



HAMBRO®

Proven Concrete Floor System



Hambro® Composite Floor System Technical Manual



www.hambrosystems.com

INTRODUCTION

This manual has been developed
in order to assist you
in understanding the Hambro®
Composite Floor System,
and for you to have at your fingertips
the information necessary
for a simple 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 that you
contact your local Hambro representative,
who is qualified and prepared
to assist in the selection of a Hambro
system that is best suited
for your project's requirements.



U.S. PATENT NOS:

3818083 3819143
3841597 3845594
3913296 3945168
3979868 4015396
4584815 4729201

CANADA PATENT NO:

874180

OTHER U.S. & FOREIGN PATENTS PENDING



Underwriters
Laboratories Inc.®

www.hambro.ws

GENERAL INFORMATION

DESCRIPTION

The Hambro Composite Floor System has been used with different types of construction i.e. masonry, steel frame buildings, poured in place or precast concrete as well as wood construction, from the single family detached house to multistory residential and office complexes.

The Hambro Composite Floor System essentially consists of a hybrid concrete/steel tee-beam in one direction and an integrated continuous one-way slab in the other direction, and is illustrated in figures 1 and 2.

Depending on the span, the loads and the type of form to support concrete poured in place, the Hambro steel joist may have a different configuration at top chord.

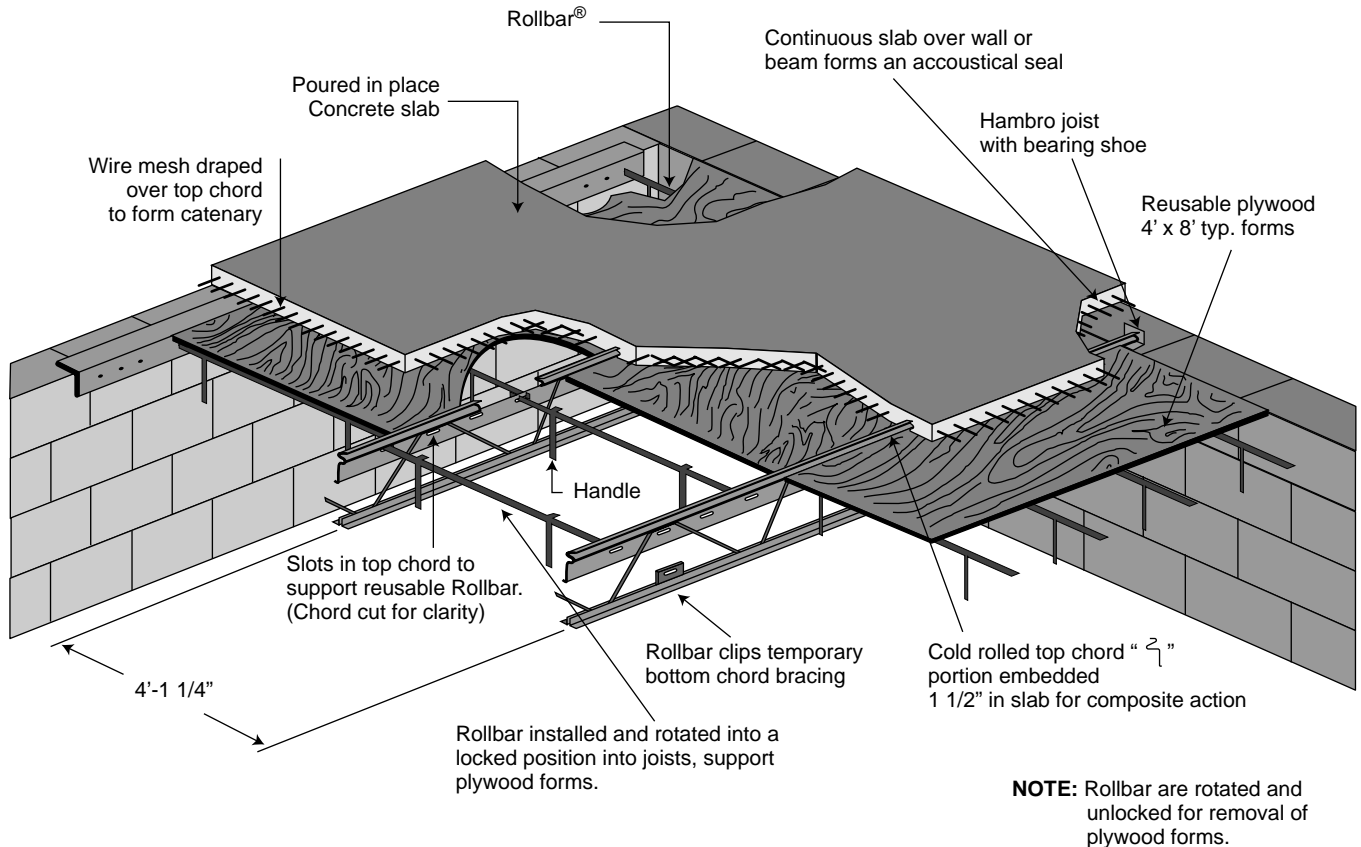


Fig. 1
Hambro® D500™ Composite Floor System

The unique Z top chord section has three basic functions:

1. It is a compression member component of the Hambro non-composite joist during the concreting stage. Remember that the system is not shored.
2. It is a "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 locks with and supports the slab forming system (rollbars and forms).
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, consisting of bent rods, ties the top and bottom chords together and resists the vertical shear in the conventional truss manner.

The concrete slab is reinforced with welded wire mesh at the required locations and behaves structurally as a continuous one-way reinforced concrete slab.

GENERAL INFORMATION

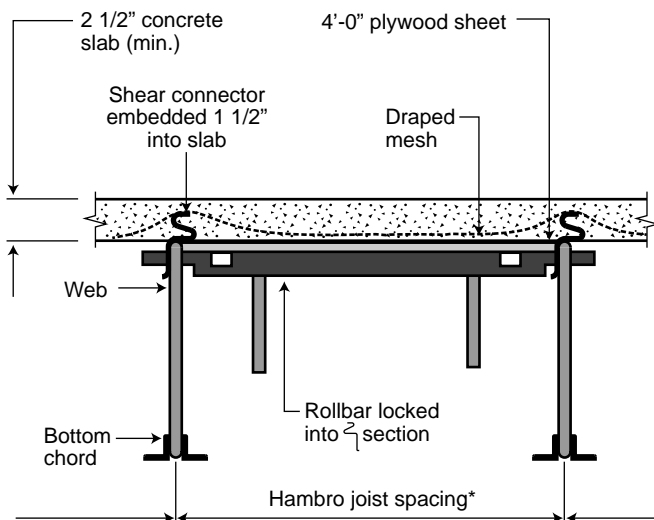


Fig. 2

* Normally 4'-1 1/4" to accommodate standard 4'-0" wide plywood forms, but can be altered to suit job conditions.

The rigid plywood sheets and rollbars, when locked into the ζ section, not only act as simple forms for placing concrete, but provide the essential lateral and torsional stability to the entire Hambro floor system during the concreting stage.

The interaction between the concrete slab and Hambro joist begins to occur once the wet concrete begins to set. The necessary composite interaction for construction loads is achieved once the concrete strength, f'_c , reaches 1,000 psi.

This will usually occur within 24 hours. Even in the coldest of winter concrete pouring conditions, construction heating will maintain the concrete at temperatures necessary for this strength gain. When in doubt, concrete test cylinders can be used to verify strength.

The result is a composite floor system having a sound transmission class (STC) of 57 with the addition of a gypsum board ceiling.

Fire resistance ratings of up to 3 hours are easily achieved with the Hambro Composite Floor System by the installation of a gypsum board ceiling directly under the joists. Other types of fire protection could be used. Refer to U.L.I. publications for their use.

The Hambro Composite Floor System has been subjected to many tests both in laboratories and in the field.

ADVANTAGES

- The Hambro joists are custom manufactured to suit particular job conditions and are easily installed. It is important to remember that the Hambro joist modular spacing can be adjusted to suit varying conditions.
- The Hambro forming system provides a rigid working platform. Masonry walls or tie beams may be filled, when required, using the Hambro floor as a working deck.
- Shallower floor depths can be used because of the increased rigidity of the system resulting from the composite action.
- The wide Hambro joist spacing allows greater flexibility for mechanical engineers and contractors. Standard pipe lengths can be threaded through the Hambro web system - this means fewer mechanical joints.
- The ceiling plenum can accommodate all electrical and mechanical ducting, eliminating the need for bulkheading and dropped ceilings.
- The interlocking of concrete with steel provides excellent lateral diaphragm action with the composite joists acting as stiffeners for the entire system.
- Other subtrades can closely follow Hambro, thereby shortening completion time.
- The rollbars and plywood sheets are reusable.

SPECIFICATIONS

PART 1 - GENERAL

1.1 INCLUDES

- A. Composite floor joist system of steel joists with cast-in-place concrete slab.

1.2 RELATED SECTIONS

- A. Section 03300 Cast-In-Place Concrete.

1.3 REFERENCES

- A. ACI 301 - Specifications for Structural Concrete
- B. ACI 318 - Building Code Requirements for Structural Concrete
- C. AISC Specification for the Design of Cold-Formed Steel Structural Members
- D. ASTM A 1008 Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High Strength Low-Alloy with Improved Formability.
- E. ASTM C 39 - Standard Test Method for Compressive Strength of Cylinders Concrete Specimens.
- F. AWS D1.1 Structural Welding Code Steel.
- G. Steel Joist Institute (SJI)

1.4 DESIGN REQUIREMENTS

- A. Design of Composite Floor Joist System:
 - 1. Flexural Design: Ultimate Strength Method and as described by manufacturer.
 - 2. Joist Top Chord Member: AISC Specification for the Design of Cold-Formed Steel Structural Members.
 - 3. Joist Web & Bottom Chord members: (SJI)
 - 4. Concrete Slab: ACI 318
- B. Design Joists to Resist Combined Weight of:
 - 1. Wet concrete (specified slab thickness)
 - 2. Welded wire fabric reinforcement
 - 3. Formwork
 - 4. Rollbar
 - 5. Construction Load: *20 psf* maximum

1.5 SUBMITTALS

- A. Comply with Section 01330 Submittal Procedures.
- B. Product Data: Submit manufacturer's product data for composite floor joist system.
- C. Shop Drawings: Submit manufacturer's shop drawings indicating material lists; mark numbers; types, locations and spacing of joists and accessories; and special conditions requiring top or bottom bracing.

- 1. Calculated dimensions on shop drawings shall be used.
- 2. Scaling of drawings shall not be permitted.

- D. Product Certificates: Submit manufacturer's product certificates signed by manufacturer, certifying materials comply with specified requirements.
- E. Welder's Certifications: Submit welders' certifications signed by Contractor certifying welders comply with quality assurance requirements.

1.6 QUALITY ASSURANCE

- A. Welding Materials and Methods of Fabrication: Manufacturer's standard shop practice.
- B. Welder's Qualifications: Certify that each welder is AWS certified in accordance with AWS D1.1
 - 1. Joist Repairs and Modifications in Field: Performed by AWS certified welders in accordance with AWS D1.1.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Delivery:
 - 1. Deliver joists to site banded in nested bundles and tagged with Identification Plate attached at one end, at joist shoe.
 - 2. Indicate on Joist Identification Plates:
 - a. Manufacturer
 - b. Country (Plant)
 - c. Project number
 - d. Joist mark
- B. Storage:
 - 1. Store materials in accordance with manufacturer's instructions.
 - 2. Protect materials from corrosion, deformation, and other damage.
 - 3. Store joists upright on level surface, off ground.
 - 4. Do not stack joists.
- C. Handling:
 - 1. Protect joists from damage during unloading, storage, handling, and installation.
 - 2. Hoist joists by crane in accordance with manufacturer's instructions.

SPECIFICATIONS

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Hambro Structural Systems, 450 E. Hillsboro Blvd, Deerfield Beach, Florida 33441
Phone (800) 546-9008 / (954) 571-3030
Fax (800) 592-4943 / (954) 571-3031
Website: www.hambro.ws

2.2 COMPOSITE FLOOR JOIST SYSTEM

- A. Designation: Hambro Composite Floor Joist System
- B. Joists, Rollbar, and Standard Bearing Shoes: Furnished by Manufacturer
- C. Joists:
1. Joist Depth: as indicated on the drawings.
 2. Top chord member:
 - a. Act as a continuous shear connector
 - b. ASTM A 1008, Grade 50, cold rolled steel, 13 gauge minimum
 - c. F_y : 50,000 psi minimum
 3. Bottom Chord Member:
 - a. Hot-rolled or cold-rolled steel angles
 - b. F_y : 50,000 psi minimum
 4. Web Members:
 - a. Hot-rolled steel bars, 7/16 inch diameter minimum, some continuous
 - b. Bent at top chord joist locations
 - c. F_y : 44,000 psi minimum
 5. Shop painting: Rust-inhibitive primer
- D. Rollbar
1. Steel
 2. Removable
 3. Design to support the following, until formwork is removed after concrete has reached a minimum compressive strength of 500 psi, determined by testing concrete cylinders in accordance with ASTM C 39.
 - a. Plywood forms
 - b. Slab dead weight
 - c. Welded wire fabric weight
 - d. Construction Load 40 psf
 4. Act as temporary bridging and spacers for joists.
- E. Standard Bearing Shoes
1. Angle Shape: Steel, 4 inches by 1 3/4 inches by 1/4 inch, 4 3/4 inches wide, unless otherwise indicated on the drawings
 2. Shop Painting: Rust-inhibitive primer

- F. Forms: Plywood
1. Sheets: 4 feet by 8 feet typical
 2. Thickness: 3/8 inch, 1/2 inch, 5/8 inch or 3/4 inch
- G. Concrete:
1. Minimum Ultimate Compressive Strength, f'_c : 3,000 psi @ 28 days
 2. Standard Weight: 145 pcf
 3. Maximum Aggregate Size: 3/4 inch
 4. As specified in Section 03300, unless specified otherwise in this section.
- H. Concrete Reinforcement: welded wire fabric.
1. Size: As indicated on the drawings.
 2. F_y : 60,000 psi minimum
 3. Flat Sheets. Do not use rolls.
 4. As specified in Section 03300 unless specified otherwise in this section.

2.3 FABRICATION

- A. Fabrication: Manufacturer's standard shop practice.
- B. Joist Top Chord: Fabricate joist top chord to allow for 1-1/2 inches embedment into concrete slab.
- C. Joist Cambers: Camber is optional, but when provided, approximate camber will be as follows:

Joist Span (Range):	Prefabricated Camber
15 ft. to 20 ft.	1/2 in. to 3/4 in.
20 ft. to 25 ft.	3/4 in. to 7/8 in.
25 ft. to 30 ft.	7/8 in. to 1 1/16 in.
30 ft. to 40 ft.	1 1/16 in. to 1 1/2 in.

2.4 SOURCE QUALITY CONTROL

- A. Joists:
1. Manufacturer's facility having continuous quality control program and subjected to plant inspections by approved independent agency.
 2. Inspection shall include checking:
 - a. Size
 - b. Span
 - c. Assembly
 - d. Welds

SPECIFICATIONS

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive composite floor joist system.
- B. Notify Engineer of conditions that would adversely affect installation.
- C. Do not start installation until unsatisfactory conditions are corrected.

3.2 INSTALLATION

- A. Install composite floor joist system in accordance with the following:
 - 1. Manufacturer's installation manual
 - 2. Approved erection drawings
 - 3. Amendments issued by manufacturer
- B. Construction Loads
 - 1. Do not exceed load-carrying capacity of composite floor joist system with construction loads.
 - 2. Concentrated construction loads: Do not place loads (i.e. bundles of plywood, sheetrock or rollbar), exceeding the design load of the slab, on joist system, but rather on supporting walls or beam.
 - 3. Concentrated Construction Loads Exceeding Design Load Capacity: Construction Loads exceeding the design load capacity of the floor system must be fully supported, and shored to grade.
- C. Erect joists level, plumb and to proper locations and elevations.
- D. Perform shimming as required with metal shim material, ensuring total shoe contact.
- E. Special Conditions requiring top and/or bottom bracing shall be indicated on the erection drawings, prepared by the manufacturer.
- F. End Anchorage: Anchor or embed joist shoes as indicated on the drawings.
- G. Joist Sweep: After installation, allowable joist sweep shall be *1 inch in 20 feet*.
- H. Construction Loads: Do not exceed load carrying capacity of composite floor joist system with construction loads.
- I. Minimum Joist Bearing:
 - 1. Steel Supports: *2 1/2 inches*
 - 2. Masonry and Concrete Supports: *3 1/2 inches*
 - 3. Bearing Capacity of Supporting Units: Comply with applied shoe end reaction, based on minimum supplied bearing areas as follows:
 - a. Bearing on structural steel: *11.8 square inches*
 - b. Other Bearing Conditions: *16.6 square inches*

J. Damaged Joists:

- 1. Do not install damaged joists.
- 2. Repair or replace damaged joists before installation.
- 3. Do not make field repairs to damaged joists without written approval from the manufacturer and Engineer.
- 4. Make repairs to damaged joists in accordance with repair details from the manufacturer.
- 5. Receive written approval from Engineer of joist repair before installation.

3.3 CONCRETE PLACEMENT

A. Concrete:

- 1. In accordance with ACI 301
- 2. As specified in Section 03300, unless specified otherwise in this Section.

B. Welded Wire Fabric:

- 1. Laps: In accordance with ACI 318
- 2. As specified in Section 03300, unless specified otherwise in this section.

C. Place concrete to slab thickness as indicated on the drawings. Do not pour concrete in excess of the thickness indicated on the drawings.

D. Maintain minimum depth of concrete cover above joist top chord in accordance with manufacturer's instructions.

E. Construction Loads: Do not drop bucket loads of concrete in concentrated area over joists.

F. Vibrate concrete lightly but thoroughly. Ensure full encasement of the joist top chord in concrete.

G. Construction Joints:

i. Parallel to Joists:

- 1. Locate construction joints midway between joists.
- 2. Do not locate construction joints closer than *6 inches* from top chord.

ii. Perpendicular to joists:

- 1. Locate construction joints over supporting wall or beam.

H. Formwork Removal: Remove formwork after concrete has reached a minimum compressive strength of *500 psi*, as determined by testing concrete cylinders in accordance with ASTM C 39.

3.4 PROTECTION

- A. Protect concrete from foot traffic until concrete has reached a minimum compressive strength of *1,000 psi*, as determined by testing concrete cylinders in accordance with ASTM C 39.

