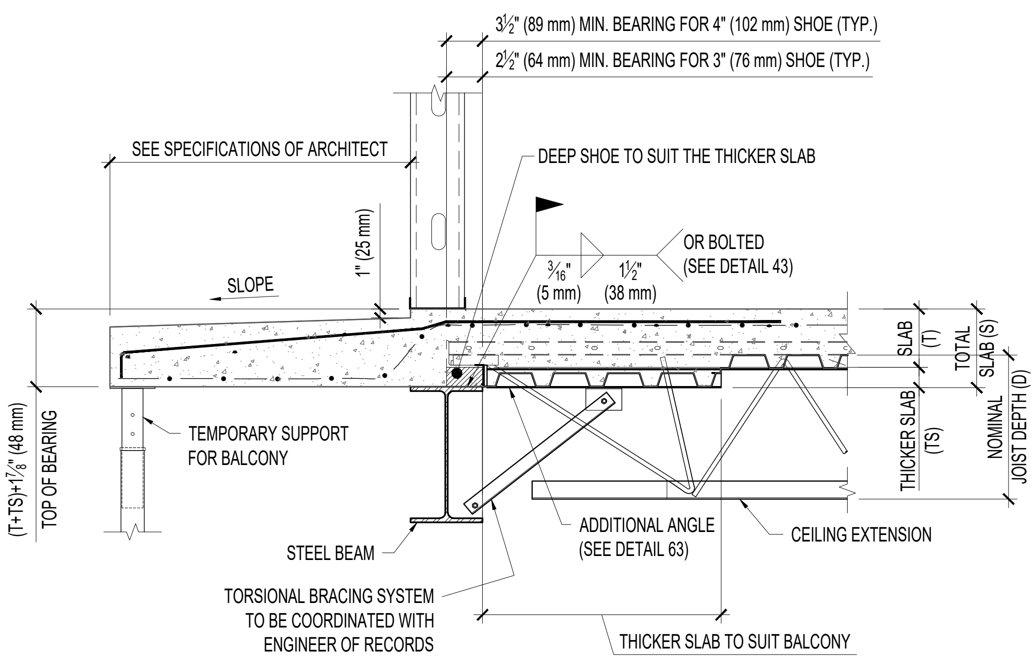
HEADER SUPPORT



NOTE:
IF THERE IS A JOIST SITTING ON THE HEADER BEAM, THE DIMENSION 3⅛" (80 mm) WILL BECOME 3⅜" (86 mm) AND "T" WILL BECOME "T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS".

DETAIL 64

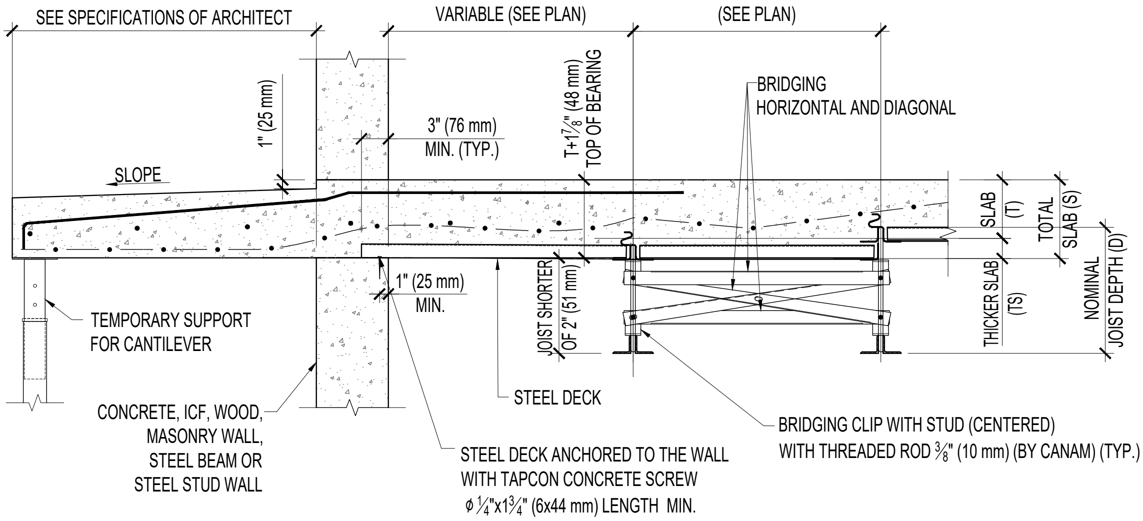
CANTILEVERED BALCONY (JOIST PERPENDICULAR TO BALCONY)



T+1⅞" (48 mm) = (SLAB THICKNESS + THICKER SLAB) + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 65

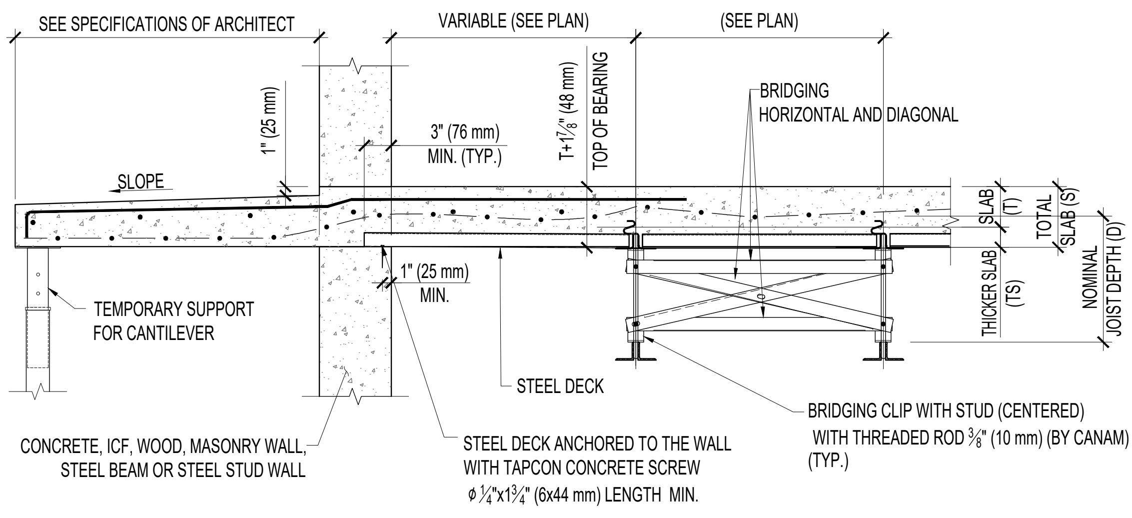
CANTILEVERED BALCONY (SHALLOW JOIST PARALLEL TO BALCONY)



IMPORTANT:
BRIDGING ANGLES, TO BE INSTALLED AFTER FORMS, ARE STRIPPED BUT BEFORE REMOVAL OF CANTILEVER TEMPORARY SUPPORTS.

DETAIL 66

CANTILEVERED BALCONY (JOIST PARALLEL TO BALCONY)

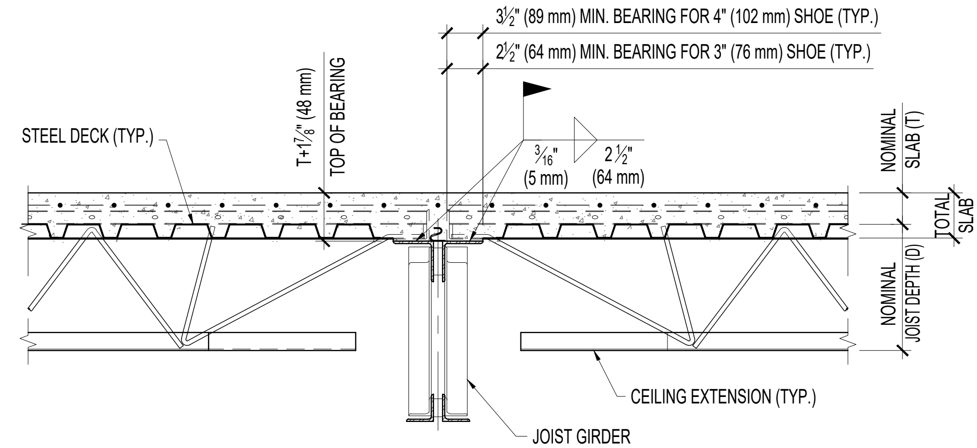


IMPORTANT:
BRIDGING ANGLES, TO BE INSTALLED AFTER FORMS, ARE STRIPPED BUT BEFORE REMOVAL OF CANTILEVER TEMPORARY SUPPORTS.

ENGINEERING TYPICAL DETAILS – HAMBRO MD2000 ON GIRDER

DETAIL 67

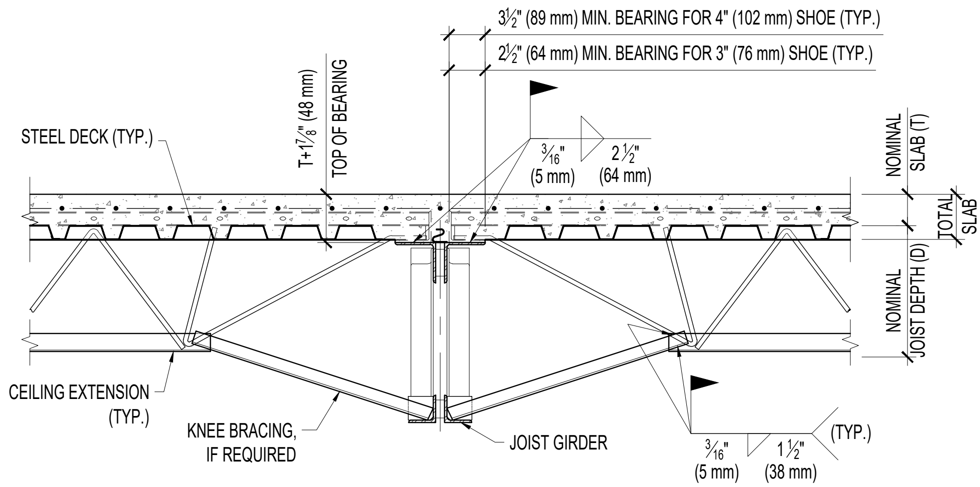
JOIST BEARING ON GIRDER



T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 68

JOIST BEARING ON GIRDER

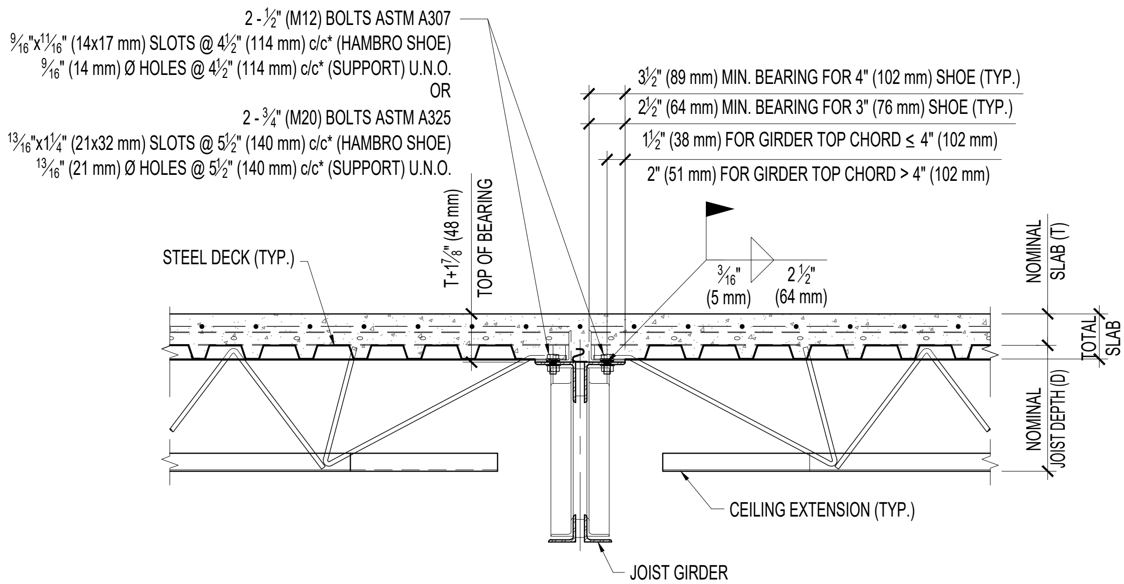


T+1⅞" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
KNEE BRACING, IF REQUIRED, SEE ——— ON DRAWING. SIZE TO BE DETERMINED.

DETAIL 69

BOLTED JOIST ON GIRDER

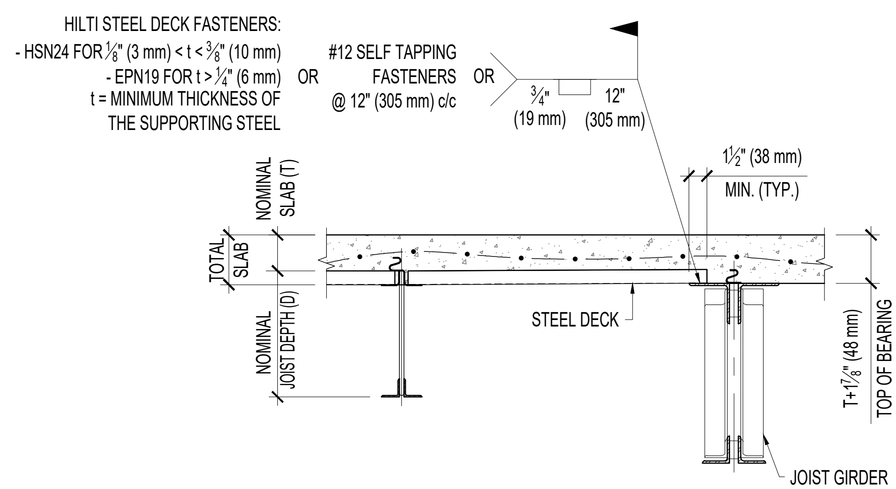


T+1 7/8" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

* WHEN DEEP SHOE, THE c/c OF HOLE IS DIFFERENT, CONSULT THE APPROPRIATE DETAILS ON PLAN.