FIRE RATINGS

Fire Protection floor/ceiling assemblies using Hambro® have been tested by independent laboratories. Fire resistance ratings have been issued by Underwriters Laboratories Inc. which cover gypsum board, accoustical tile and spray on

protection systems. Reference to these published listings should be made in detailing ceiling construction. Check your UL directory for the latest updating of these listings, or see the UL website at <http://www.ul.com/database>

UL DESIGN #	RATING (hr.)	SLAB THICKNESS (in.)	CEILING	BEAM RATING (hr.)
G-003	2	2 1/2	Suspended or panel	-
G-213	2 3	3 4	Suspended or panel Suspended or panel	2 3
G-227	2	2 1/2	Suspended or panel	3
G-228	2	3 1/4	Suspended or panel	2
G-229	2 3	3 4	Suspended or panel Suspended or panel	2 3
G-524	1 - 2 3	2 1/2* 3 1/2*	Gypboard 1/2" Gypboard 1/2"	2 3
G-525	3	3 1/4	Gypboard 5/8"	3
G-702	1 - 2 - 3	Varies*	Spray on	-
G-802	1 - 2 - 3	Varies*	Spray on	-

* Normal and lightweight concrete.

ACOUSTICAL PROPERTIES

SOUND TEST

The Hambro composite floor system has undergone a series of acoustical tests both in the field and laboratory.

RESULTS & DISCUSSION

Materials	STC	IIC
Hambro D500™ Floor Joist System	57 **	30 **

* With a drywall ceiling.

** All results are based on laboratory testing.

- Sound Transmission class (STC) = 57.

The Hambro assembly has a “SOUND TRANSMISSION CLASS” of 57. 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.

- Impact Isolation class (IIC) = 30.

The Hambro assembly has an “IMPACT ISOLATION CLASS” of 30. IIC is a rating designed to measure the impact sound isolation provided by 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.



Harold R. Mull, Bell and Associates, Inc. / acoustical engineering & noise control 181 Main Street Norwalk CT 06851 · 203-847-4529

SINCE 1959

October 23, 1981

Canam Hambro
4878 N.W. 167th Street
Miami, Florida 33014

Gentlemen:

I have reviewed the chart you submitted to us showing the % reduction of apparent loudness for your floor system over that of the 45 STC minimum requirement. The percent reduction achieved through an increase of 12 STC (45 to 57) is substantial and does indeed represent a 220% reduction in loudness in the receiving space.

I have also reviewed the test reports showing an STC of 57. They appear to have been conducted according to accepted procedures and we can assume the data to be fully reliable. It is important to note that the field tests confirmed the laboratory measurements of the STC class so that there is no difference in efficiency between a laboratory installation and a field installation.

The canam hambro system will provide the required reduction for luxury apartments and office buildings where sound isolation is an important factor.

Yours very truly,

A handwritten signature in black ink that reads 'Harold R. Mull'. The signature is fluid and cursive.

Harold R. Mull
President

HAROLD R. MULL

He has authored many papers and contributed to several educational books on acoustics. He is past president of the National Council of Acoustical Consultants and currently vice chairman of the E-33 (Environmental Acoustics) committee of the American Society for Testing Materials. He is also a Fellow of the Acoustical Society of America, member of the Institute of Noise Control Engineering, and is a senior member of the Institute of Electrical and Electronics Engineering having served as chairman of the Cleveland section of IEEE.

ACOUSTICAL PROPERTIES

DESIGN PRINCIPLES AND CALCULATIONS - SLAB DESIGN

THE HAMBRO SLAB

The slab component of the Hambro D500 Composite Floor System behaves as a continuous one-way slab carrying loads transversely to the joists, and often is required to also act as a diaphragm carrying lateral loads to shear walls or other lateral load resisting elements.

At the present time, the Hambro slab has been designed by conventional ultimate strength design procedures of ACI 318 and section capacities are based on ultimate strength principles while the moments are still determined by using the elastic moment coefficients for continuous spans. This procedure is present in most other building codes.

In accordance with most building code requirements, the Hambro slab capacity is determined for two basic loading arrangements: a) uniform dead and live load extending in all directions, and b) a "standard" concentrated live load, applied anywhere, together with the slab dead loads. It is important to remember that the live load arrangements of a) and b) do not occur simultaneously. These loading arrangements will be discussed in detail.

MOMENT:

The basic ultimate strength moment expressions from ACI are shown below:

$$M_u = A_s a_u d \dots\dots\dots (1)$$

Where

M_u = ultimate moment capacity of slab
(ft.-kips/ft. width)

A_s = area of reinforcing mesh in the direction of the slab span (in. ²/ft. width)

$$a_u = \phi f_y (1 - .59 w) / 12000$$

ϕ = flexure factor = 0.9

f_y = yield strength of reinforcing mesh = 60,000 psi
(or as calculated by the ACI offset provision)

$$w = p \frac{f_y}{f'_c}$$

p = tension steel ratio = A_s/bd

f'_c = compressive strength of concrete
= 3,000 psi

b = unit slab width = 12"

d = distance from extreme compression fibre to centroid of reinforcing mesh (in.)
= 1.6" for 2 1/2" slab

It is a simple matter, then, to determine M_u for any combination of A_s and d . Taking into account 3/4" concrete cover, "d" is taken to be 1.6" for the 2 1/2" slab thickness. The ACI Ultimate Strength Design Handbook Vol. 1, Publication SP17, contains tabulated values for "a_u" (note that a_u increases as the tension steel ratio "p" decreases).

CRACK CONTROL PROVISIONS:

When design yield strength f_y for tension reinforcement exceeds 40,000 psi, cross sections of maximum positive and negative moment shall be so proportioned that the quantity z given by:

$$z = f_s \sqrt[3]{d_c A} \dots\dots\dots (2) \text{ [ACI 10.6.3.4]}$$

does not exceed 175 kips per in. for interior exposure and 145 kips per in. for exterior exposure. Calculated stress in reinforcement at service load f_s (kips per sq. in.) shall be computed as the moment divided by the product of steel area and internal moment arm. In lieu of such computations, f_s may be taken as 60 percent of specified yield strength f_y .

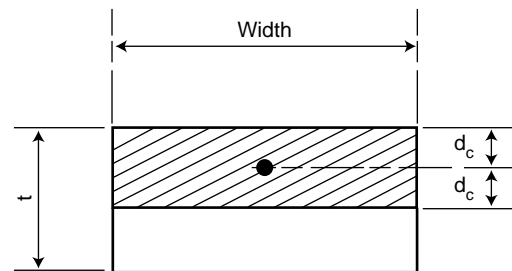


Fig. 1

Considering the negative moment region where the mesh rests directly on the embedded top chord connector, the centroid of the mesh is 1.6" above the extreme concrete compression fibre. With 6" wire spacing and $t = 2 1/2"$, $d_c = 0.9"$;

$$A \text{ (hatched area)} = 1.8 \times 6 = 10.8 \text{ in.}^2;$$

$$\text{Using } f_s = 60\% \text{ of } 60 \text{ ksi} = 36 \text{ ksi};$$

"z" in formula 2 becomes 77 kips per inch.

Even for a 3" slab with the lever arm still at 1.6" and $d = 1.4"$, "z" = 103 kips per inch, well under the allowable.

SHEAR STRESS

The ultimate shear capacity, v_{cu} , which is a measure of diagonal tension, is unaffected by the embedment of the top chord section as this principal tensile crack would be inclined and radiate away from the z section. Furthermore, there is no vertical weak plane through which a premature "punching shear" type of failure could occur.

DESIGN PRINCIPLES AND CALCULATIONS - SLAB DESIGN

A check of the v_{cu} capacity for $d = 1.6''$ (2 1/2" slab) and $f'_c = 3,000$ psi is shown:

$$v_{cu} = \frac{V_u}{\phi bd} \dots\dots\dots (3)$$

$$V_u = \phi v_{cu} bd \dots\dots\dots (4)$$

Substituting the following values in (4): $v_{cu} = 2\sqrt{f'_c} = 100$ psi, $b = 12''$, $d = 1.6''$, $\phi = .85$, results in:

$$V_u = 1,785 \text{ lbs.}$$

With a Load Factor of 1.7, the 2 1/2" slab spanning 4-1 1/4" c/c has a safe shear capacity of 525 psf.

DEFLECTION:

The span / thickness ratio $49.5 / 2.5 = 20$ is less than the maximum allowable 24 for the one end continuous condition. Slab deflection, Δ , due to a uniformly distributed load, can be written as:

$$\Delta = \frac{K_1 w L^4}{E_c I_c} \dots\dots\dots (5)$$

$$\frac{\Delta}{L} = \frac{K_1 w L^3}{E_c I_c} \dots\dots\dots (6)$$

For the same w , E_c and slab end conditions, (6) can be rewritten:

$$\frac{\Delta}{L} = K_2 \frac{L^3}{I_c}$$

Hence, the Δ / L ratios of different floors can be used to assess relative deflection.

Example:

HAMBRO 2 1/2" SLAB / 4' - 1 1/4" SPAN

$$I_c = 12 (2.5)^3 / 12 = 15.6 \text{ in.}^4$$

$$\Delta / L = L^3 / I_c = (4.1)^3 / 15.6 = 4.4$$

7 1/2" SLAB / 20' SPAN

$$I_c = 12 (7.5)^3 / 12 = 422 \text{ in.}^4$$

$$\Delta / L = L^3 / I_c = (20)^3 / 422 = 19$$

Clearly, then, the Hambro slab deflections expressed in terms of Δ / L are less with Hambro than with a 7 1/2" slab spanning 20'.

UNIFORM LIVE LOAD ARRANGEMENT:

Generally, the slab capacity is checked against the condition where the dead and live loads are uniformly distributed.

A load factor of 1.7 is used for both dead and live load capacities. For a more exact analysis, factored loads of 1.4D and 1.7L should be considered.

Refer to Fig. 2 for location of the design moments below.

Ultimate positive moment, M_u :

exterior span $1.7 w_s L_1^2 / 11$ location 1

interior span $1.7 w_s L_2^2 / 16$ location 3

Ultimate negative moment, M_u :

exterior span $1.7 w_s L^2 / 10$ location 2

interior span $1.7 w_s L_2^2 / 11$ location 4

Where

L_1, L_2 = clear span (ft.) is less than 1 3/4" less than joist spacing.

L = average of L_1 and L_2 (ft.)

w_s = total design load (dead + live) in psf

Note that a conservative load factor of 1.7 has been used for dead and live load.

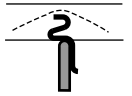
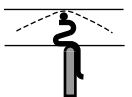
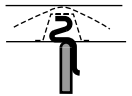
When $L_1 = L_2$, maximum mesh stress occurs at location 2.

When $L_1 \leq 0.9 L_2$, maximum mesh stress occurs at location 4.

The slab load tables are reproduced in Table 1.

DESIGN PRINCIPLES AND CALCULATIONS - SLAB DESIGN

Table 1 - Slab Capacity Chart (Total Load in psf)

SLAB THICKNESS (t)	d	MESH SIZE $F_y = 60,000$ psi	4'-1 1/4" JOIST SPACING	
			Exterior	Interior
$t \geq 2 \frac{1}{2}"$  No chair	1.6"	6 x 6 W2.0 x W2.0	114	123
		6 x 6 W2.0 x W2.9	157	172
		6 x 6 W4.0 x W4.0	210	230
$t \geq 3"$ with 1/2" Rod (shop welded to top chord) 	2.1"	6 x 6 W2.9 x W2.9	206	226
		6 x 6 W4.0 x W4.0	279	306
$t \geq 3 \frac{1}{2}"$ with 2 1/2" Chair 	2.6"	6 x 6 W2.9 x W2.9	256	280
		6 x 6 W4.0 x W4.0	347	380

Note: Slab capacities are based on mesh over joists raised as indicated.

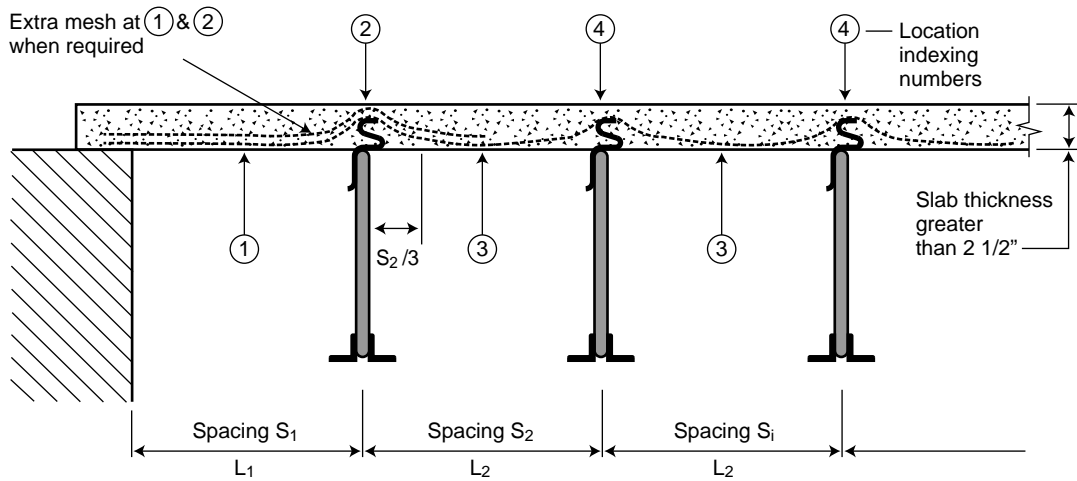


Fig. 2

DESIGN PRINCIPLES AND CALCULATIONS - SLAB DESIGN

CONCENTRATED LIVE LOAD REQUIREMENTS

Building Codes usually stipulate designing to possible concentration of live loads. Typical examples of some of these situations are listed in Table 2. Check your local codes for exact requirements.

The loads are applied over an area $2\ 1/2'$ by $2\ 1/2'$ and it is important to remember that they are not applied simultaneously with the uniformly distributed live loads.

Table 2

USE	MINIMUM CONCENTRATED LOAD (lb.)
Classrooms	1000
Floors of offices, manufacturing buildings, hospital wards, stages	2000
Floor areas used by passenger cars	2500*

* Some building codes use 2000 lbs.

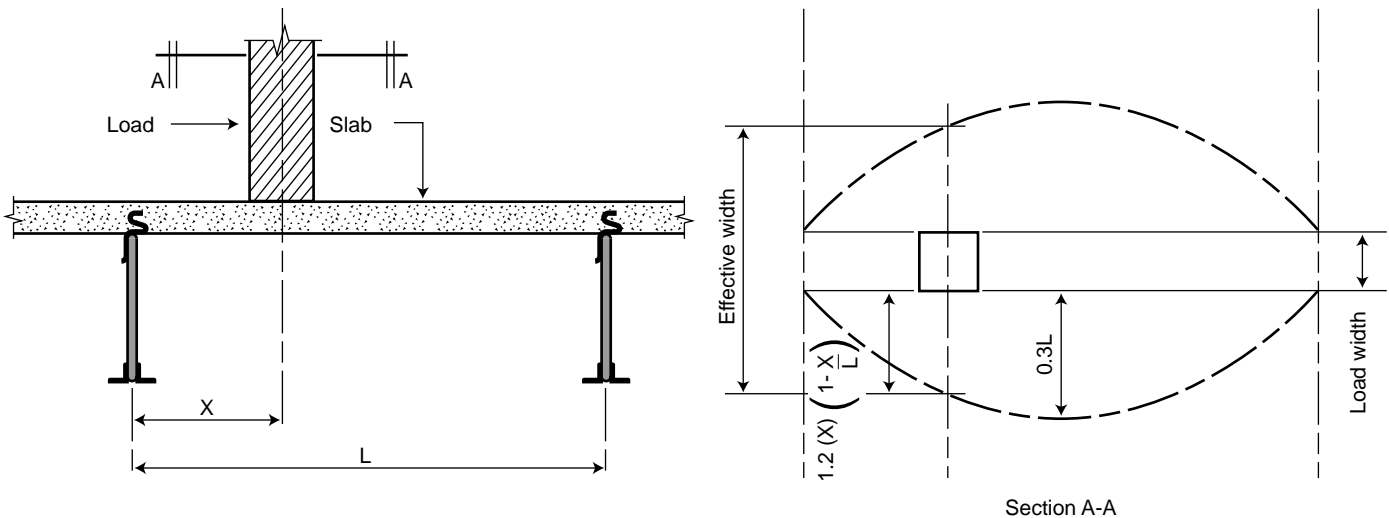


Fig. 3
Lateral Distribution of Concentrated Loads




The intensity of concentrated loads on slabs is reduced due to lateral distribution. One of the accepted methods of calculating the “effective slab width,” which is used by Hambro, actually appears in Section 317 of the British Standard Code of Practice CP114 and is reproduced in Fig. 3. Note that the amount of lateral distribution increases as the load moves closer to mid

span, and reaches a maximum of $0.3L$ to each side; the effective slab width resisting the load is a maximum of load width + $0.6L$.

An abbreviated summary of the calculations is shown in Tables 3 and 4.



DESIGN PRINCIPLES AND CALCULATIONS - SLAB DESIGN

TABLE 3 - Concentrated Loads with 4'-1 1/4" Joist Spacing

CONCENTRATED LOAD	SLAB THICKNESS	MESH SIZE	SPECIAL REMARKS	
2000 lbs. on 2'-6" square area (office building)	2 1/2"	6 x 6 - W2.9	Extra layer @ ①	No "chairs" on 
		6 x 6 - W2.9	Single layer throughout but S ₁ = 3'-10" max.	
	3"	6 x 6 - W2.9	Extra layer @ ① and ②	
		6 x 6 - W2.9	Single layer throughout but S ₁ = 4'-0" max.	
		6 x 6 - W2.9	Single layer throughout	
2500 lbs. on 2'-6" * square area plus 2" asphalt wearing surface	3"	6 x 6 - W2.9	Extra layer @ ① and ②	No "chairs" on 
		6 x 6 - W2.9	Single layer throughout but S ₁ = 2'-10" max.	
4000 lbs. on 3'-6" square area (office building for some codes)	2 1/2"	6 x 6 - W4.0	S ₁ = 4'-0"	No "chairs" on 
	3"	6 x 6 - W2.9	Extra layer @ ① and ②	
		6 x 6 - W2.9	Single layer throughout but S ₁ = 2'-10" max.	

* Some building codes use different bearing areas.

TABLE 4 - Concentrated Loads with 5'-1 1/4" Joist Spacing

CONCENTRATED LOAD	SLAB THICKNESS	MESH SIZE	SPECIAL REMARKS	
2000 lbs. on 2'-6" square area (office building)	3"	6 x 6 - W2.9	Extra layer @ ① and ②	No "chairs" on 
4000 lbs. on 3'-6" square area (office for some codes)	3"	6 x 6 - W4.0	Extra layer @ ① and ②	No "chairs" on 

CONCRETE MIX

Top size of the coarse aggregate should not exceed 3/4" or as dictated by applicable codes. A slump of 4" is recommended.