DETAIL 70

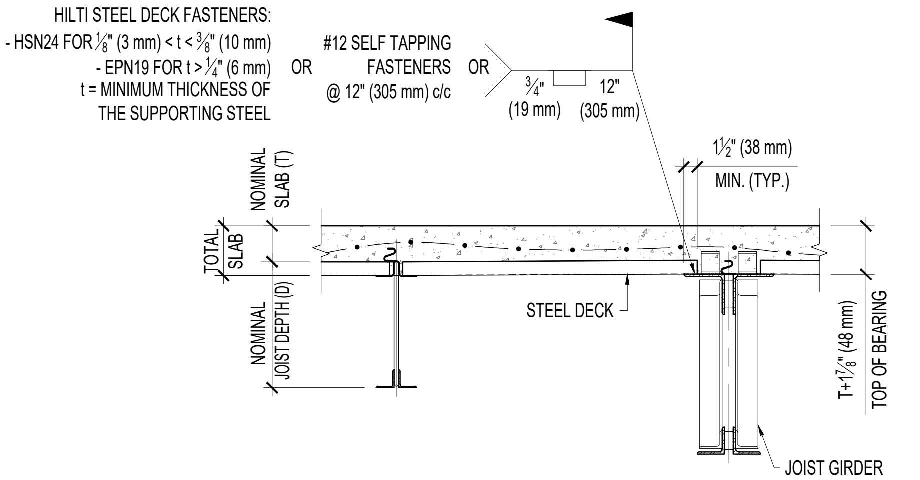
JOIST PARALLEL TO A GIRDER WITHOUT SHEAR CONNECTORS



T+1 7/8" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

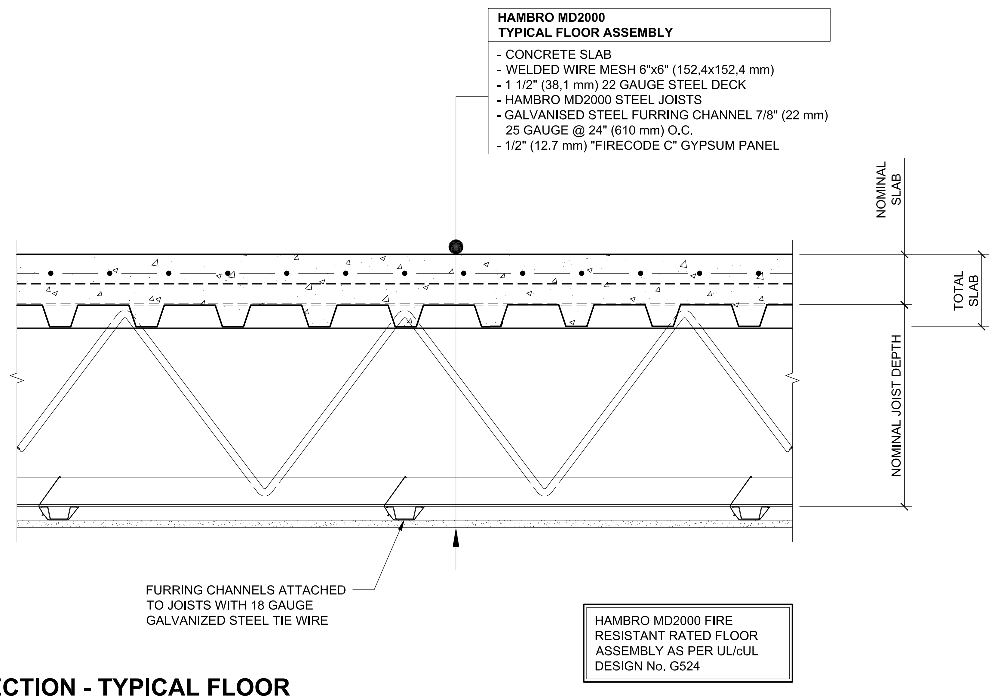
DETAIL 71

JOIST PARALLEL TO A GIRDER WITH SHEAR CONNECTORS

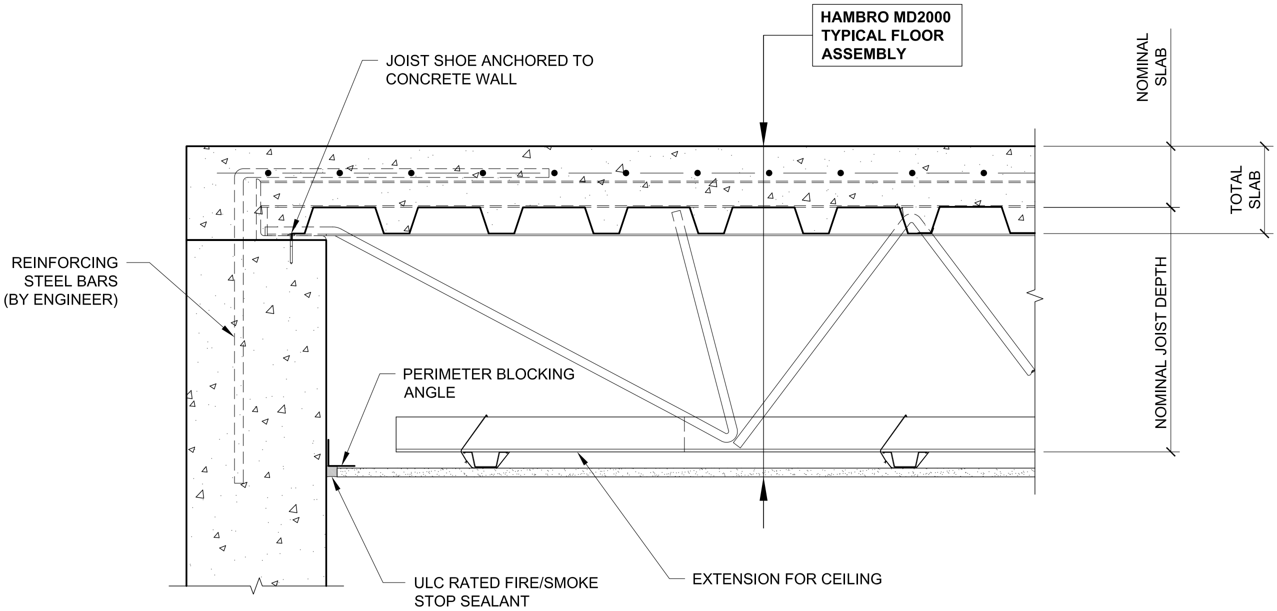


T+1 7/8" (48 mm) = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

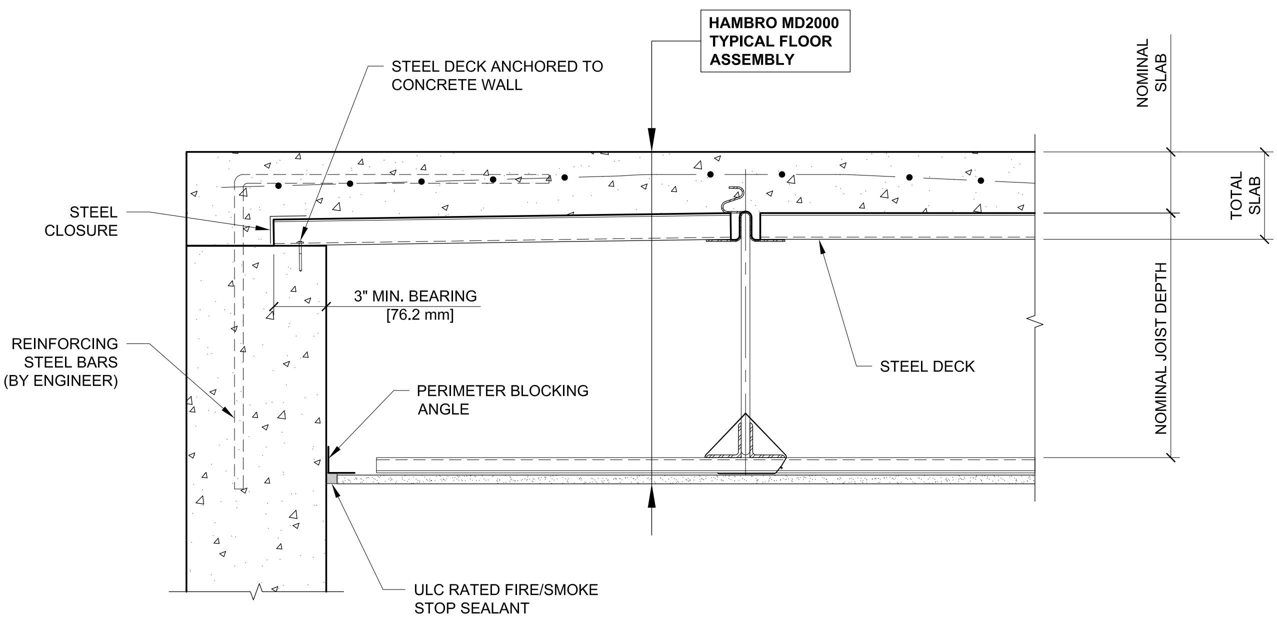
ARCHITECTURAL TYPICAL DETAILS – HAMBRO MD2000 (MDH SERIES)



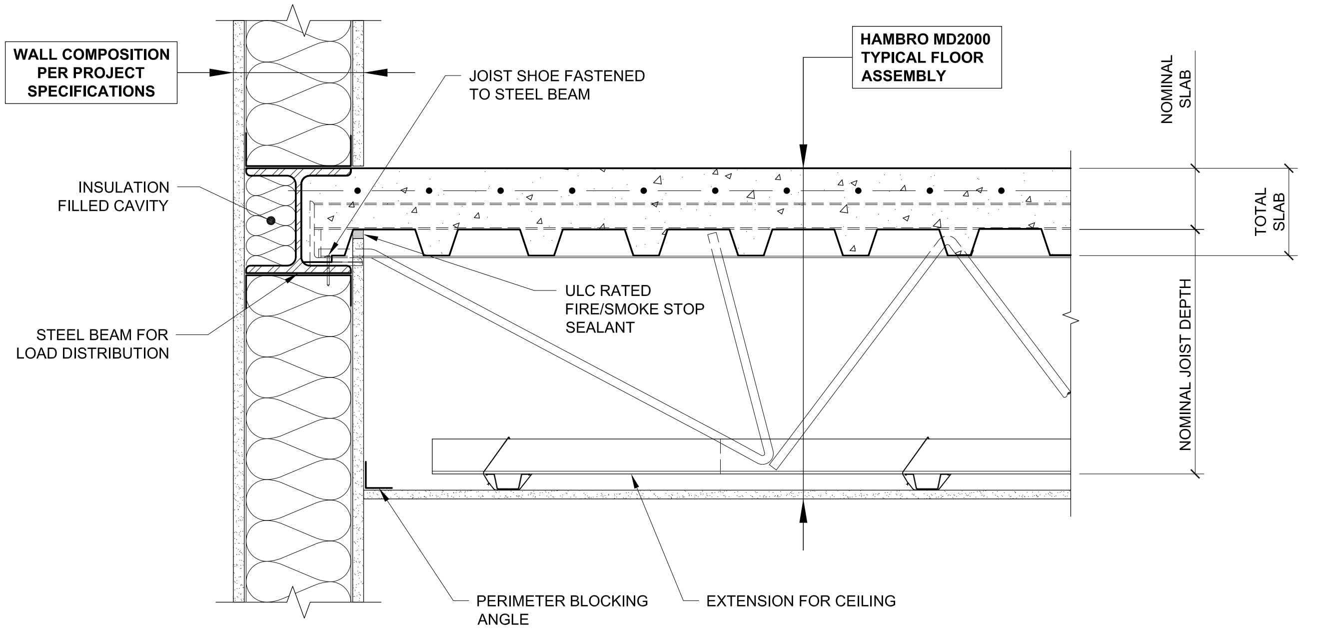
SECTION - TYPICAL FLOOR



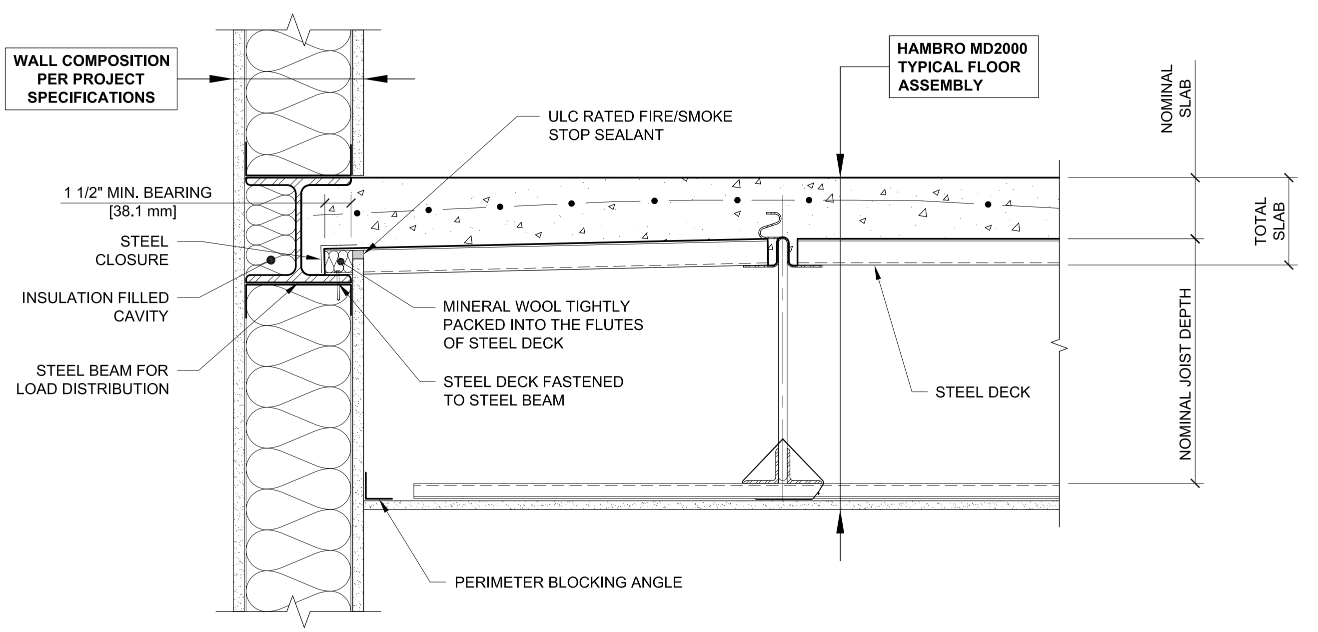
CONCRETE WALL
(PERPENDICULAR)



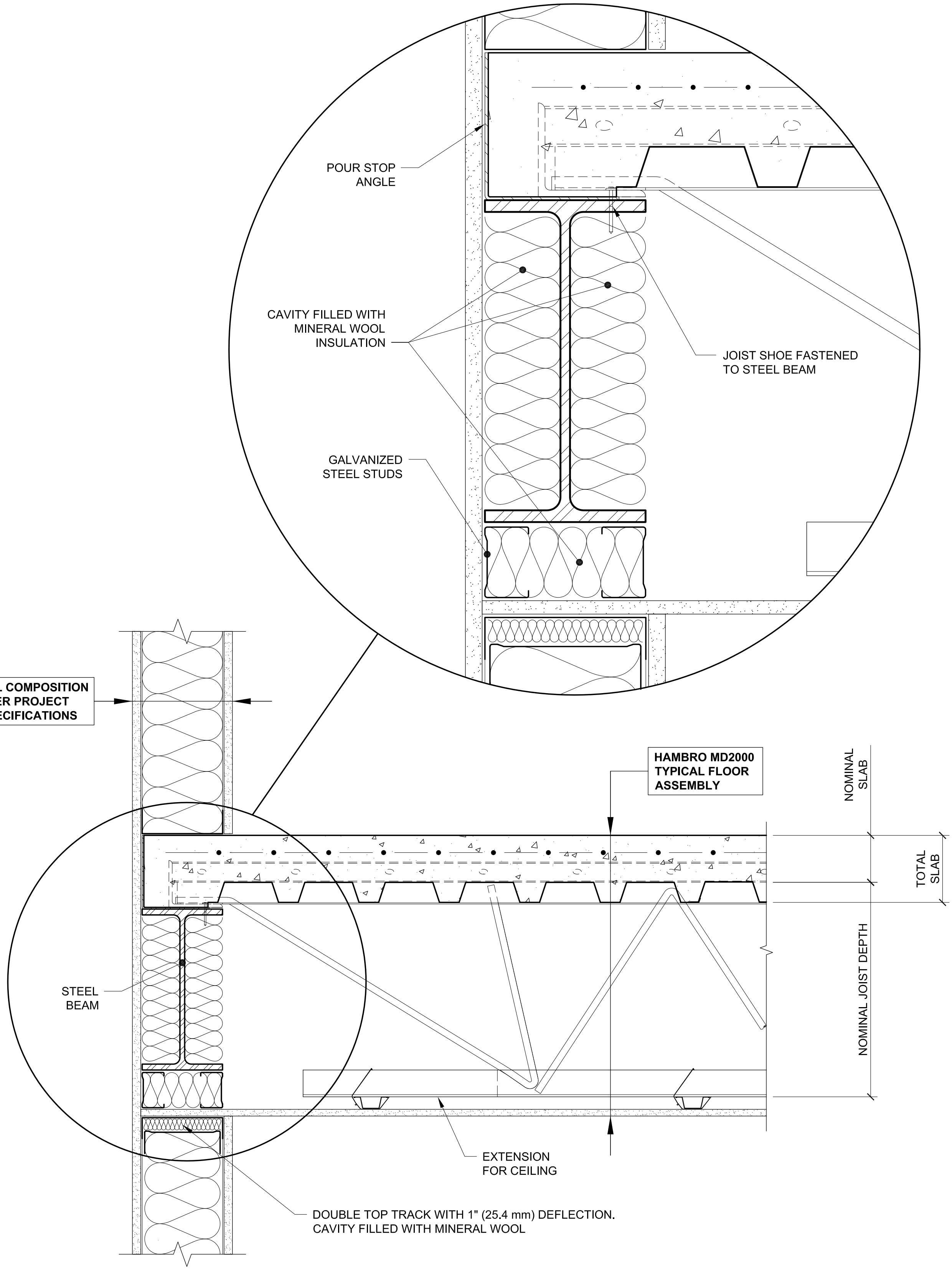
CONCRETE WALL
(PARALLEL)



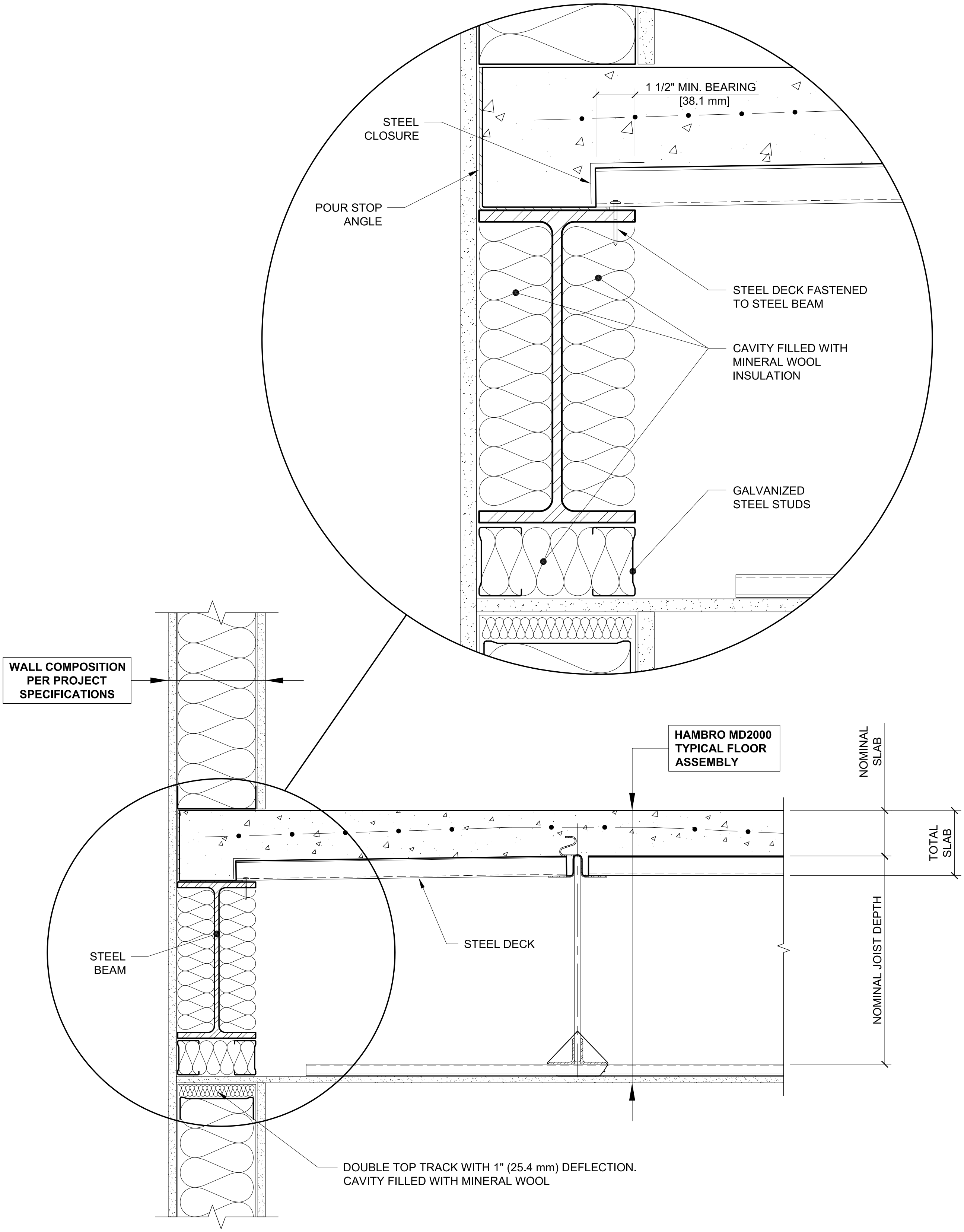
LOAD BEARING STEEL STUD WALL (PERPENDICULAR)