DESIGN PRINCIPLES AND CALCULATIONS - NON-COMPOSITE DESIGN

NON-COMPOSITE DESIGN

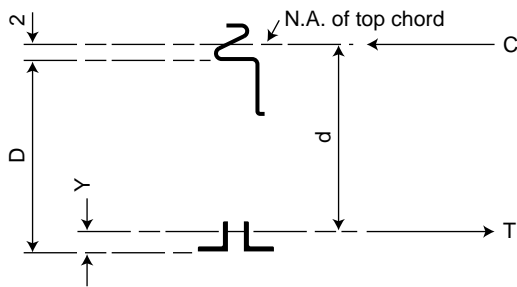


Fig. 4

The top chord must be verified for the loads applied at the non-composite stage. From the previous example, we have the following results:

• Dead load:

Slab 2 1/2": 31 psf
 Formwork and joist: 5 psf
 36 psf

• Live load:

Construction live load: 20^* psf
 56 psf

* Reduces beyond 25' span at a rate of 1 psf for each 2.5' of span.

Moment Capacity of Joist = $C \times d$ or $T \times d$

i.e. $\frac{W_{nc} L^2 \times 12}{8} = C \times d$ or $T \times d$, whichever is the lesser

$W_{nc} = 56 \times \text{joist spacing} = plf$

$L = \text{clear span} + 4'' \text{ (ft.)}$

$C = \text{area of top chord (sq. in.)} \times \text{working stress (psi)}$

$T = \text{area of bottom chord (sq. in.)} \times \text{working stress (psi)}$

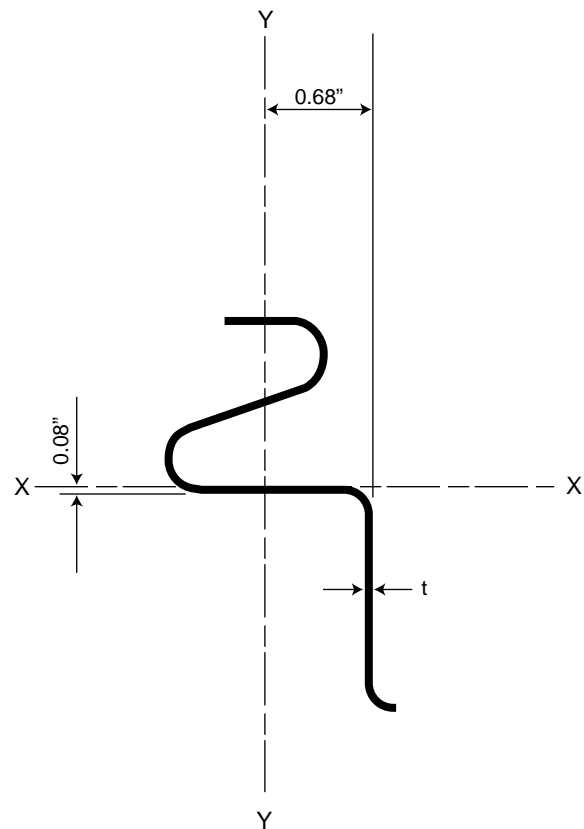
$d = \text{effective lever arm in inches}$
 $= D + 0.08 - y$

From the above formula, the maximum "limiting span" may be computed for the non-composite (construction stage) condition. For spans beyond this value, either the top chord must be strengthened or joist propped. 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.

The bottom chord is sized for the total factored load which is more critical than the construction load.

Hambro top chord properties are provided to assist you in computing the non-composite joist capacities.

TOP CHORD PROPERTIES



$$I_x = 0.66 \text{ in.}^4$$

$$\text{Top Chord } S_x = 0.45 \text{ in.}^3$$

$$\text{Bottom Chord } S_x = 0.287 \text{ in.}^3$$

$$L_y = 0.187 \text{ in.}^4$$

$$S_y = 0.167 \text{ in.}^3$$

$$t = 13 \text{ ga.} = 0.090 \text{ in.}$$

$$A_{net} = 0.56 \text{ in.}^2$$

$$= (\text{deducting } 3/8'' \text{ deep slot} = 6.25 \times 0.090)$$

$$F_y = 50 \text{ ksi min.}$$

$$F_a = 29.1 \text{ ksi}$$

DESIGN PRINCIPLES AND CALCULATIONS - COMPOSITE DESIGN

FLEXURE DESIGN

In the past, conventional analysis of composite beam sections has been linearly elastic. Concrete and steel stresses have been determined by transforming the composite section to a section of one material, usually steel, from which stresses are then determined with the familiar formula, $f = My / I$, and then compared to some limiting values which have been set to ensure an adequate level of safety. Although this procedure is familiar to most engineers, it does not predict the level of safety with as much accuracy as does an ultimate strength approach which is based on the actual failure strengths of the component materials.

It is now known that the flexural behavior at “ultimate” failure stages of composite concrete/steel beams and joists is similar to that of reinforced concrete beams - the elastic neutral axis begins to rise under increasing load as the component materials are stressed into their inelastic ranges. The typical stress-strain characteristics of the concrete and steel components are shown in fig. 5.

The various loading stages of the Hambro composite joist are indicated in fig. 6. As load is first applied to the composite joist, the strains are linear. The “elastic” neutral axis, concrete and steel stresses can be predicted from the conventional transformed area method. Generally speaking, the Hambro composite joist behaves in this “elastic” manner when subjected to the total working loads. With increasing load, failure always begins initially with yielding of the bottom chord. In (a), all of the bottom chord has just reached the yield stress, F_y . The maximum concrete strains will likely have just progressed into the inelastic concrete range, but the maximum concrete stress will still be less than $0.85 f'_c$.

With a further increase in load, large inelastic strains occur in the bottom chord and the ultimate tensile force, T_u , remains equal to $A_s F_y$. The strain neutral axis rises, as does the centroid of the compression force. Part (b) depicts the stage when the maximum concrete stress has just reached $0.85 f'_c$. At this stage, the ultimate resisting moment has increased slightly due to a small increase in lever arm.

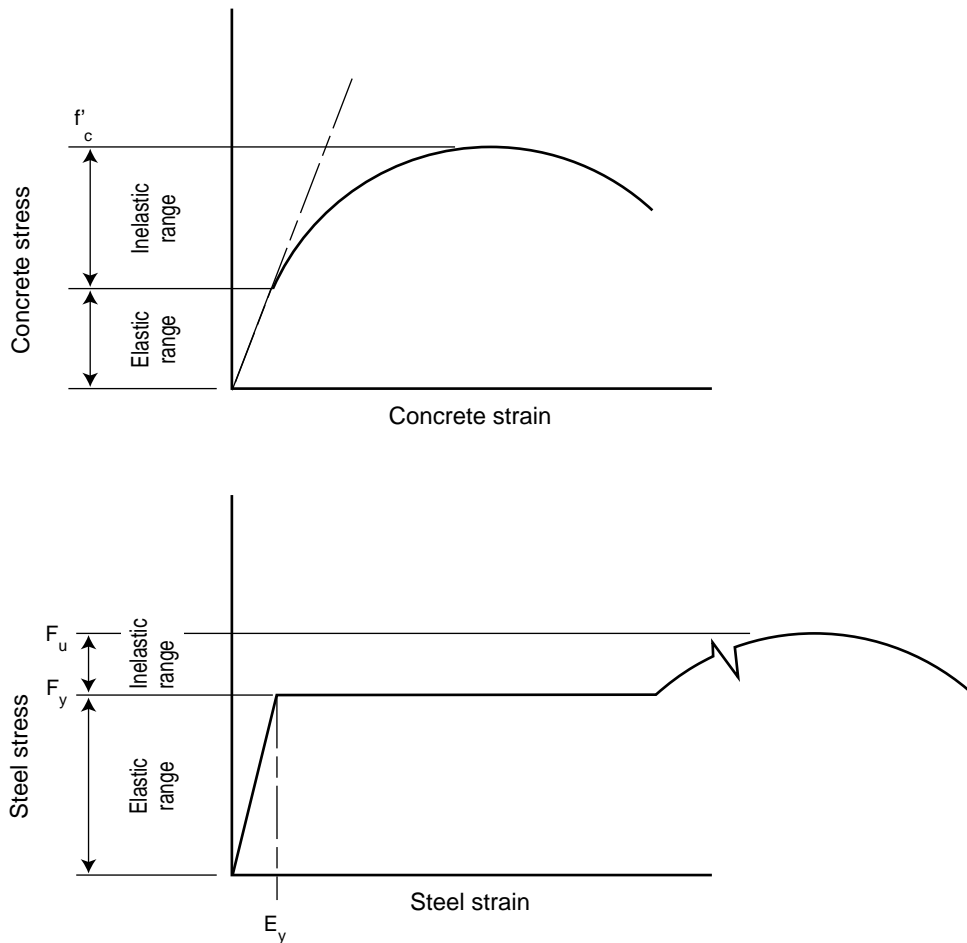


Fig. 5
Concrete and Steel Stress - Strain Curves

DESIGN PRINCIPLES AND CALCULATIONS - COMPOSITE DESIGN

VARIOUS FLEXURAL FAILURE STAGES

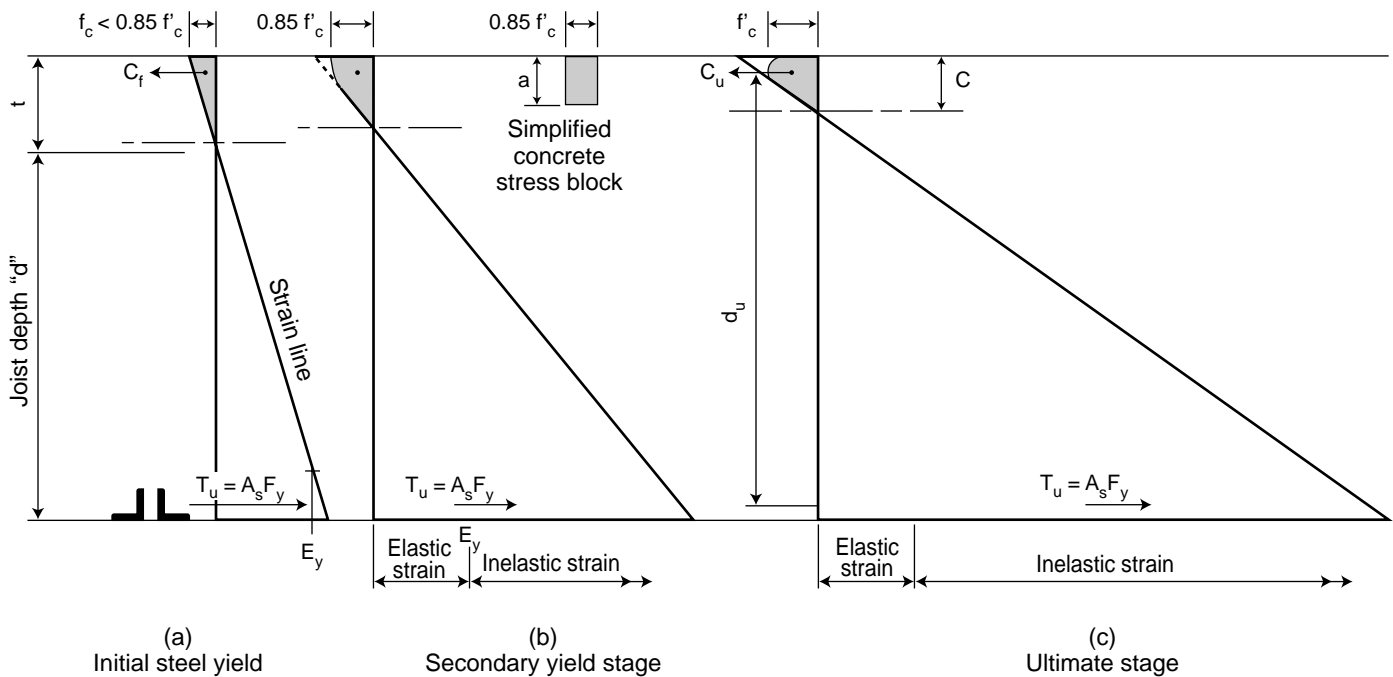


Fig. 6

Upon additional load application, the steel and concrete strains progress further into their inelastic ranges. The strain neutral axis continues to rise and the lever arm continues to increase as the centroid of compression force continues to rise. In (c), final failure occurs with crushing of the upper concrete fibers. At this point, the maximum lever arm, d_u , has been reached. In load capacity calculations, the simplified concrete stress block as shown in (c) is universally used.

It is a simple matter to calculate the ultimate moment capacity of any Hambro composite joist, knowing the bottom chord size.

$$T_u = A_s F_y \dots\dots\dots (7)$$

Also, C_u must equal T_u . Using an additional 0.9 concrete stress factor

$$C_u = 0.9 \times 0.85 f'_c ab \dots\dots\dots (8)$$

Where b = lesser of span / 4, joist spacing, or 16 t ; $f'_c = 3,000$ psi

Equating (7) and (8) results in "a" becoming the only unknown and is easily calculated by the expression:

$$a = \frac{T_u}{0.9 \times 0.85 f'_c b} \dots\dots\dots (9)$$

The lever arm, d_u , can now be determined and the ultimate moment capacity, M_u , is calculated from the expression:

$$M_u = T_u d_u \dots\dots\dots (10)$$

Now M_u also = $M_u = \frac{W_u L^2}{8} \dots\dots\dots (11)$

Equating (10) and (11), $W_u = \frac{8 T_u d_u}{L^2}$

Using a load factor of 1.7, the working load capacity (total dead and live load) of the composite joist per unit length,

$$W_s = \frac{W_u}{1.7}$$

For a more exact analysis, factored loads will be considered.

DESIGN PRINCIPLES AND CALCULATIONS - WEB DESIGN

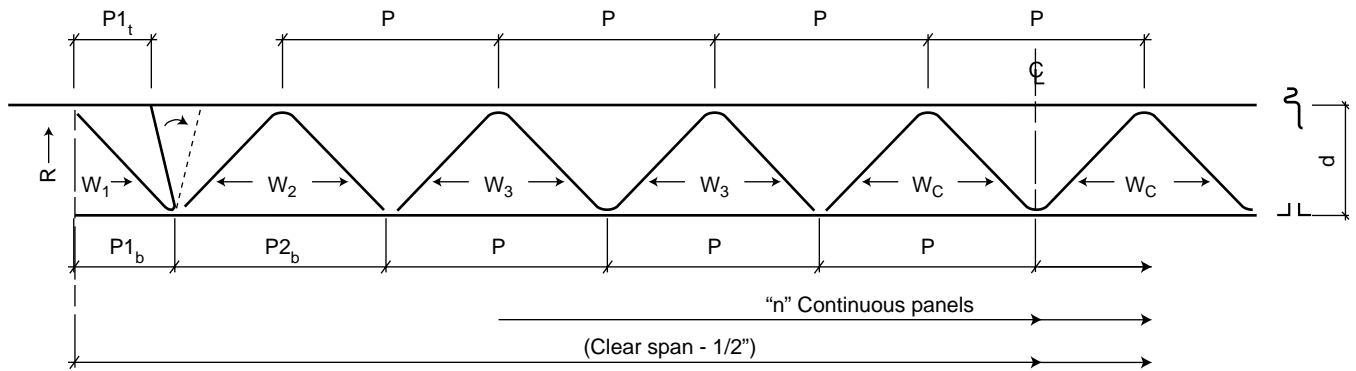
VERTICAL SHEAR (WEB DESIGN)

The vertical shear forces are assumed to be carried entirely by the web member, forces being calculated using the conventional pin jointed truss analysis method. These assumptions result in calculated bar forces which have been shown by tests to be as much as 15% higher than the actual values because the slab, acting compositely with σ_1 section, is stiff enough to transmit some load directly to the support. This is particularly true of web members at the joist ends - those which are subjected to the highest vertical shear.

EFFECTIVE LENGTH OF COMPRESSION DIAGONAL

With the web member forces calculated as below, the bar sections are sized to prevent failure in either axial tension or axial compression using conventional working stress design procedures. As per AISC specifications fig. 7 is used as a reference in determining the effective length, k_l , of the compression diagonals.

It is important to note that the web members are sized for the specified load capacity including concentrated loads where applicable. Furthermore, the webs are designed according to the latest requirements of the Steel Joist Institute.



NOTE: W_3 for longer span.

Fig. 7
D500™ and MD2000® Geometry

WEB GEOMETRY (in.)				
NOM. DEPTH "d"	P_{1_t}	P_{1_b}	P_{2_b}	P
8, 10	6 @ 12	6 @ 16	12	20
12	10 @ 16	10 @ 21	16	24
14, 16	15 @ 24	15 @ 32	20	24
18, 20, 22, 24	19 @ 24	19 @ 32	24	24

DESIGN PRINCIPLES AND CALCULATIONS - INTERFACE SHEAR

SHEAR

Composite action between the ζ_1 section and the concrete slab exists because of the unique shear resistance developed along the interface between the two materials. This shear resistance, which has been called "bond" or "interface shear" is primarily the result of a "locking" or "clamping" action in the longitudinal direction between the concrete and the ζ_1 section when the composite joist is deflected under load. Another contributing factor to the shear resistance is the lateral compression stress or "poisson's effect" which results from slab continuity in the lateral direction. This continuity prevents lateral expansion from occurring as a result of longitudinal compression stresses and thus lateral compression stress results. However, this effect has been ignored in determining interface shear capacity which has been based on full scale testing of spandrel joists having only a 6" slab overhang on one side for its entire span length. A cross-section of a test specimen is illustrated in fig. 8.

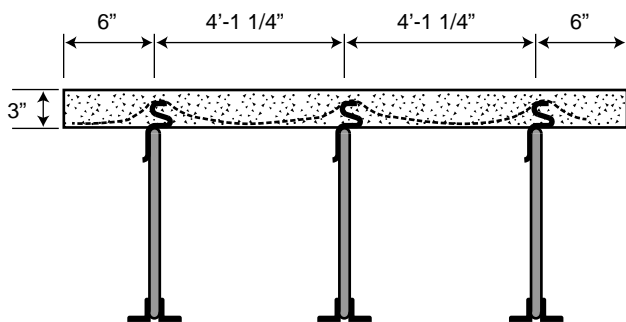


Fig. 8

It was decided to base the limiting interface shear value on this most critical condition as this could often occur in practice with large duct openings. Also, one would expect some additional shear resistance to occur due to some form of friction (or plain "bond") mechanism, however, **full scale tests have not shown any significant differences in results among specimens whose ζ_1 section were clean or painted.**

SHEAR FORCE

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 well known equation:

$$q = \frac{VQ}{I_C} \dots\dots\dots (12)$$

Where q = horizontal shear flow per mm of length (lb./in.)

V = vertical shear force at the section (lb.) due to superimposed loads

Q = statical moment of the effective concrete in compression (hatched area) about the elastic N.A. of the composite section (in.³)

I_C = moment of inertia of the composite joist (in.⁴)

And $Q = \frac{by}{n} (Y_c - y/2)$ and $y = y_c$ but $\nless t$

Where b = effective concrete flange width (in.) = lesser of $L/4$ or joist spacing

n = modular ratio = $E_s/E_c = 9.2$ for $f'_c = 3$ ksi

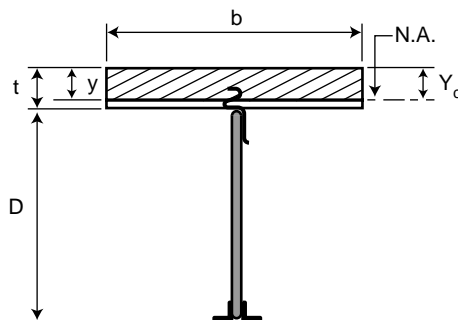
t = slab thickness (in.)