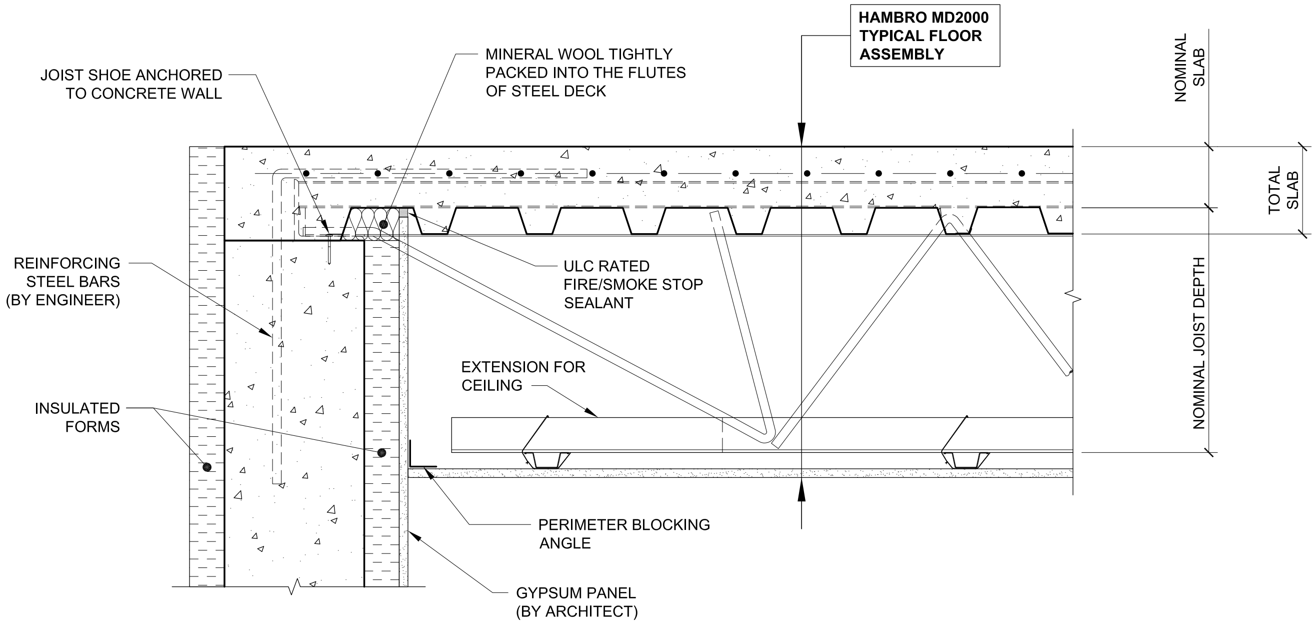
LOAD BEARING STEEL STUD WALL (PARALLEL)



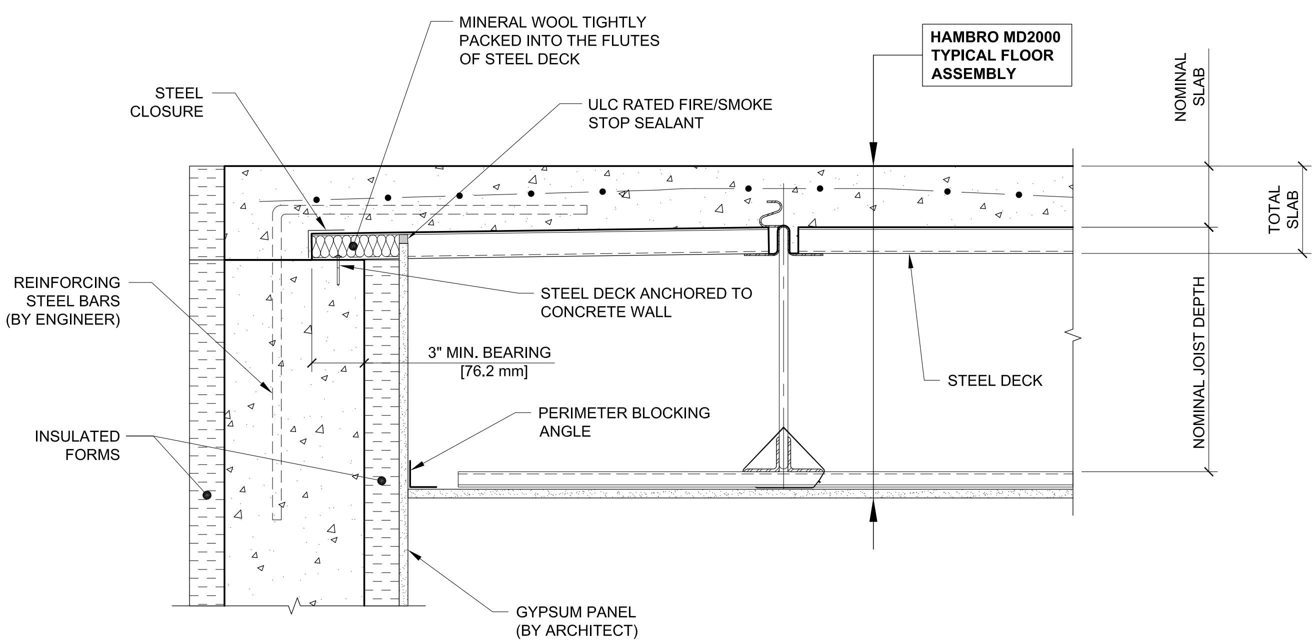
STRUCTURAL STEEL (PERPENDICULAR)



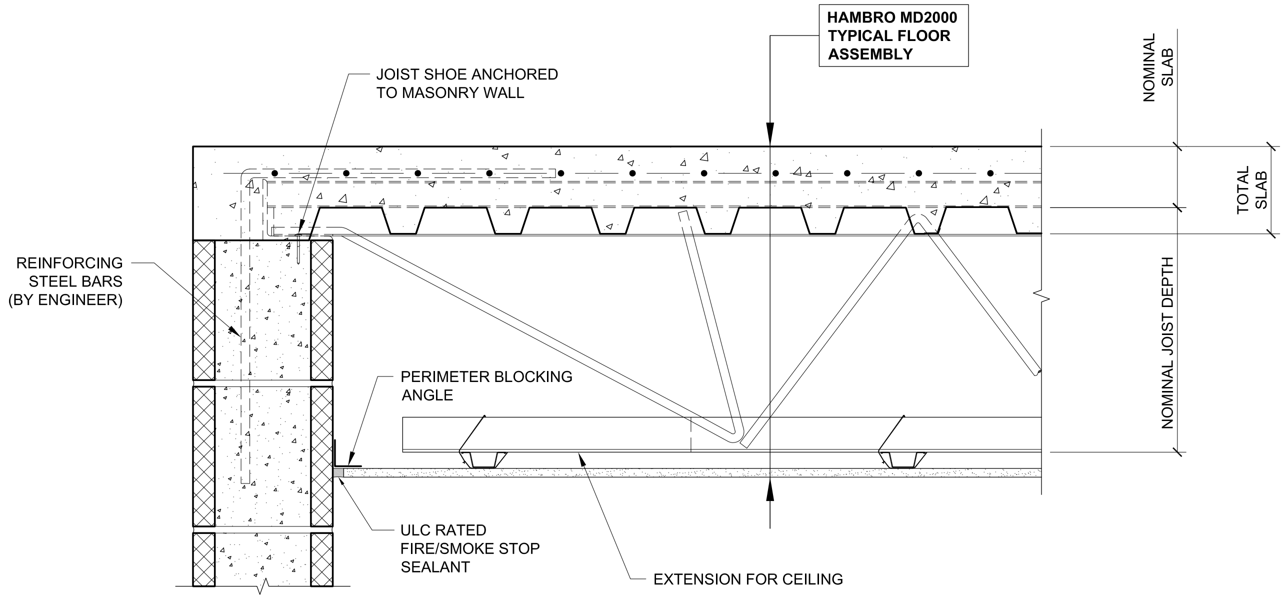
STRUCTURAL STEEL (PARALLEL)



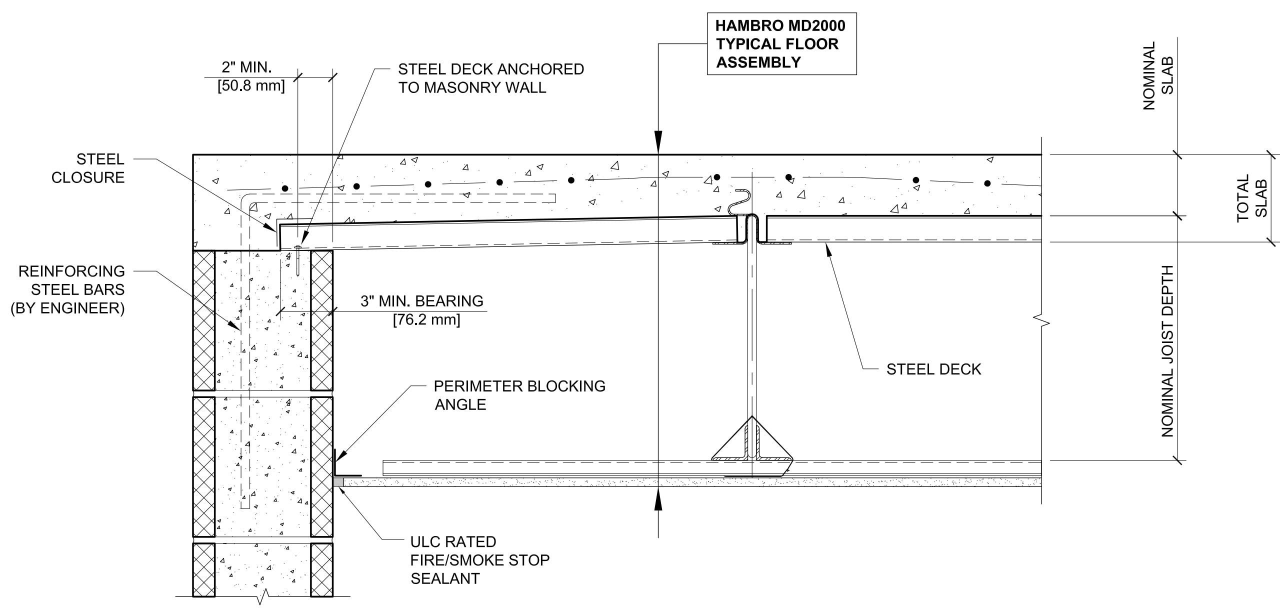
INSULATED CONCRETE FORMS WALL (PERPENDICULAR)



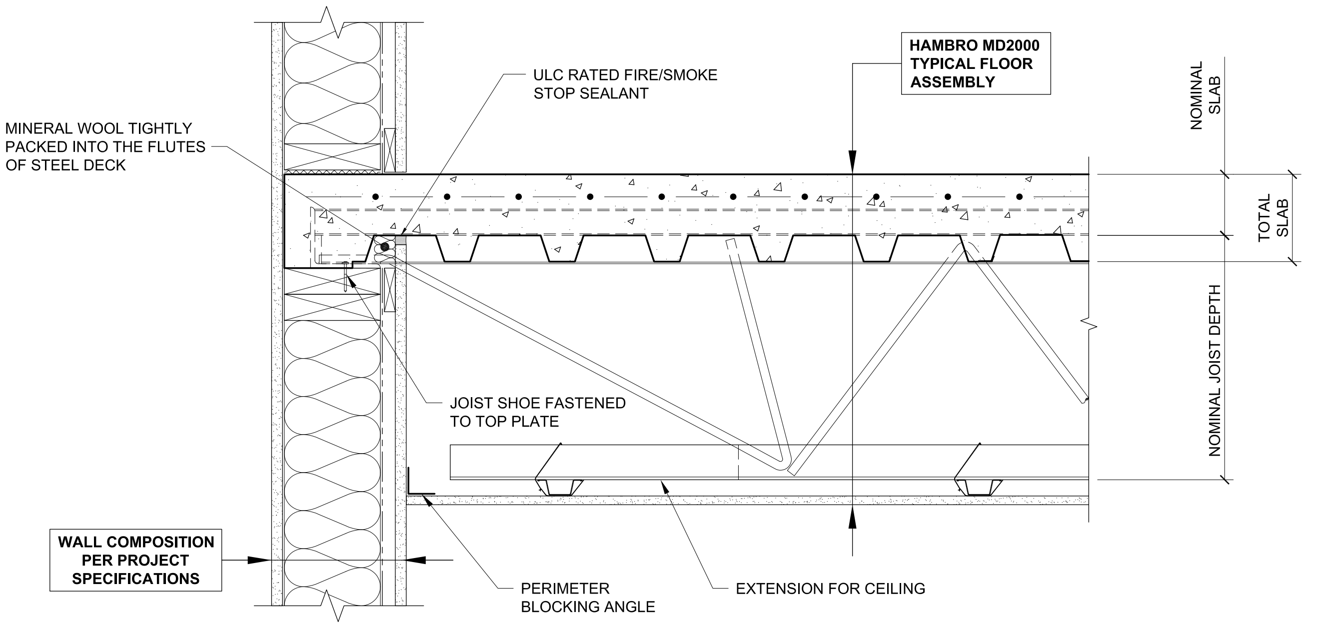
INSULATED CONCRETE FORMS WALL (PARALLEL)



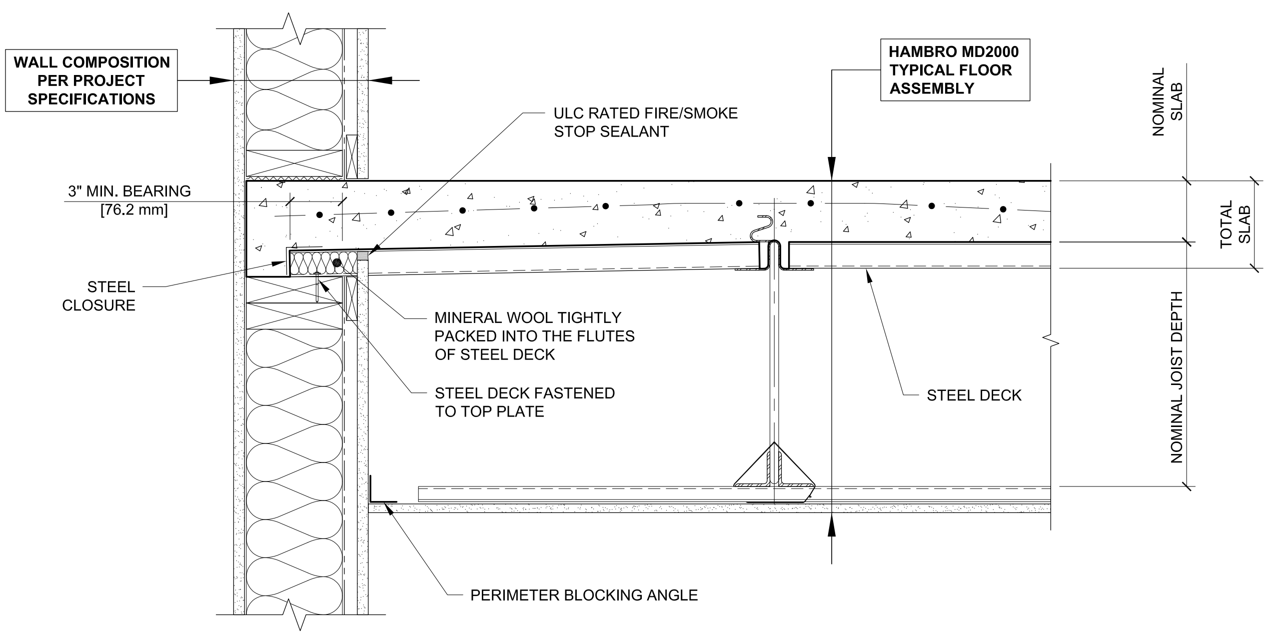
LOAD BEARING MASONRY WALL (PERPENDICULAR)