Y_c = depth of N.A. from top of concrete slab

y = Y_c when N.A. lies within slab

= t when N.A. lies outside slab

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



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

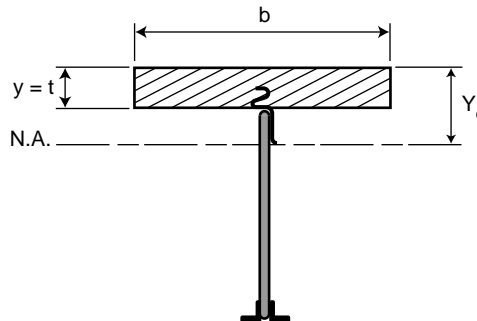


Fig. 9

DESIGN PRINCIPLES AND CALCULATIONS - INTERFACE SHEAR

For a uniformly loaded joist, the average interface shear s , at ultimate load when calculated by ultimate strength principles, would be:

$$s = \frac{2T_u}{L} \dots\dots\dots (13)$$

and would represent the average shear force, per unit length, between the points of zero and maximum moment. Some modification to this formula would occur when the strain neutral axis at failure would be located within the ζ_1 section. As this modification is slight and would only occur with bottom chord areas greater than 1.84 sq. in., it is neglected.

Compare the elastic and ultimate approaches:

Since $M_u = T_u d_u$ equation (13) can be rewritten:

$$S = \frac{2M_u}{d_u L} \dots\dots\dots (14)$$

Also, for a uniformly distributed load,

$$M_u = \frac{V_u L}{4} \dots\dots\dots (15)$$

Subscripts u , are added to equation (12) to represent the arbitrary "q" force at failure:

$$q_u = \frac{V_u Q}{I_c} \dots\dots\dots (16)$$

Combining (14) and (16) results in:

$$\frac{q_u}{s} = \frac{D_u L}{2M_u} \times \frac{V_u Q}{I_c} \dots\dots\dots (17)$$

and, substituting (15) into equation (17)

$$\frac{q_u}{s} = \frac{2QD_u}{I_c} \dots\dots\dots (18)$$

The value I_c/Qd_u has been calculated for the various Hambro composite joist sizes, is a constant, and = 1.1. Substituting this in (18),

$$\frac{q_u}{s} = 1.82$$

This verifies that q and s are closely related and that the interface shear force does, in fact, vary from a maximum at zero moment (maximum vertical shear) to a minimum at maximum moment (zero vertical shear). The more recent full scale testings programs have consistently established a failure value for $q_u = 1,300 \text{ lb./in.}$ and using a safety factor of 1.85, the safe limiting interface shear, $q = 700 \text{ lb./in.}$ This is sometimes converted to "bond stress" $u = q / \text{embedded } \zeta_1 \text{ perimeter} = q / 7.0$. Hence, the safe limiting "bond stress" $u = 700 / 7 = 100 \text{ psi.}$

As a further safety factor, the bond stresses are usually limited to a value less than 90 psi.

DESIGN PRINCIPLES AND CALCULATIONS (MINI-JOIST SERIES)

THE MINI-JOIST SERIES

The standard Hambro ζ section, being 3 3/4" deep, possesses sufficient flexural strength to become the major steel component of the mini-joist series. The three sizes that are currently being used are illustrated in the figure below and spans beyond 8' can be achieved with the heavier SRTC unit. Other sizes are also available.

The composite capacities of the TC, RTC & SRTC units are calculated on the basis of "elastic tee beam analysis". The effective flange width, b , equals the lesser of span/4, or joist spacing. With the mini-joist spaced at 4'-1 1/4" and 16 t = 40", b is dictated by span/4. The calculations are simplified somewhat by using only two values for " b ", 12" up to 7'-6" spans and 24" for 8' spans. The load table lists total load capacity in plf.

Full scale tests have demonstrated consistently that shoe plates are not required - the Zee section is simply notched at each bearing end with the lower horizontal portion of the "Zee" becoming the actual bearing surface. **Note that where the non-composite end reaction exceeds 1,000 lbs. the notched ends are reinforced with a 1/2" diameter bar 8" long.**

This is to prevent the Zee section from "straightening out" at the bearing ends. It is interesting to note that this is not a problem during the composite service stage, even with its higher total loads, as the 2 1/2" slab carries the vertical shears.

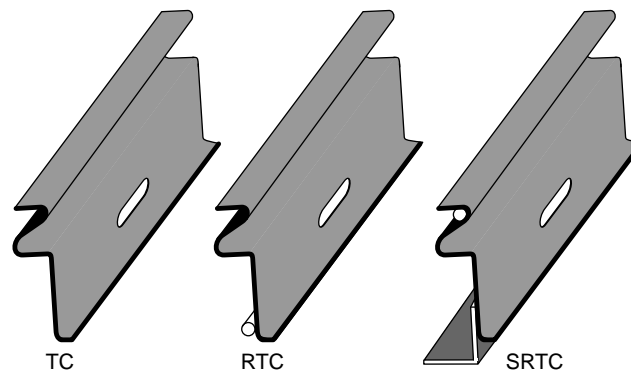





Fig. 10

TABLE 5: Mini-joist H Series Chart Capacity (Maximum Total Unfactored Load in plf)

TYPE	CONDITIONS	PROPERTIES		CLEAR SPAN								
		I	S	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	6'-0"	7'-0"	7'-6"	8'-0"
		in. ⁴	in. ³									
TC 	COMPOSITE	2.29	0.60	1198	895	694	550	443				
	NON-COMP.	0.66	0.29	575	427	332	263	213				
RTC 	COMPOSITE	5.09	1.31	2627	1949	1519	1215	985	689	514	447	394
	NON-COMP.	1.63	0.75	1502	1125	870	694	566	398	291	254	222
SRTC 	COMPOSITE	b = 12" 9.84	2.36									
	NON-COMP.	b = 24" 11.60	2.55						1231	919	804	763
			1.60						845	624	546	497

DESIGN PRINCIPLES AND CALCULATIONS (SAMPLE CALCULATION)

FLEXURAL CALCULATIONS - COMPOSITE

Joist = H1207
F_y = 50 ksi
Clear Span = 21'-0"
Bottom Chord A_s = 0.72
y = 0.44"

b = lesser of 16 t, L/4, Joist Spacing
= 40"
f'_c = 3,000 psi
t = Slab = 2.5"

Dead Load = 60 psf
Live Load = 40 psf
Total Load = 100 psf

LEVER ARM

$$\begin{aligned}
 d_u &= Doal - y - a/2 \\
 &= 14.5 - 0.44 - 0.392/2 \\
 &= 13.86"
 \end{aligned}$$

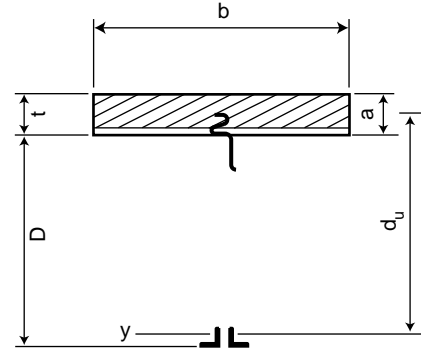


Fig. 11

OVERALL DEPTH

$$\begin{aligned}
 Doal &= D + t \\
 &= 12" + 2.5" \\
 &= 14.5"
 \end{aligned}$$

DESIGN SPAN

$$\begin{aligned}
 L &= Clear Span + 4" \\
 &= 21.33'
 \end{aligned}$$

$$\begin{aligned}
 a &= \frac{A_s \times F_y}{0.9 \times 0.85 \times f'_c \times b} \\
 &= \frac{0.72 \times 50}{0.9 \times 0.85 \times 3 \times 40} \\
 &= 0.392"
 \end{aligned}$$

WORKING LOAD

$$\begin{aligned}
 W_s &= \frac{A_s \times F_y \times d_u \times 8,000}{1.7 \times L^2 \times 12} \\
 &= \frac{0.72 \times 50 \times 13.86 \times 8,000}{1.7 \times 21.33^2 \times 12} \\
 &= 430 \text{ lb./ft.}
 \end{aligned}$$

DESIGN PRINCIPLES AND CALCULATIONS - DIAPHRAGM DESIGN

THE HAMBRO SLAB AS A DIAPHRAGM

With the increasing use of the Hambro system in earthquake prone areas such as Anchorage, Los Angeles, etc., as well as in high buildings, a testing program was conducted to clearly establish how the Hambro Composite Floor System behaved as a diaphragm in transferring horizontal shears to the supporting structure.

OBJECTIVE

To study the behavior and strength of the Hambro System acting as a diaphragm, and to determine a suitable structural design method.

DESCRIPTION

Fourteen small-scale test specimens, 2' x 3' were tested in the Structures Laboratory of Carleton University, using the 120 kip / 54.5 M tonne capacity Tinius Olsen Universal testing machine. The specimens were set up in such a way as to induce extremely high shear forces in the slab, thereby leading to shear failures. The specimens incorporated the following variable conditions:

- Variable slab thicknesses
- Variable concrete strengths
- Variable direction of embedded top chord parallel and perpendicular to direction of applied load
- Variable mesh size

Control specimens which did not have any top chord were used as the basis for comparison.

Close observations were made of each test specimen to determine general behavior, such as cracking and actual failure modes.

RESULTS AND DISCUSSION

The test specimens yielded meaningful results – test data correlated very well with the “shear friction” design approach, which is outlined by the ACI (American Concrete Institute) Standard 318. The tests clearly established that the horizontal shear resistance of the slab is dependent **only** on the “available” mesh steel area that passes over the top chord.

The following is a synopsis of the significant test results:

1. Shear friction, i.e. cracking along the top chord, is the dominant mode of failure and always occurs before flexural or diagonal tension failure.
2. Diaphragm buckling, i.e. vertical movement of the slab due to lateral loads, will not occur provided that the joists are prevented from vertical movement at their supports and thus are forced to bend and provide resistance to any out of plane movement of the slab.
3. For shear force transfer perpendicular to the direction of the \bar{z}_1 , the test specimen behaved as if the \bar{z}_1 were not present.
4. The weakest condition is shear force transfer parallel to the direction of the \bar{z}_1 .
5. The calculated shear friction failure load (via ACI 318) is conservative and always less than the actual test specimen failure loads.
6. Drift or lateral movement of the slab can be calculated as the sum of the flexural and shear deflections.
7. Using the shear friction approach, the procedure to design Hambro slab as a diaphragm is the same as a conventional slab.

DESIGN PRINCIPLES AND CALCULATIONS - LATERAL LOAD DISTRIBUTION

LATERAL LOAD DISTRIBUTION FOR LINE LOADS

Line loads are often encountered in construction, i.e. a concrete block wall or even a load bearing concrete block wall. It is always desirable to have a floor system that is stiff enough to allow these line loads to be distributed to adjacent joists rather than it be carried by the joist that happens to be directly under it.

The Hambro Composite Floor System provides the designer with this desirable feature.

This was conclusively proven by randomly selecting a sample of five similar adjacent joists in a bay in an apartment structure and line loading the center one.

The joists were 12" deep, had a clear span of 21'- 3" and a 3" thick slab. The loads were applied using brick pallets. At every load stage, steel strains as well as deflections were measured.

The distribution of load to each of the five joists can be determined by comparing deflections or stresses at similar locations in the five joists under investigation.

Tests have demonstrated that for a line load applied to a typical joist in a bay, the actual distribution of load to that joist is approximately 40% of the applied load. The distribution of load to the adjacent joist on either side is approximately 21% of the applied load and to the next adjacent joist approximately 9% of the applied load.

DESIGN LOADS

The engineer of record and the architect of record should specify the joist depth, slab thickness, mesh size and the design loads (dead, live and total load together with special point loads where applicable).

For maximum economy, the Hambro composite joist will be designed to specifically meet these loading requirements. Live load deflection will be limited to $L/360$.

Example of Joist Identification:

$$\text{Joist Depth} = 16 \text{ in.}$$

$$\text{Live Load} = 40 \text{ lbs. / sq. ft.}$$

$$\text{Dead Load} = 60 \text{ lbs. / sq. ft.}$$

$$\text{Total Load} = 100 \text{ lbs. / sq. ft.}$$

Designate joist as H16/410

$$410 = 100 \text{ psf} \times 4.1 \text{ ft. (spacing)}$$

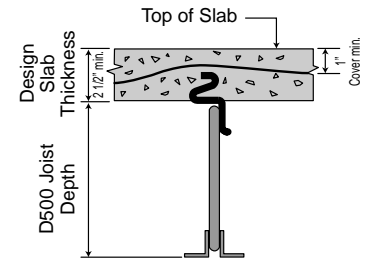
Or simply: H16 with the live, dead and total loads clearly listed on the framing plans.

HAMBRO SPAN TABLES

TABLE 6: D500™ Clear Span Table

Slab Thickness	Residential		Commercial		
	2 1/2"	3"	3"	3 1/2"	3 3/4"
Joist Depth*	LL = 40 psf	LL = 40 psf	LL = 50 psf	LL = 50 psf	LL = 50 psf
	DL = 59 psf	DL = 65 psf	DL = 65 psf	DL = 71 psf	DL = 74 psf
8"	20' - 0"	20' - 0"	20' - 0"	20' - 0"	20' - 0"
10"	25' - 0"	25' - 0"	25' - 0"	25' - 0"	25' - 0"
12"	30' - 0"	30' - 0"	30' - 0"	28' - 0"	26' - 6"
14"	33' - 0"	31' - 0"	31' - 0"	31' - 0"	29' - 0"
16"	36' - 0"	33' - 6"	33' - 6"	33' - 6"	31' - 0"
18"	38' - 6"	36' - 0"	36' - 0"	36' - 0"	33' - 0"
20"	41' - 0"	38' - 6"	38' - 6"	38' - 6"	35' - 6"
22"	43' - 0"	40' - 6"	40' - 6"	40' - 6"	37' - 0"
24"	43' - 0"	43' - 0"	43' - 0"	43' - 0"	39' - 0"

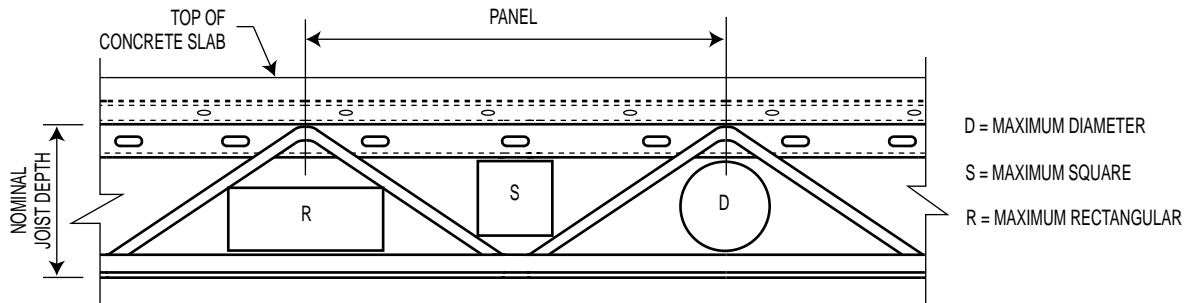
* Total floor depth = D500™ Joist depth plus slab thickness



NOTES:

- Minimum slab thickness = 2 1/2"
- Minimum top chord cover = 1"
- $f'_c = 3,000 \text{ psi}$, $F_y = 50 \text{ ksi}$
- Table reflects uniform loads only.
- Standard spacing is 4'-1 1/4"
- Live load deflection design standard: $L/360$
- Design clear spans, other than those shown in the above table, require additional structural review.

Maximum Duct Openings



DEPTH (in.)	PANEL (in.)	D (in.)	S (in.)	R (in. x in.)
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	9 1/2 x 6 11 x 5
16	24	10	8	10 1/2 x 6 1/2 13 x 5
18	24	11	8 1/2	11 x 7 12 1/2 x 6
20	24	11 1/2	9	12 x 7 13 x 6
22	24	12	9 1/2	12 x 8 14 x 6
24	24	12 1/2	10	13 x 8 14 x 7

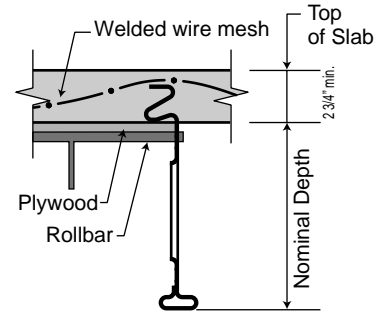
NOTE: For other configurations, the maximum limits will be defined by the joist geometry.

HAMBRO SPAN TABLES

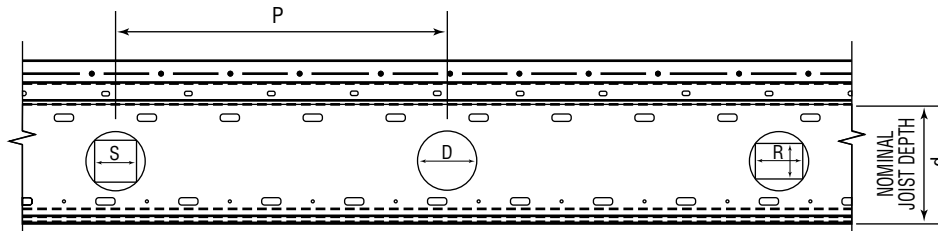
TABLE 7: D510™ Clear Span Table

Unshored					
Slab Thickness	2 3/4"	3"	3 1/2"	4"	4 1/2"
Joist Depth*	LL = 40 psf	LL = 40 psf	LL = 40 psf	LL = 40 psf	LL = 40 psf
	DL = 62 psf	DL = 65 psf	DL = 70 psf	DL = 76 psf	DL = 82 psf
8"	15' - 2"	14' - 11"	14' - 5"	14' - 0"	13' - 7"
10"	17' - 9"	17' - 5"	16' - 10"	16' - 4"	15' - 10"
12"	19' - 6"	19' - 2"	18' - 6"	17' - 11"	17' - 5"
Shored (1 Post Shore at Mid-Span)					
8"	17' - 9"	18' - 0"	17' - 8"	17' - 4"	16' - 11"
10"	21' - 1"	20' - 6"	20' - 0"	19' - 5"	18' - 11"
12"	23' - 2"	23' - 0"	22' - 0"	21' - 4"	20' - 9"

* Total floor depth = D510 Joist depth plus slab thickness



Maximum Duct Openings



- D = MAXIMUM DIAMETER
- S = MAXIMUM SQUARE
- R = MAXIMUM RECTANGULAR

DEPTH (in.)	PANEL (in.)	D (in.)	S (in.)	R (in. x in.)
8	-	-	-	-
10	28	5	3 1/2	3 x 4
12	28	6	4 1/4	3 x 5

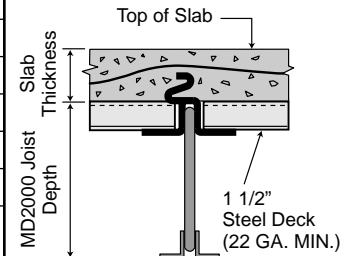
NOTE: For other configurations, the maximum limits will be defined by the joist geometry.

HAMBRO SPAN TABLES

TABLE 8: MD2000® Clear Span Table

Slab Thickness	Residential				Commercial	
	2 3/4"	3"	3 1/4"	3 1/2"	2 3/4"	3 1/4"
Joist Depth*	LL = 40 psf	LL = 40 psf	LL = 40 psf	LL = 40 psf	LL = 50 psf	LL = 50 psf
	DL = 68 psf	DL = 71 psf	DL = 74 psf	DL = 77 psf	DL = 68 psf	DL = 74 psf
8"	18' - 0"	18' - 0"	18' - 0"	18' - 0"	18' - 0"	18' - 0"
10"	22' - 6"	22' - 6"	22' - 6"	22' - 6"	22' - 6"	22' - 6"
12"	27' - 0"	27' - 0"	27' - 0"	27' - 0"	27' - 0"	27' - 0"
14"	31' - 6"	31' - 6"	31' - 6"	30' - 10"	31' - 6"	31' - 6"
16"	35' - 11"	35' - 0"	34' - 1"	33' - 2"	35' - 11"	34' - 1"
18"	38' - 7"	37' - 5"	36' - 5"	35' - 7"	38' - 7"	36' - 5"
20"	41' - 0"	39' - 11"	38' - 10"	37' - 9"	41' - 0"	38' - 9"
22"	43' - 0"	42' - 3"	41' - 0"	39' - 11"	43' - 0"	41' - 0"
24"	43' - 0"	43' - 0"	43' - 0"	42' - 1"	43' - 0"	43' - 0"

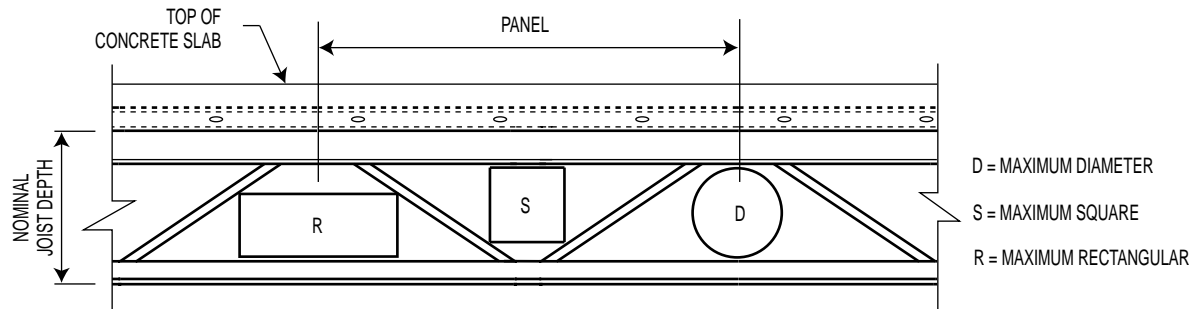
*Total floor depth = MD2000® Joist depth plus slab thickness



NOTES:

- Minimum slab thickness = 2 3/4"
- Minimum top chord cover = 1 1/4"
- $f'_c = 3,000 \text{ psi}$, $F_y = 50 \text{ ksi}$
- Joist spacing: 4'-1 1/4"
- Table reflects uniform loads only.
- Metal deck standard: 1 1/2", 22 ga (Galvanized)
- Nominal slab thickness = slab thickness + 1/2" (Concrete in Deck)
- Live load deflection design standard: $L/360$
- Design clear spans, other than those shown in the above table, require additional structural review.

Maximum Duct Openings



DEPTH (in.)	PANEL (in.)	D (in.)	S (in.)	R (in. x in.)
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	9 1/2 x 6 11 x 5
16	24	10	8	10 1/2 x 6 1/2 13 x 5
18	24	11	8 1/2	11 x 7 12 1/2 x 6
20	24	11 1/2	9	12 x 7 13 x 6
22	24	12	9 1/2	12 x 8 14 x 6
24	24	12 1/2	10	13 x 8 14 x 7

NOTE: For other configurations, the maximum limits will be defined by the joist geometry.

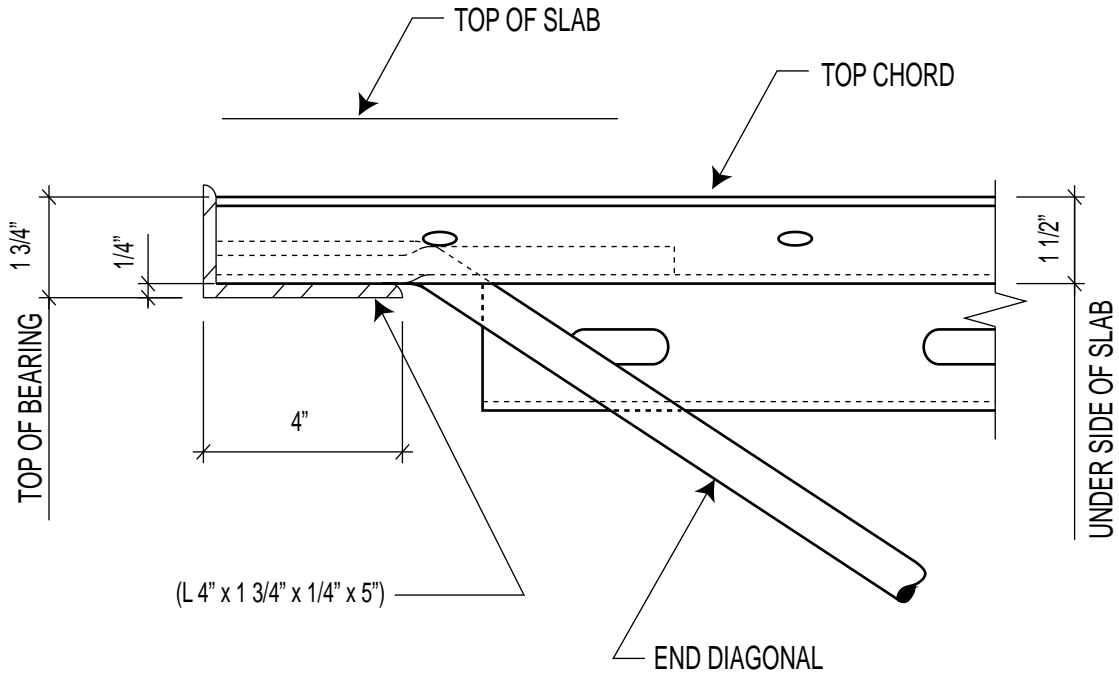
TYPICAL DETAILS

SECTION NO.	DESCRIPTION	
1	Standard Shoe	2
2	Standard Shoe / Mini-joist	
3	Joist Bearing Detail on Masonry	3
4	Masonry Bearing	
5	Joist Bearing Detail on Steel Beam	4
6	Steel Beam Bearing	
7	Joist Bearing Detail on Frame Wall	5
8	Frame Wall	
9	Deep Shoe to Suit Slab Thickness	6
10	Minimum Edge of Slab to Achieve Composite Action	
11	Joist Parallel to Beam	7
12	Header Support Detail	
13	Joist Detail at Column (Flange) Ceiling Extension	8
14	Joist Detail at Column (Web) Ceiling Extension	
15	Tie Joist Detail at Column (Flange) Bottom Chord Extension	9
16	Tie Joist Detail at Column (Web) Bottom Chord Extension	
17	Bolted Joist at Beam	10
18	Expansion Joint Detail at Intermediate Floors (at Steel Beam)	
19	Expansion Joint at Roof (at Steel Beam)	11
20	Expansion Joint Detail at Intermediate Floors (at Wall)	
21	Expansion Joint at Roof (at Wall)	12
22	Expansion Joint at Roof	
23	Hanger Plate for Dropped Slabs	13
24	Cantilevered Balcony (Joist Perpendicular to Balcony)	
25	Cantilevered Balcony Detail (Joist Parallel to Balcony)	14
27	2 Hour Fire Rated Corridor Assembly (1)	
28	2 Hour Fire Rated Corridor Assembly (2)	15
29	2 Hour Fire Rated Corridor Assembly (3)	
30	2 Hour Fire Rated Corridor Assembly (4)	16
31	Flange Hanger	

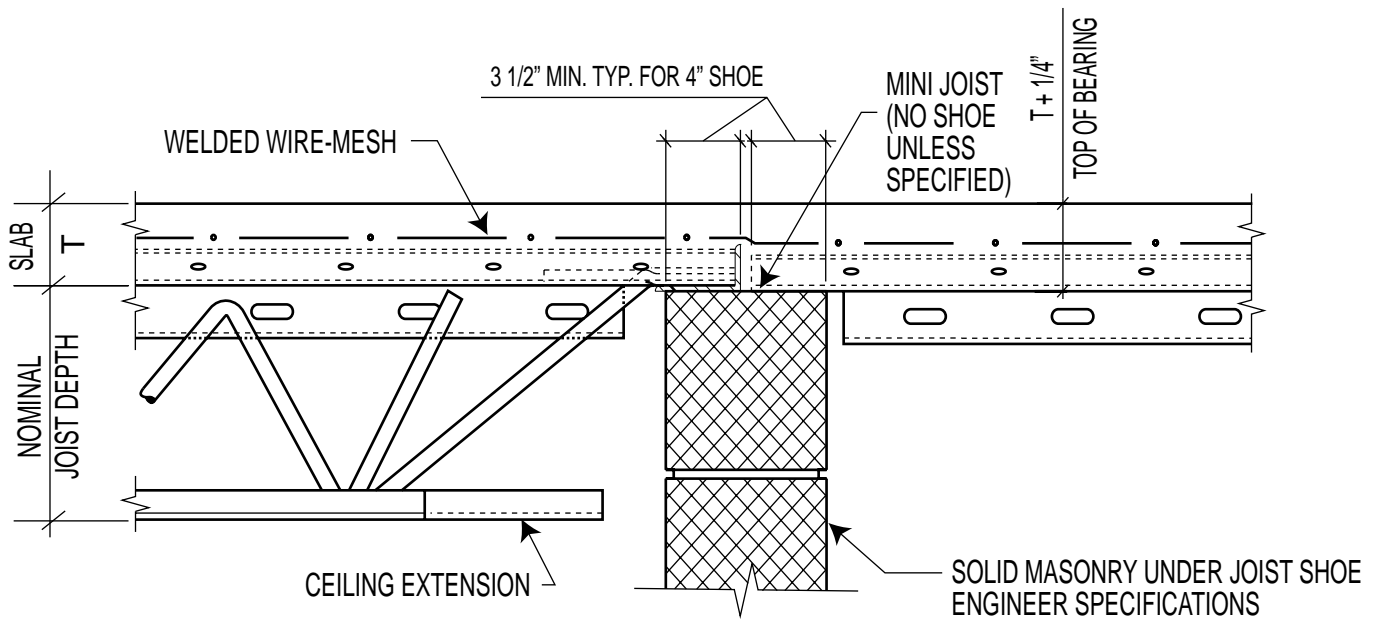
NOTE: The details shown in the following pages are representative details for certain conditions.