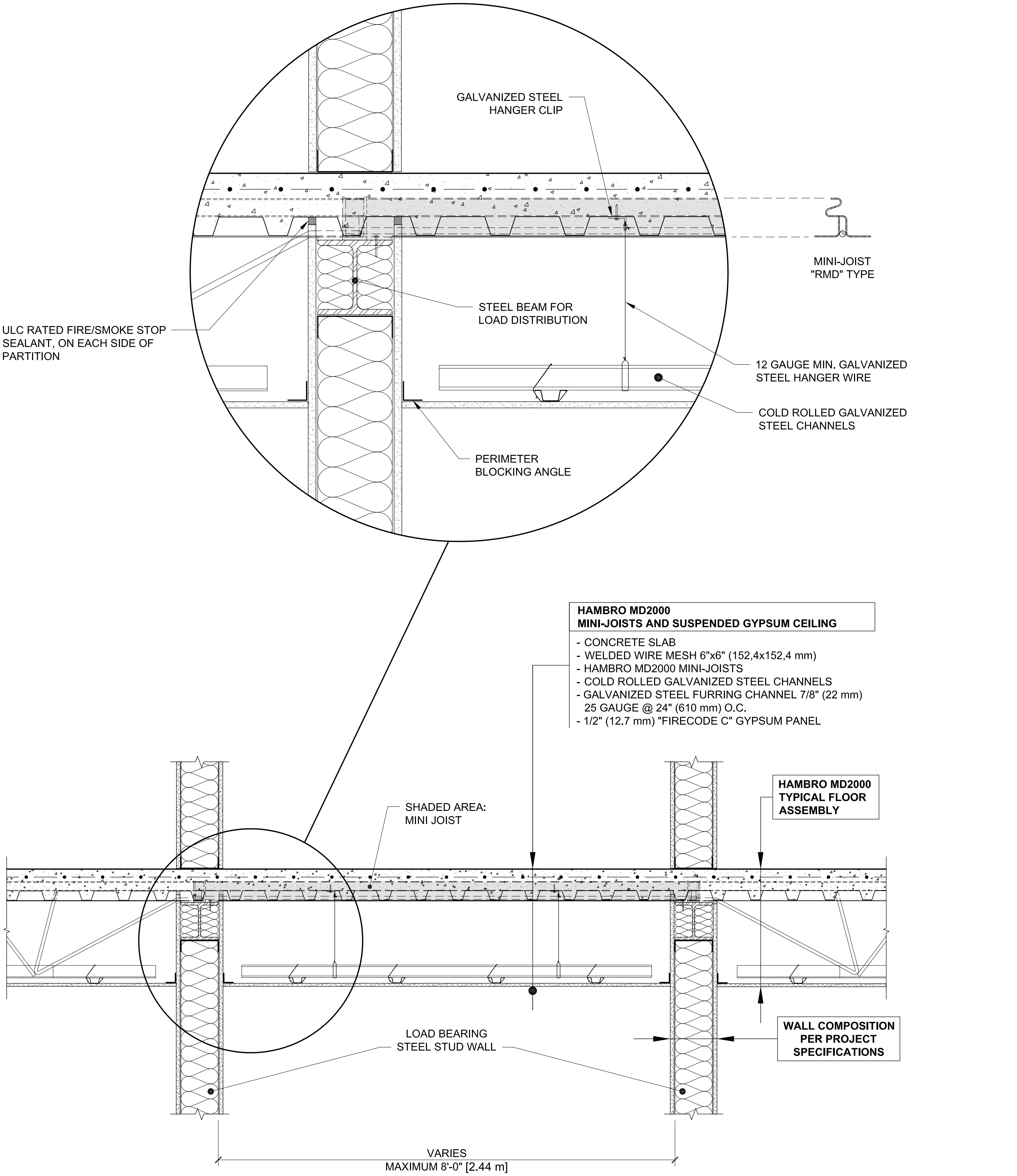
LOAD BEARING MASONRY WALL (PARALLEL)



LOAD BEARING WOOD STUD WALL (PERPENDICULAR)



LOAD BEARING WOOD STUD WALL (PARALLEL)


GALVANIZED STEEL HANGER CLIP
MINI-JOIST "RMD" TYPE
STEEL BEAM FOR LOAD DISTRIBUTION
ULC RATED FIRE/SMOKE STOP SEALANT, ON EACH SIDE OF PARTITION
12 GAUGE MIN. GALVANIZED STEEL HANGER WIRE
COLD ROLLED GALVANIZED STEEL CHANNELS
PERIMETER BLOCKING ANGLE
HAMBRO MD2000
MINI-JOISTS AND SUSPENDED GYPSUM CEILING
- CONCRETE SLAB
- WELDED WIRE MESH 6"x6" (152,4x152,4 mm)
- HAMBRO MD2000 MINI-JOISTS
- COLD ROLLED GALVANIZED STEEL CHANNELS
- GALVANIZED STEEL FURRING CHANNEL 7/8" (22 mm) 25 GAUGE @ 24" (610 mm) O.C.
- 1/2" (12.7 mm) "FIRECODE C" GYPSUM PANEL
SHADED AREA: MINI JOIST
HAMBRO MD2000 TYPICAL FLOOR ASSEMBLY
LOAD BEARING STEEL STUD WALL
WALL COMPOSITION PER PROJECT SPECIFICATIONS
VARIES
MAXIMUM 8'-0" [2.44 m]

MINI-JOISTS

PRODUCT INFORMATION AND BENEFITS

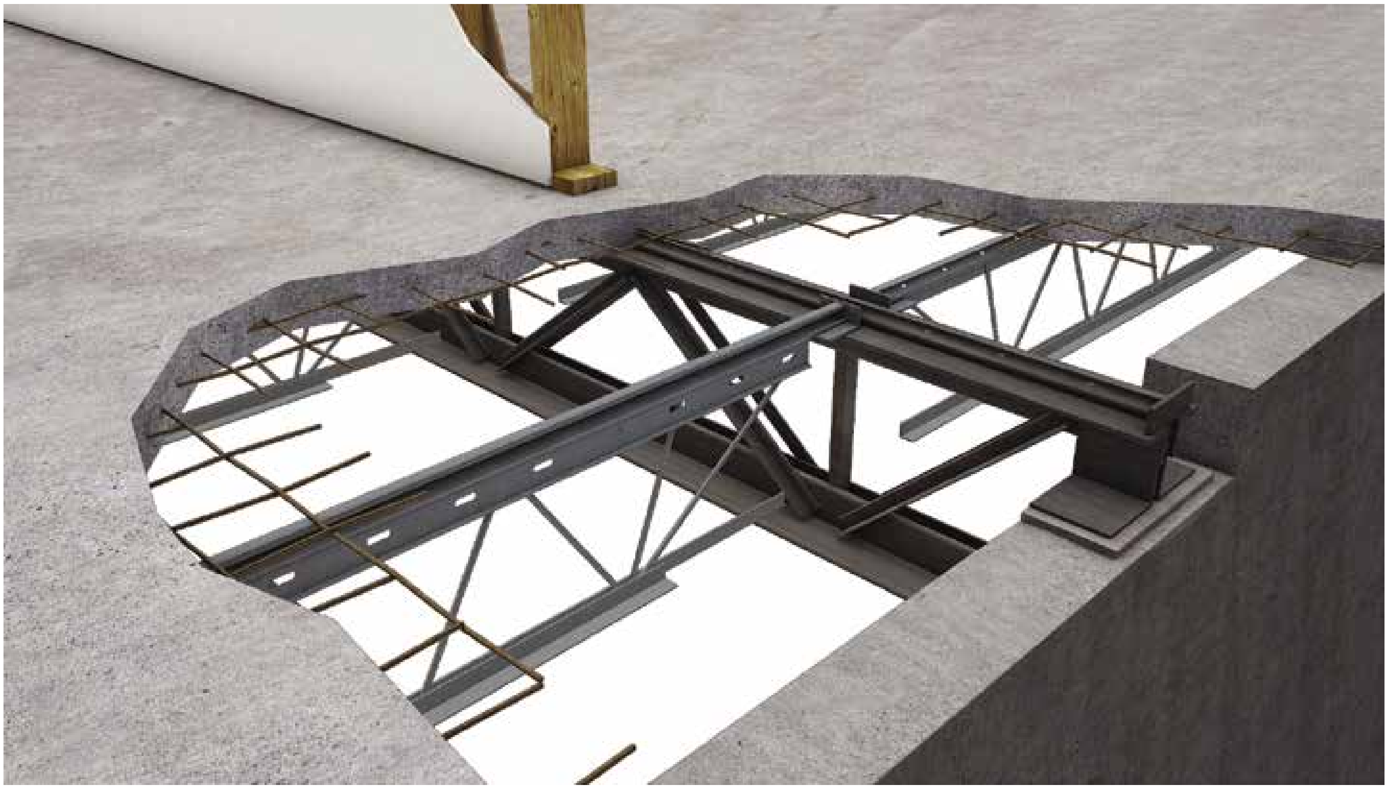
A Hambro composite girder is a primary structural component supporting joists in simple span conditions or other secondary elements such as steel beams and other Hambro composite girder.