TYPICAL DETAILS

SECTION 1 - STANDARD SHOE



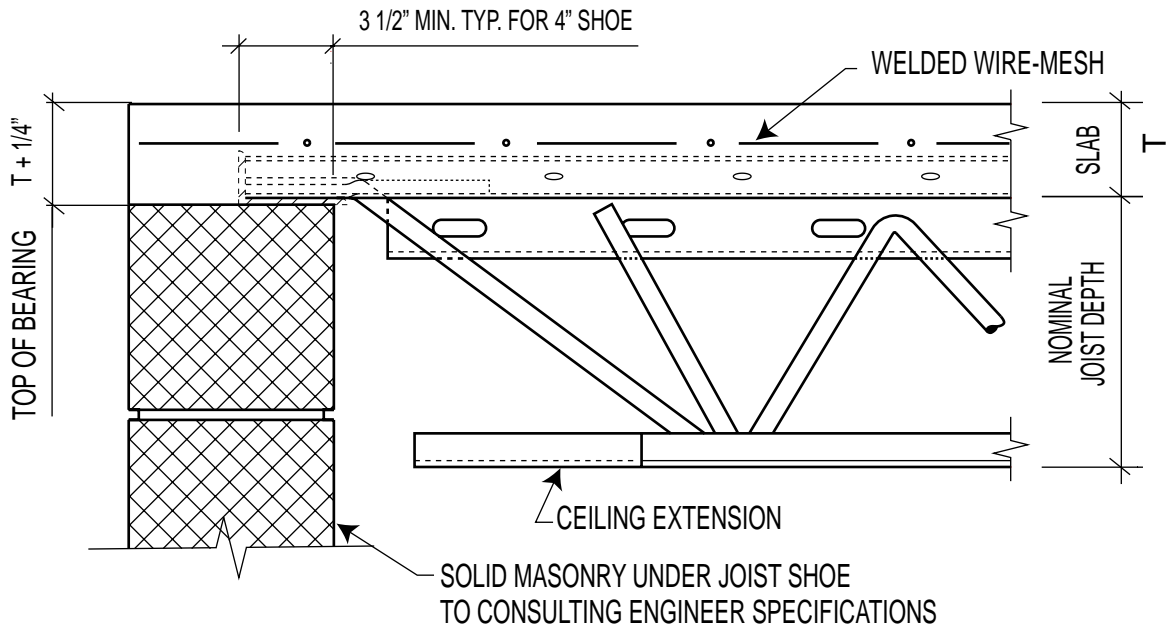
SECTION 2 - STANDARD SHOE / MINI-JOIST



$T + 1/4" = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

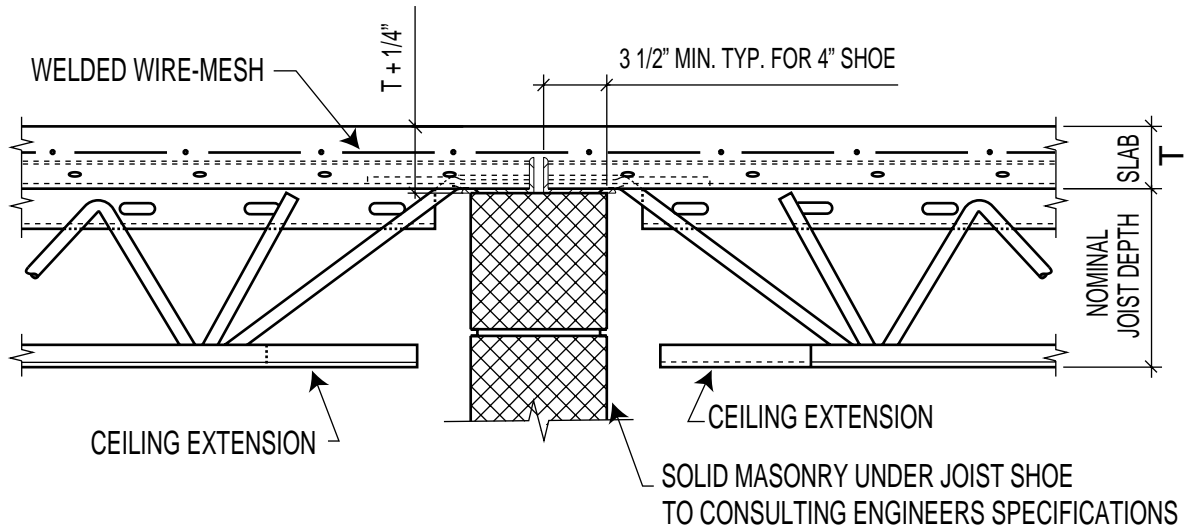
TYPICAL DETAILS

SECTION 3 - JOIST BEARING DETAIL ON MASONRY



T + 1/4" = SLAB THICKNESS + SHOE THICKNESS

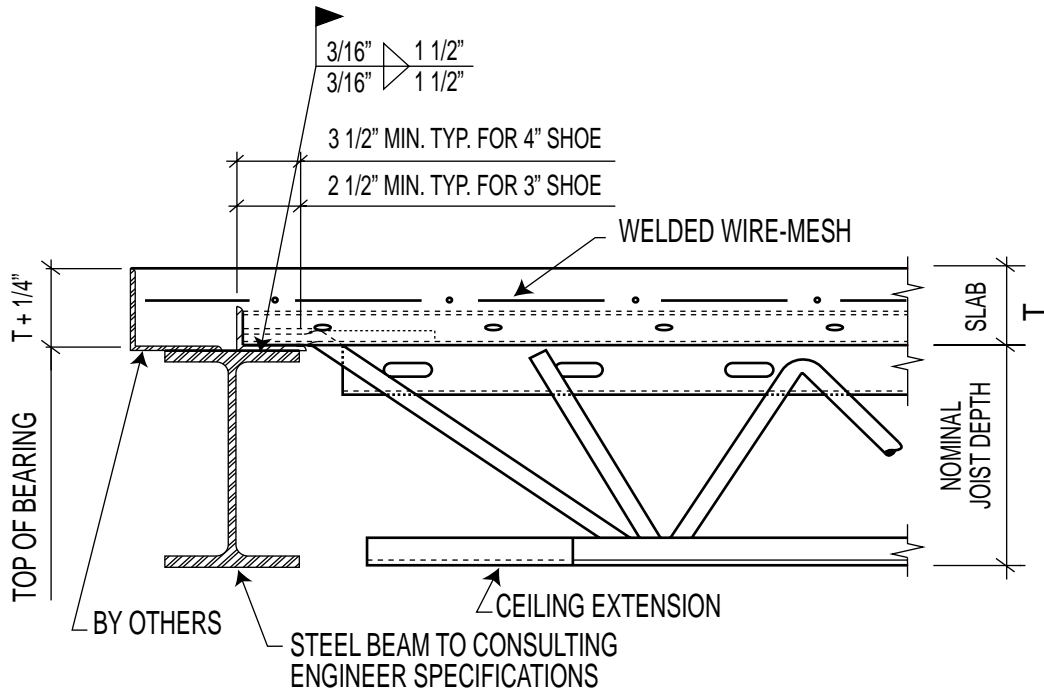
SECTION 4 - MASONRY BEARING



T + 1/4" = SLAB THICKNESS + SHOE THICKNESS

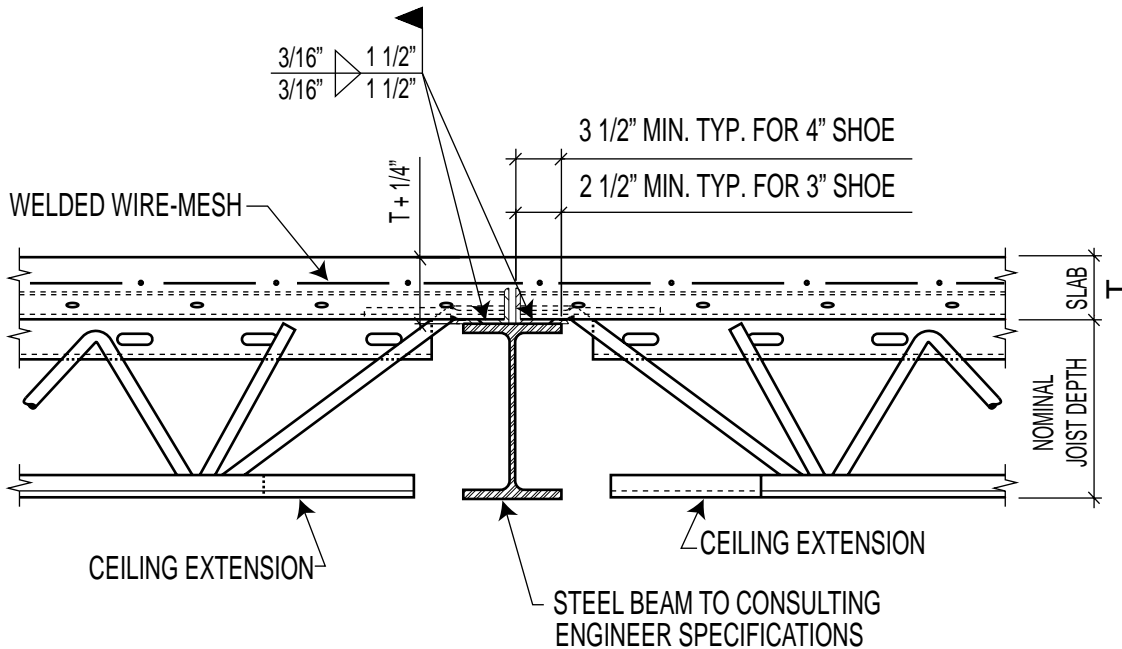
TYPICAL DETAILS

SECTION 5 - JOIST BEARING DETAIL ON STEEL BEAM



$T + 1/4" = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

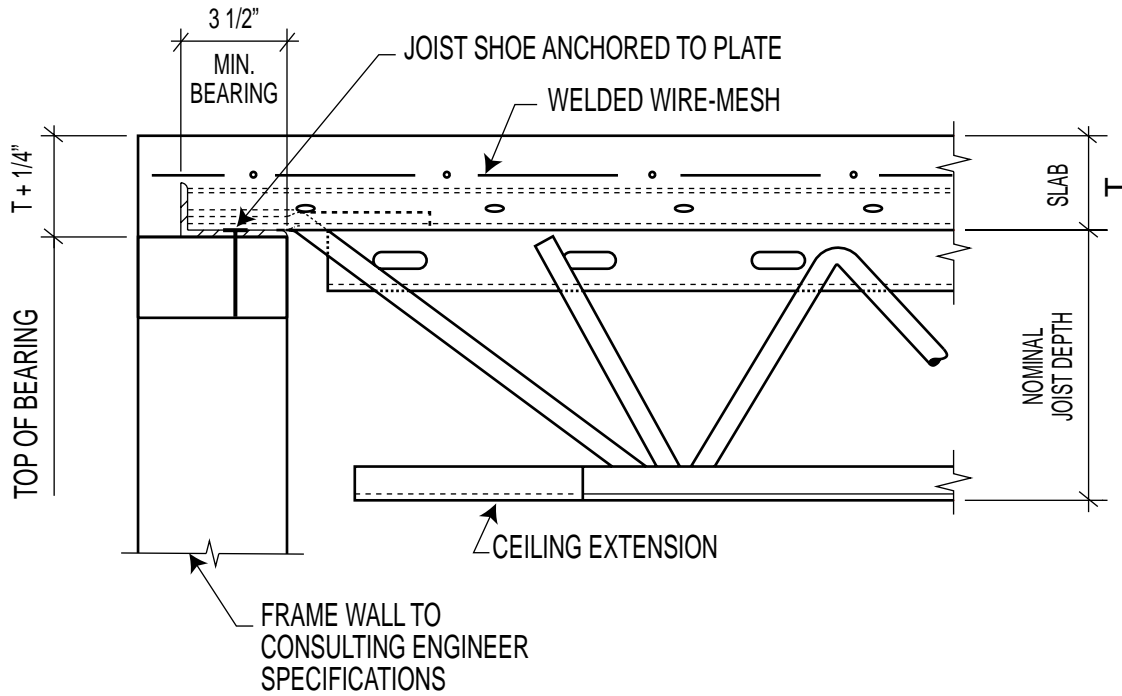
SECTION 6 - STEEL BEAM BEARING



$T + 1/4" = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

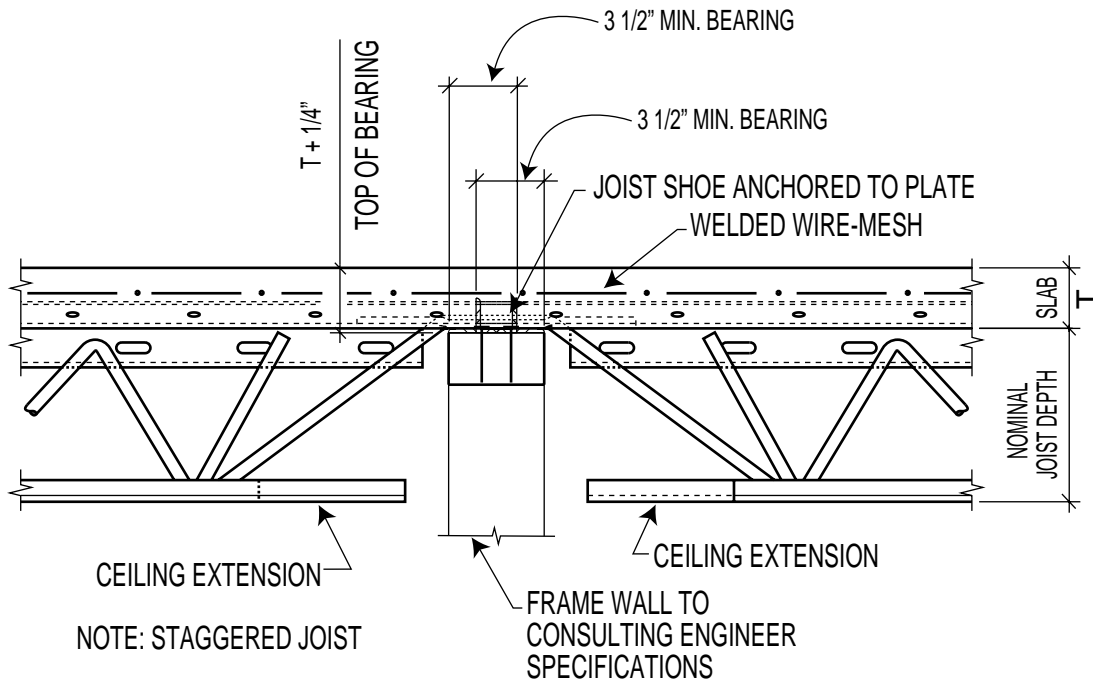
TYPICAL DETAILS

SECTION 7 - JOIST BEARING DETAIL ON FRAME WALL



$T + 1/4'' = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

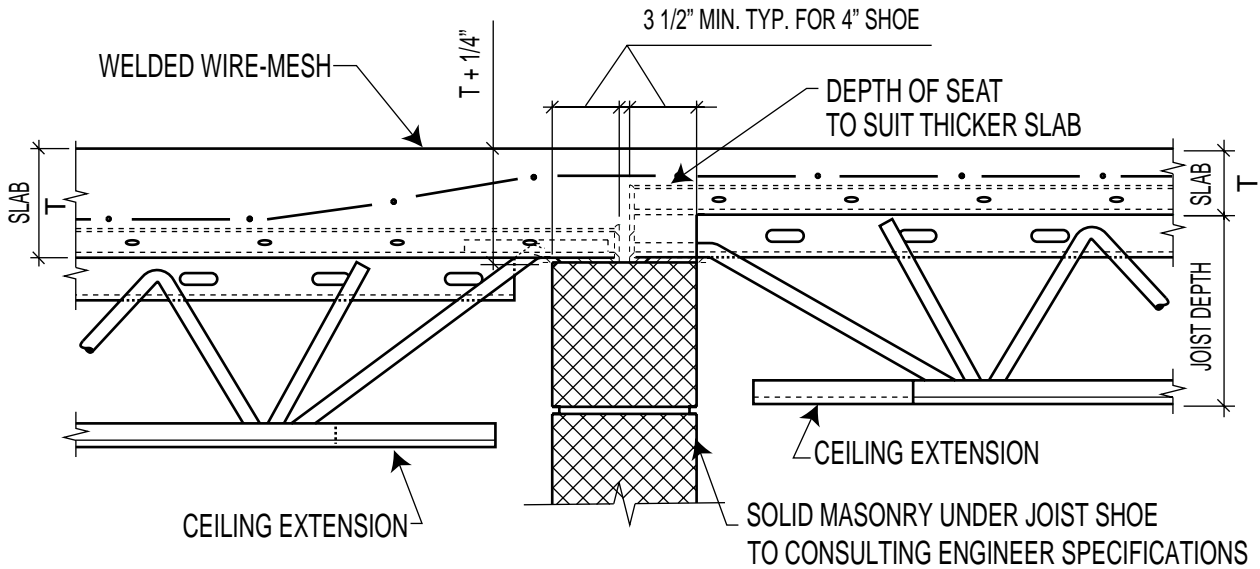
SECTION 8 - FRAME WALL



$T + 1/4'' = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

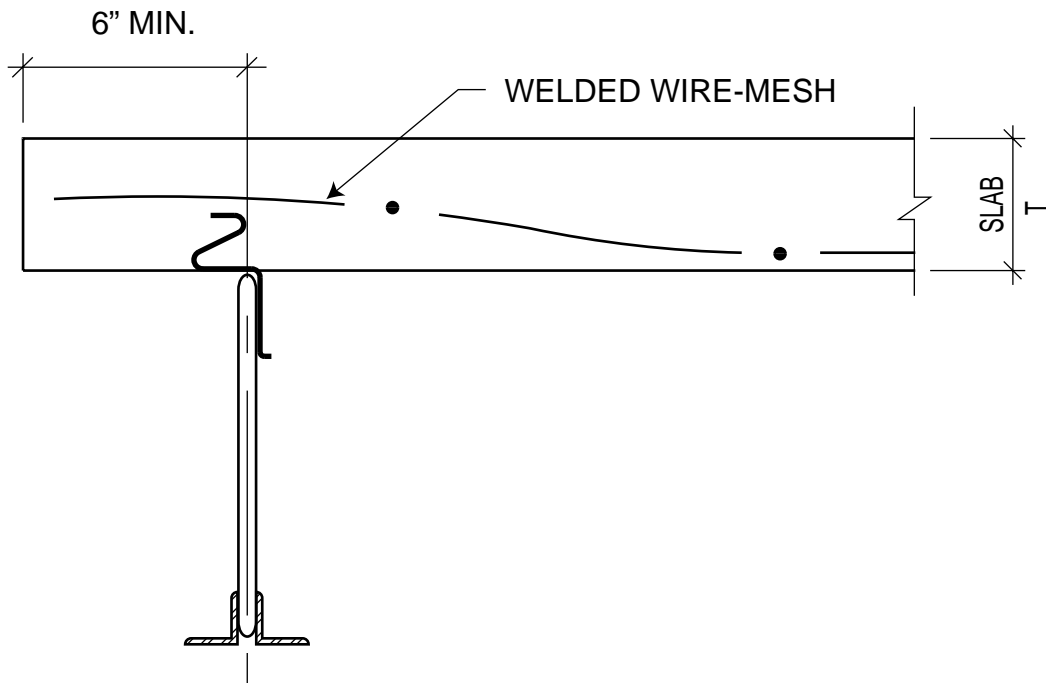
TYPICAL DETAILS

SECTION 9 - DEEP SHOE TO SUIT SLAB THICKNESS



$$T + 1/4" = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$$

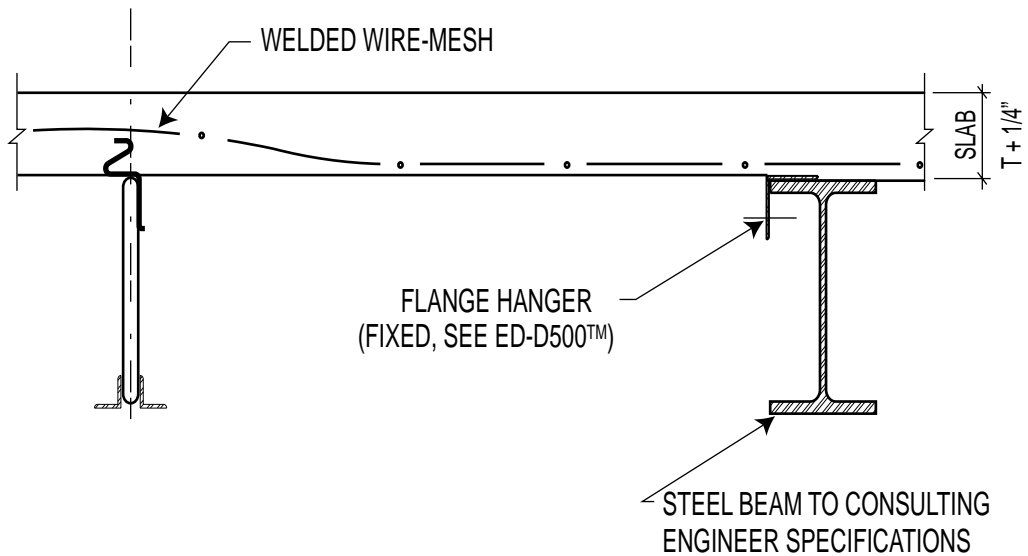
SECTION 10 - MINIMUM EDGE OF SLAB TO ACHIEVE COMPOSITE ACTION



$$T = \text{NOMINAL SLAB THICKNESS}$$

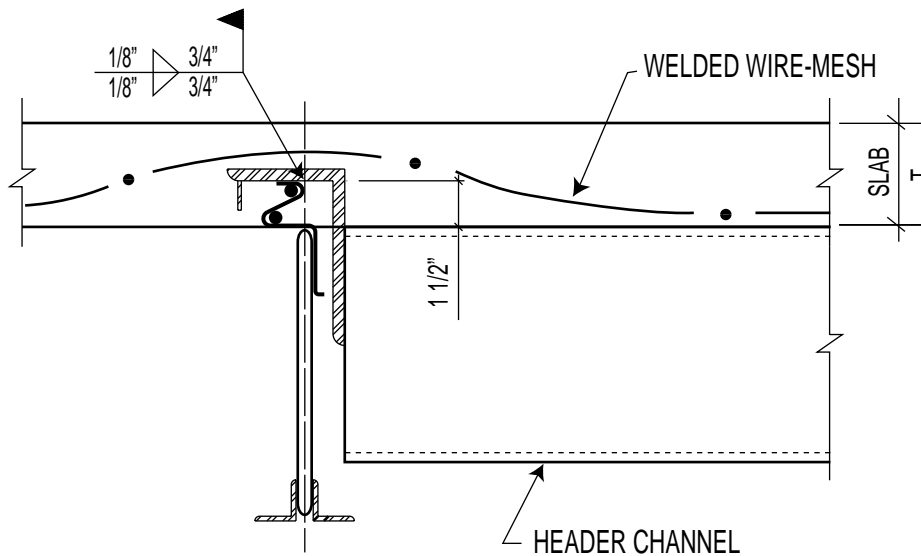
TYPICAL DETAILS

SECTION 11 - JOIST PARALLEL TO BEAM



$T + 1/4'' = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$
 (NOTE = IF F.H. IS NOT USED, T.O.B. = $T + 3/4''$)

SECTION 12 - HEADER SUPPORT

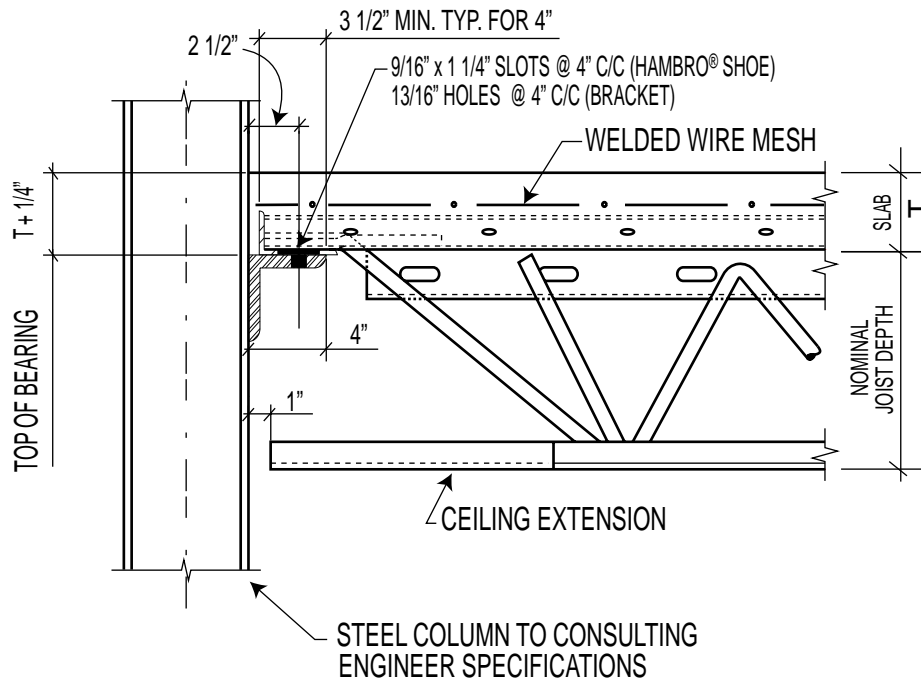


IF THERE IS A JOIST SITTING ON THE HEADER CHANNEL
 THE DIMENSION 1 1/2\"/>

$T + 1/4'' = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

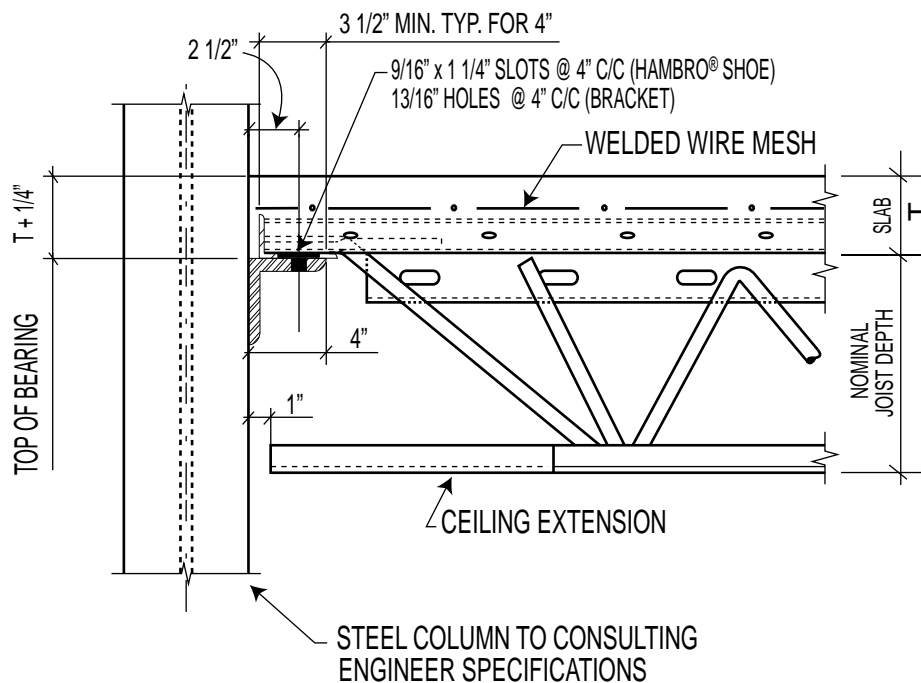
TYPICAL DETAILS

SECTION 13 - JOIST DETAIL AT COLUMN (FLANGE) CEILING EXTENSION



$$T + 1/4'' = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$$

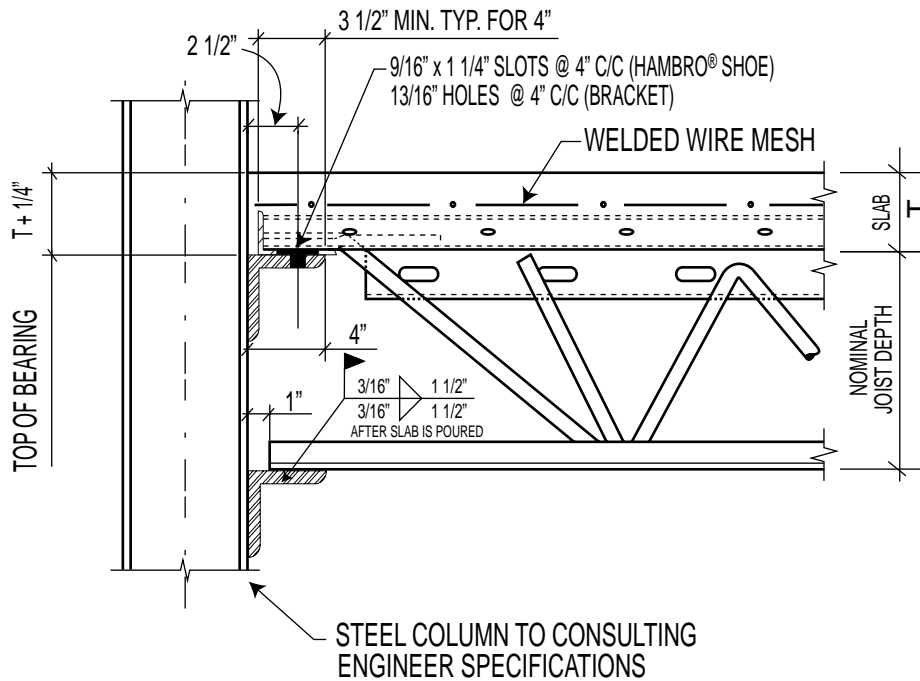
SECTION 14 - JOIST DETAIL AT COLUMN (WEB) CEILING EXTENSION



$$T + 1/4'' = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$$

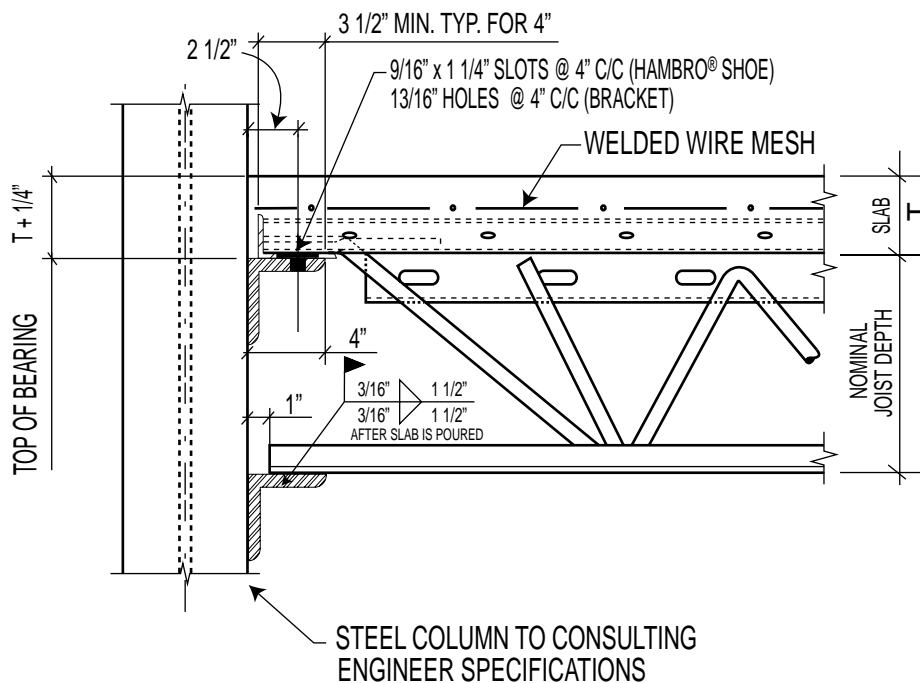
TYPICAL DETAILS

SECTION 15 - TIE JOIST DETAIL AT COLUMN (FLANGE) BOTTOM CHORD EXTENSION



T + 1/4" = SLAB THICKNESS + SHOE THICKNESS

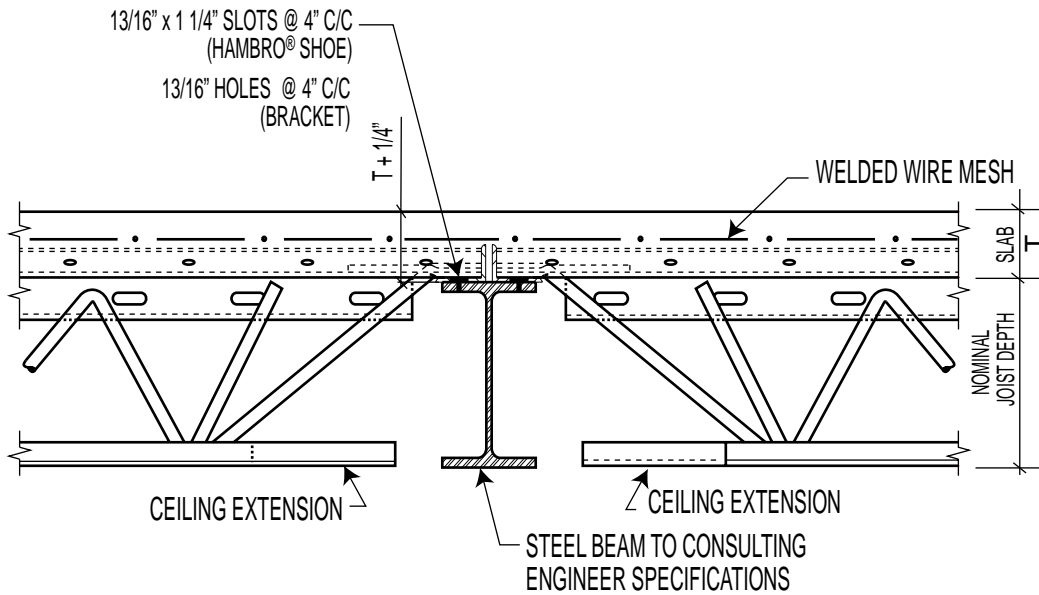
SECTION 16 - TIE JOIST DETAIL AT COLUMN (WEB) BOTTOM CHORD EXTENSION



T + 1/4" = SLAB THICKNESS + SHOE THICKNESS

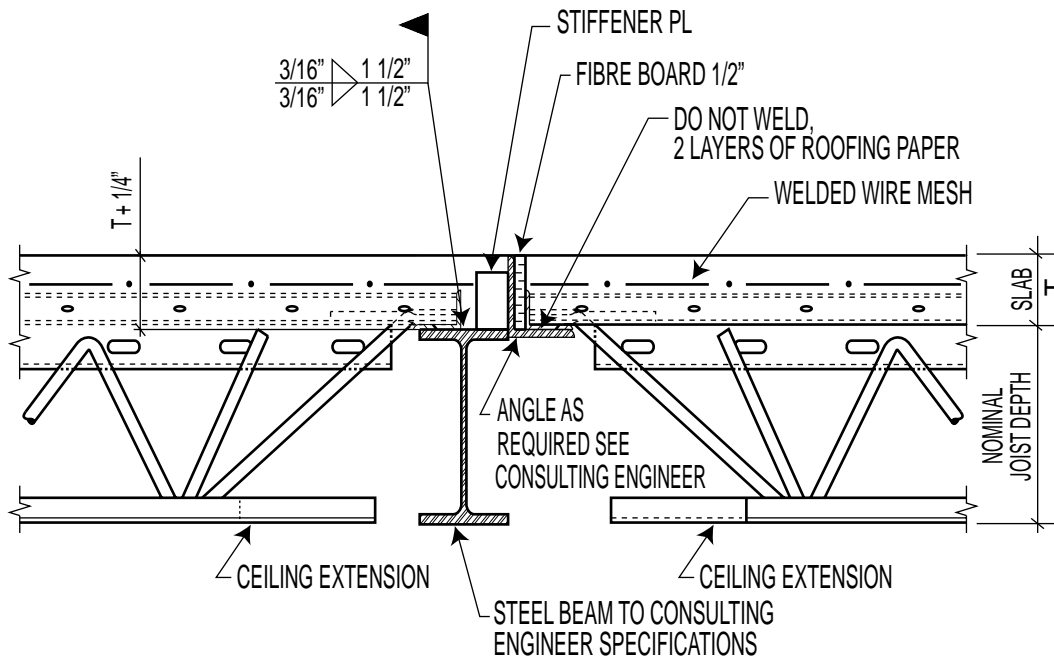
TYPICAL DETAILS

SECTION 17 - BOLTED JOIST AT BEAM



$T + 1/4" = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

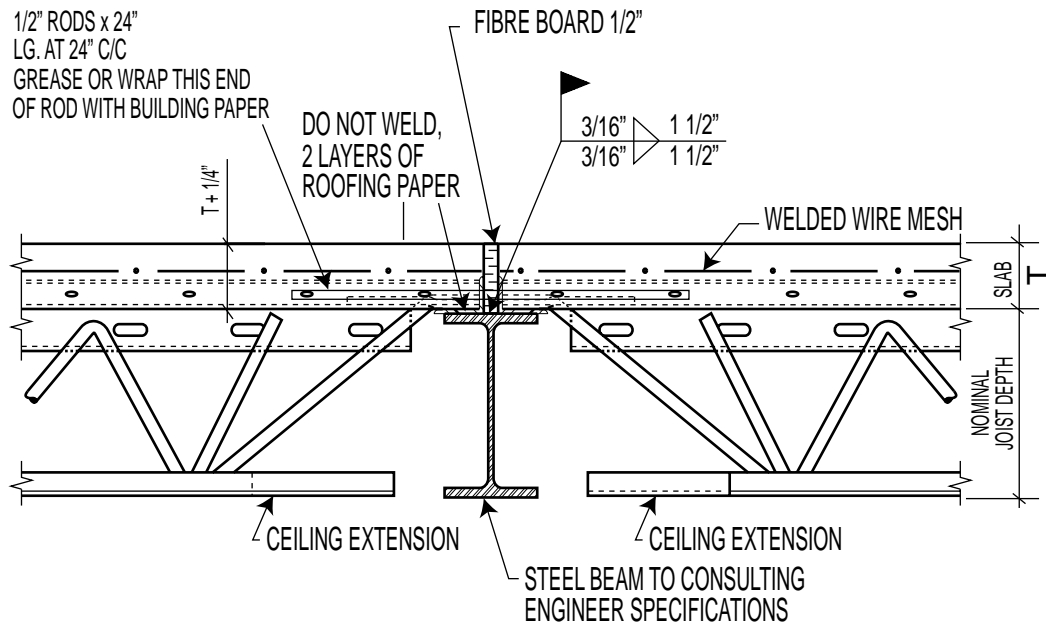
SECTION 18 - EXPANSION JOINT DETAIL AT INTERMEDIATE FLOORS (AT STEEL BEAM)



$T + 1/4" = \text{SLAB THICKNESS} + \text{SHOE THICKNESS}$

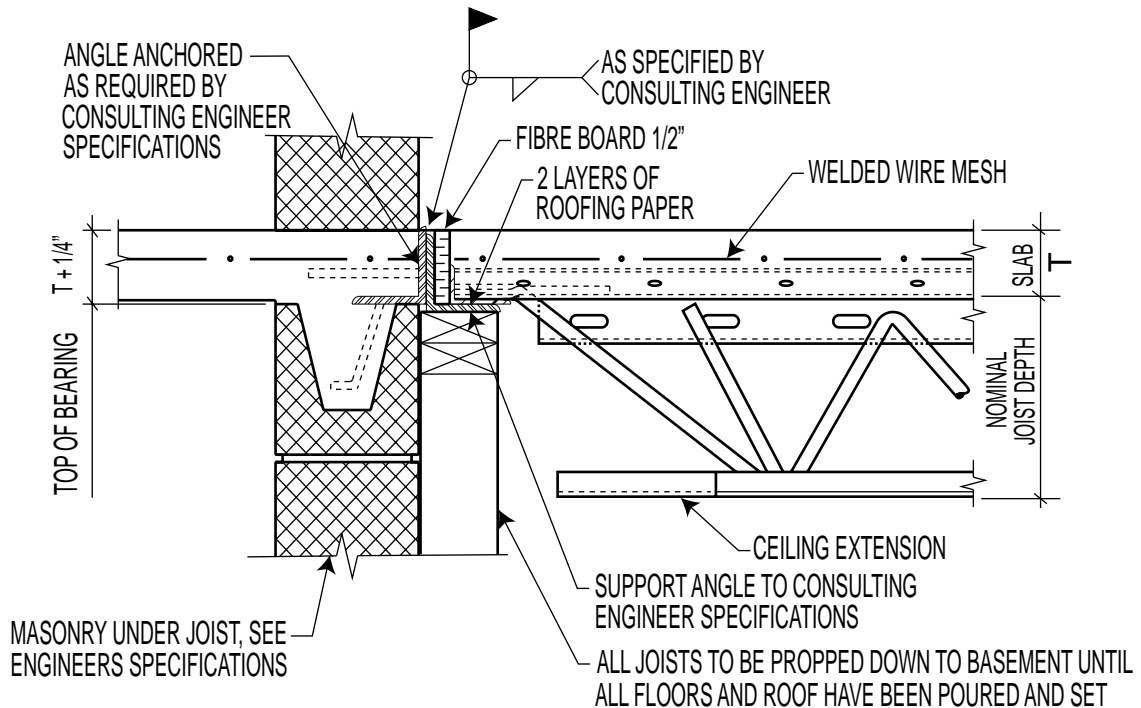
TYPICAL DETAILS

SECTION 19 - EXPANSION JOINT AT ROOF (AT STEEL BEAM)



T + 1/4" = SLAB THICKNESS + SHOE THICKNESS

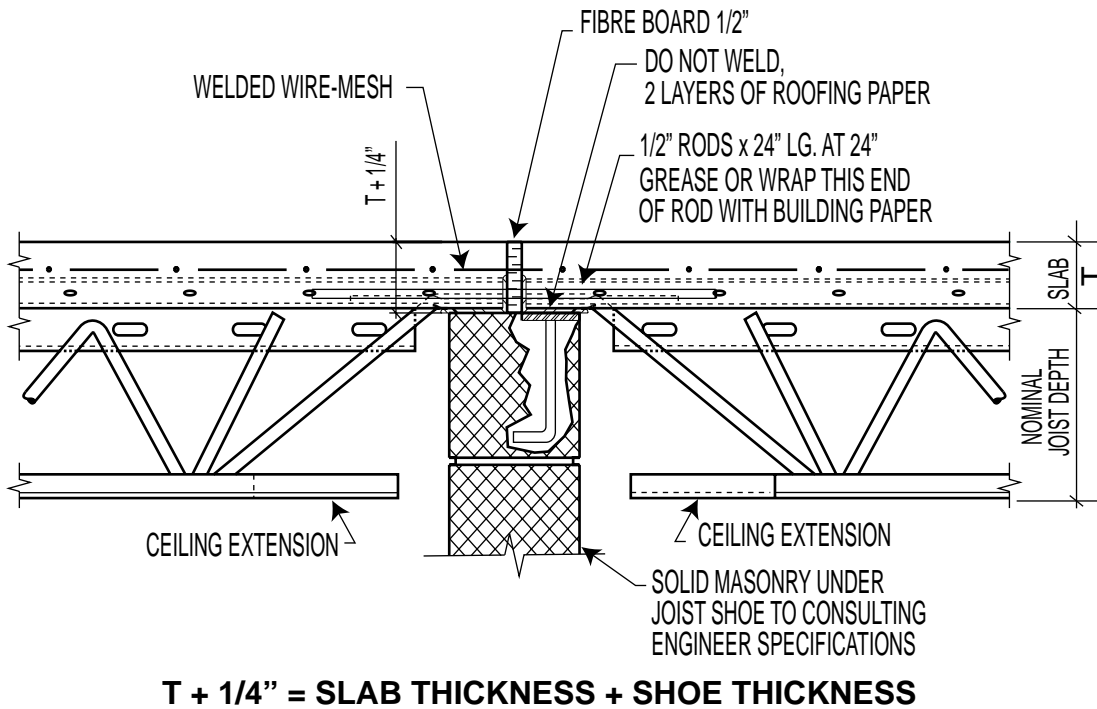
SECTION 20 - EXPANSION JOINT DETAIL AT INTERMEDIATE FLOORS (AT WALL)