It is often used in transfer slab system, designed by Canam. The Hambro transfer slab is composed of Hambro joists and girders in composite action with the concrete slab. The entire system is cambered to the specific loads applied. This particular system is ideal for use at underground parking levels and commercial spaces which have multiresidential complex on the upper floors. The girders support the loads from upper floors walls and then bear on columns and walls strategically placed to offer greater clearance length.

The Hambro transfer slab is an efficient and economical floor system since it is both fast and easy to install. It also requires less concrete and steel reinforcement than a reinforced concrete slab, thus reducing costs as well as construction time given the absence of shoring.

The girders are advantageous compared to conventional load bearing systems composed of beams with a W profile since:

1. The steel used in girders has a yield strength higher than steel used for shaped or welded beams: 55 ksi (380 MPa) versus 50 ksi (350 MPa).
2. We have better cost control for material purchases (angles) on the Canadian market compared to importing the beam sections.
3. The open web girders are lighter than the full web beams of the same depth.
4. The speed and ease of site erection improves jobsite coordination.
5. The girders can be used to facilitate the installation of ventilation ducts and plumbing as compared to a beam.



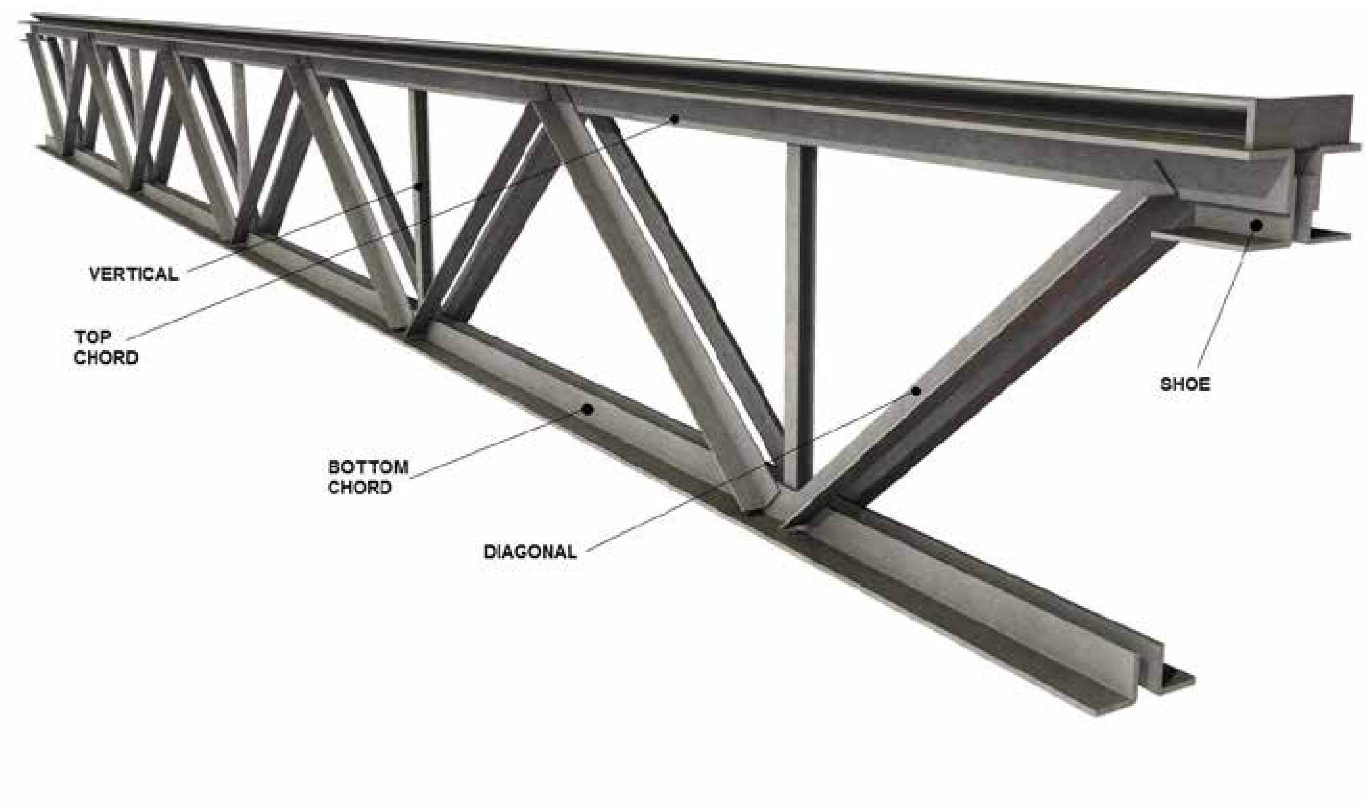
Hambro composite girder system

MAIN COMPONENTS

An open web Hambro composite girder is composed of a top chord and a bottom chord which are parallel to each other. These chords are held in place using vertical and diagonal web members. In conventional construction, a Hambro girder rests on a wall or a column and the bottom chord is held in place horizontally by a stabilizing plate.

The standard main components are:

1. Top and bottom chords: two angles back-to-back with a gap varying between 1 in. (25 mm) and 1 ⅜ in. (35 mm).
2. Diagonals: u-shaped channels or two angles back-to-back.
3. Verticals: u-shaped channels, boxed angles, plates or HSS.
4. Shoes: two angles back-to-back.



Hambro composite girder components

Hambro composite girder is cambered in manufacturing. Once the concrete is poured, the Hambro girder becomes perfectly straight.

SHEAR CONNECTOR

1. “S” shape along the entire length of the Hambro girder.
2. End plate at each extremity which confine the concrete.
3. Hambro joist shoe that are fix to the Hambro girder top chord.
4. Additional connectors as U-channel or studs.

SPAN AND DEPTH

To select an economical depth in function of loads and spans, please contact a Canam sales representative.

JOIST DESIGN ESSENTIAL INFORMATION CHECKLIST

The following joist design information checklist was created to assist the building designer in the preparation of the design drawings. This list is a reminder. If other unspecified information therein affect the Hambro system, they also need to be communicated.

		A. GENERAL INFORMATION
	A.1	Joist type
	A.2	Joist depth
	A.3	Clear span
	A.4	Uniform loads (dead and live)
	A.5	Slab thickness

		B. LOADS
	B.1	Additional uniform dead and live loads acting on the Hambro system: • Show the area of various loading (examples: concrete pavers, corridors, etc.).
	B.2	Concentrated, distributed or unbalanced loads: • Break down the content of the load and specify if it applies to top or bottom chord (examples: loads from bearing wall, medical lift, fire place, fall arrest at roof, etc.).
	B.3	Snow pile up loads: • Show, using a diagram, maximum accumulation and distribution length on a lower roof or in an adjacent obstruction such as mechanical units, etc.
	B.4	Mechanical units and openings (stairs, elevator, mechanical openings, etc.): • Specify the position, dimensions and load affecting the joist.
	B.5	Uplift from balcony: • Specify the position, dimensions, load affecting the joist and the way it connects to the system.

		C. DESIGN CRITERIA
	C.1	Maximum allowable deflections under live load and total load: • Specify deflections for special conditions (masonry, glass, etc.).
	C.2	Floor vibration criteria (if different from what is indicated in the general information of the technical manual): • Type of partition, type of support, beta ratio or the minimum composite joist inertia.
	C.3	Duct opnening passing through joists (if any): • Specify dimensions, free opening and position.
	C.4	Minimal material thickness for corrosion resistance (if applicable).
	C.5	Positions of all holes in the slab (plumbing, ventilation, stairs, etc.): • Specify positions and dimensions.
	C.6	ULC fire rating design number. Fire rated wall under Hambro slab: • Specify position.
	C.7	Slab recess: • Specify position and dimensions.
	C.8	Heating pipe • Specify dimensions of pipes.

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