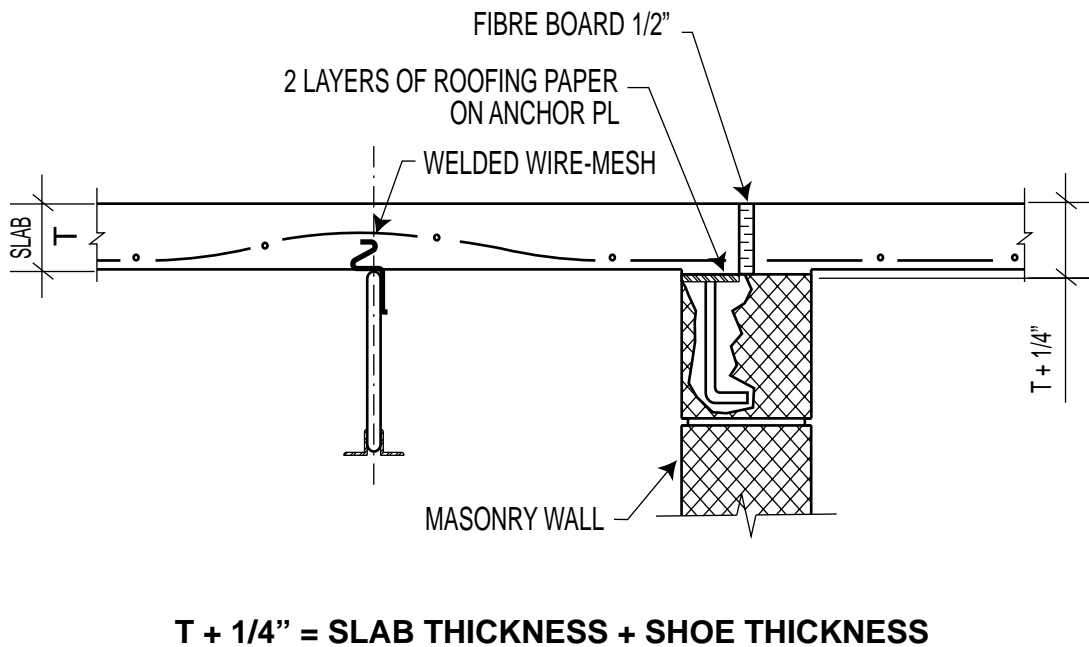
T + 1/4" = SLAB THICKNESS + SHOE THICKNESS

TYPICAL DETAILS

SECTION 21 - EXPANSION JOINT AT ROOF (AT WALL)



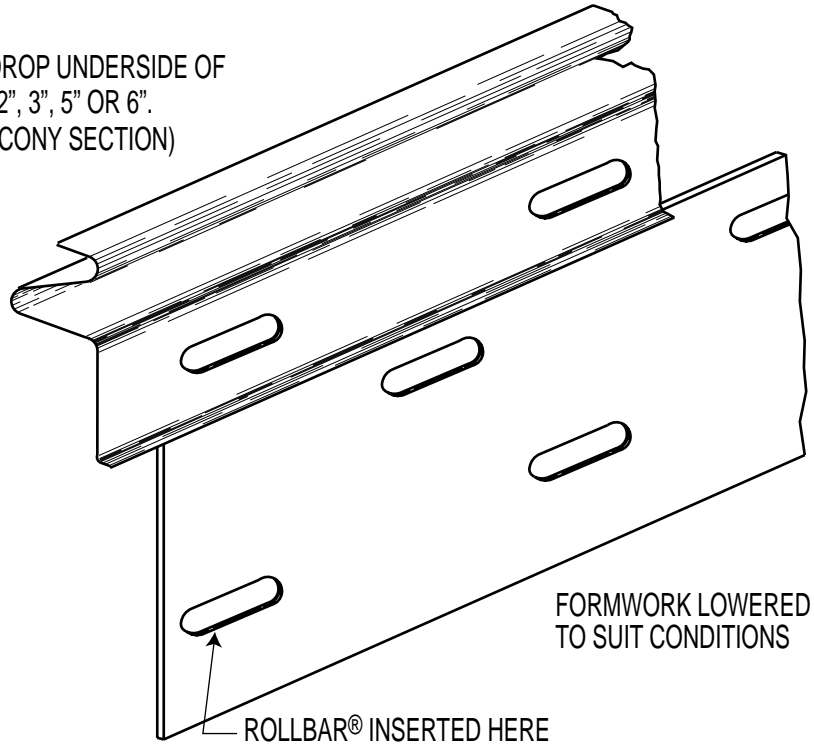
SECTION 22 - EXPANSION JOINT AT ROOF



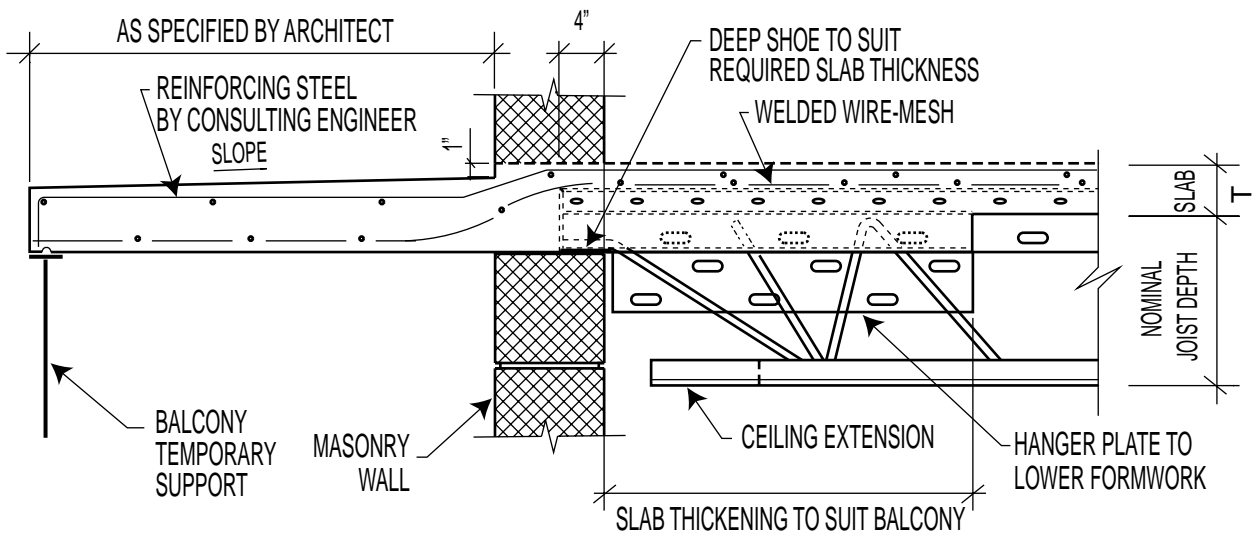
TYPICAL DETAILS

SECTION 23 - HANGER PLATE FOR DROPPED SLABS

USE TO DROP UNDERSIDE OF
SLAB BY 2", 3", 5" OR 6".
(SEE BALCONY SECTION)

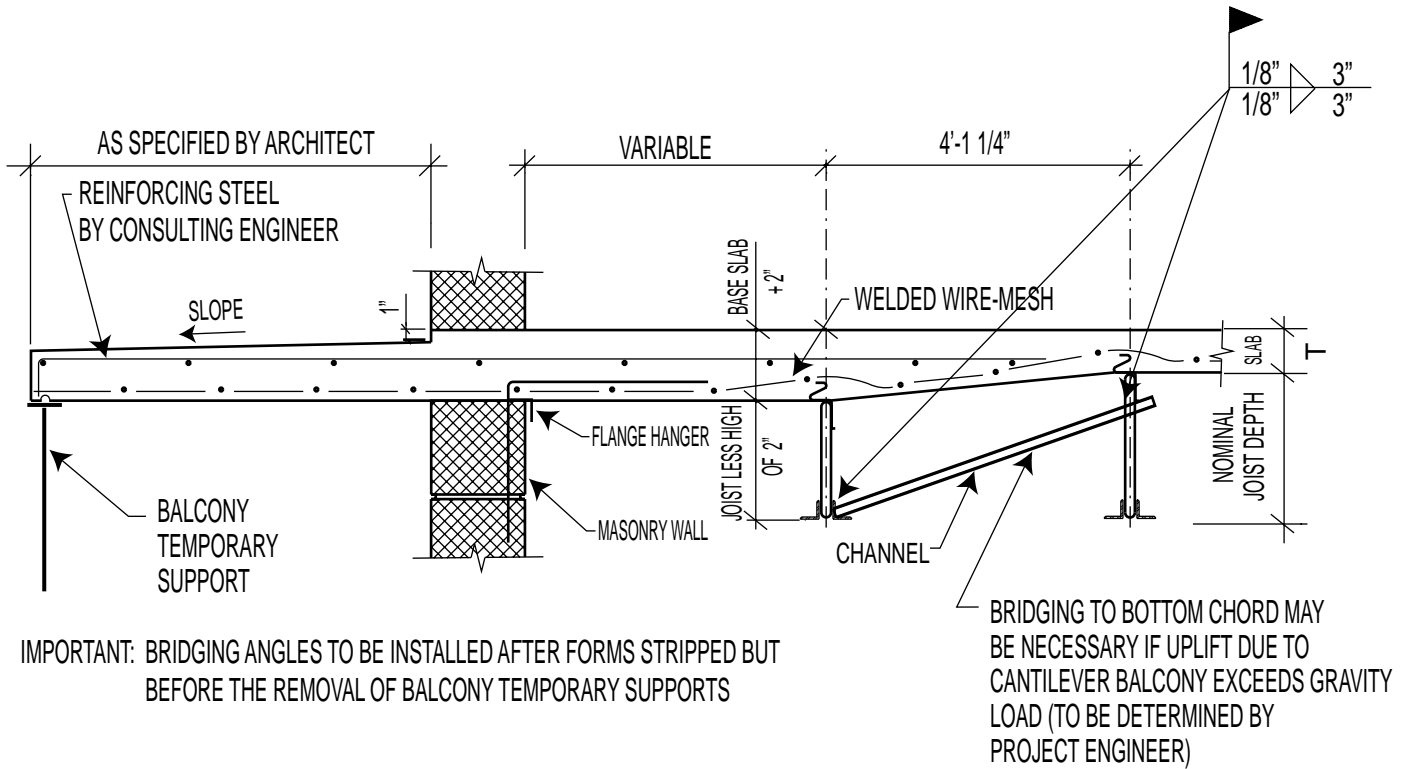


SECTION 24 - CANTILEVERED BALCONY (JOIST PERPENDICULAR TO BALCONY)

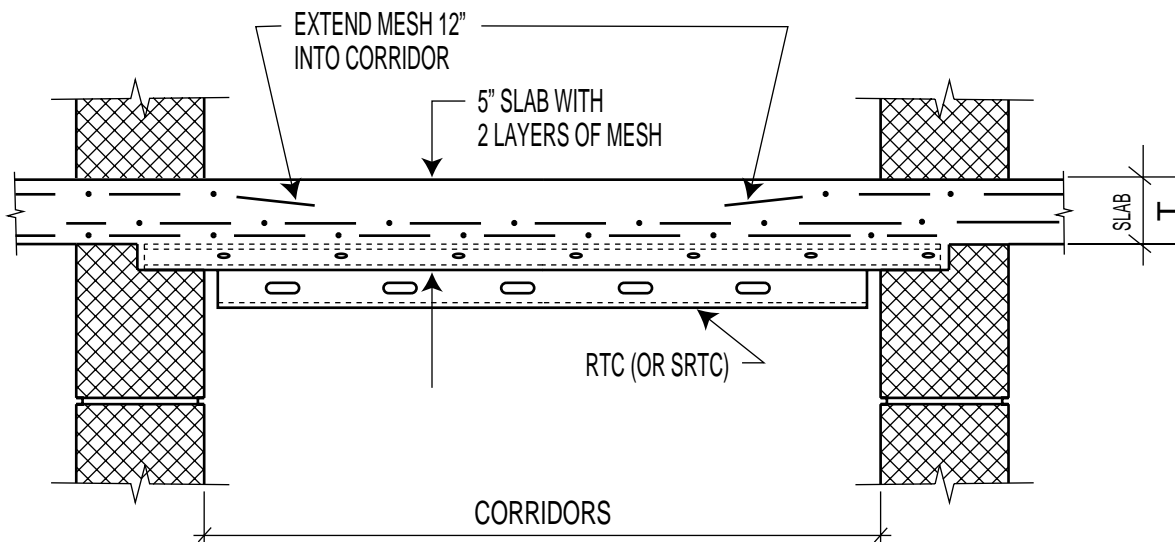


TYPICAL DETAILS

SECTION 25 - CANTILEVERED BALCONY DETAIL (JOIST PARALLEL TO BALCONY)

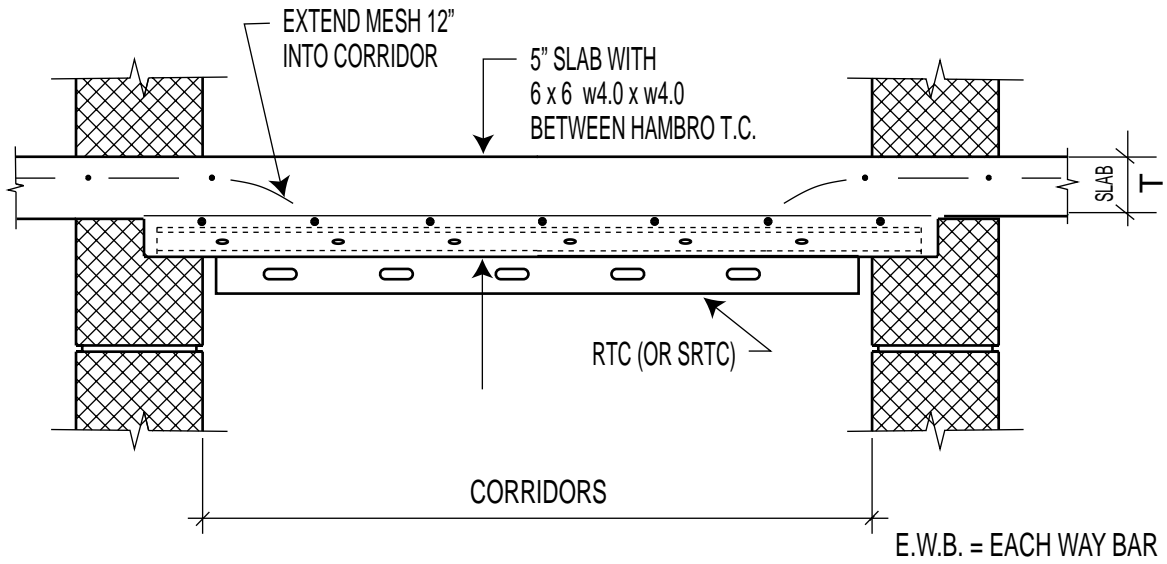


SECTION 27 - 2 HOUR FIRE RATED CORRIDOR ASSEMBLY (1)

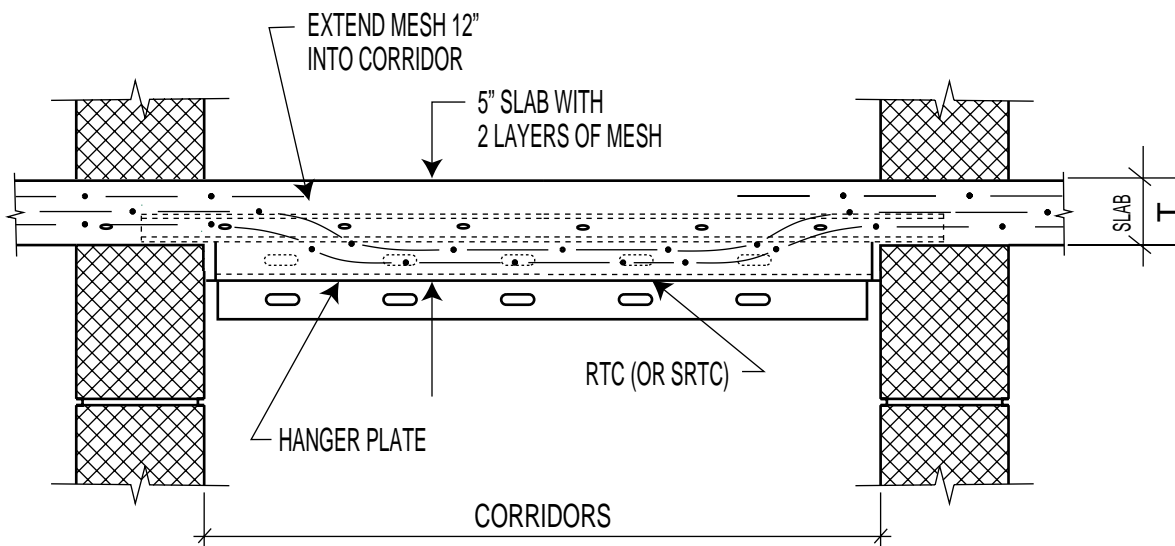


TYPICAL DETAILS

SECTION 28 - 2 HOUR FIRE RATED CORRIDOR ASSEMBLY (2)

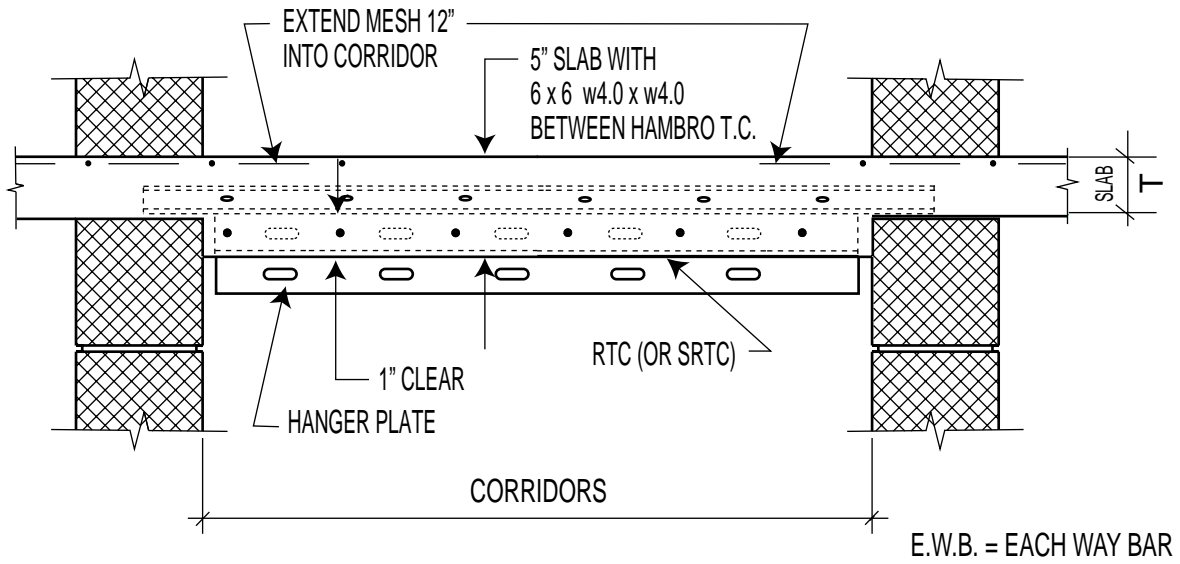


SECTION 29 - 2 HOUR FIRE RATED CORRIDOR ASSEMBLY (3)

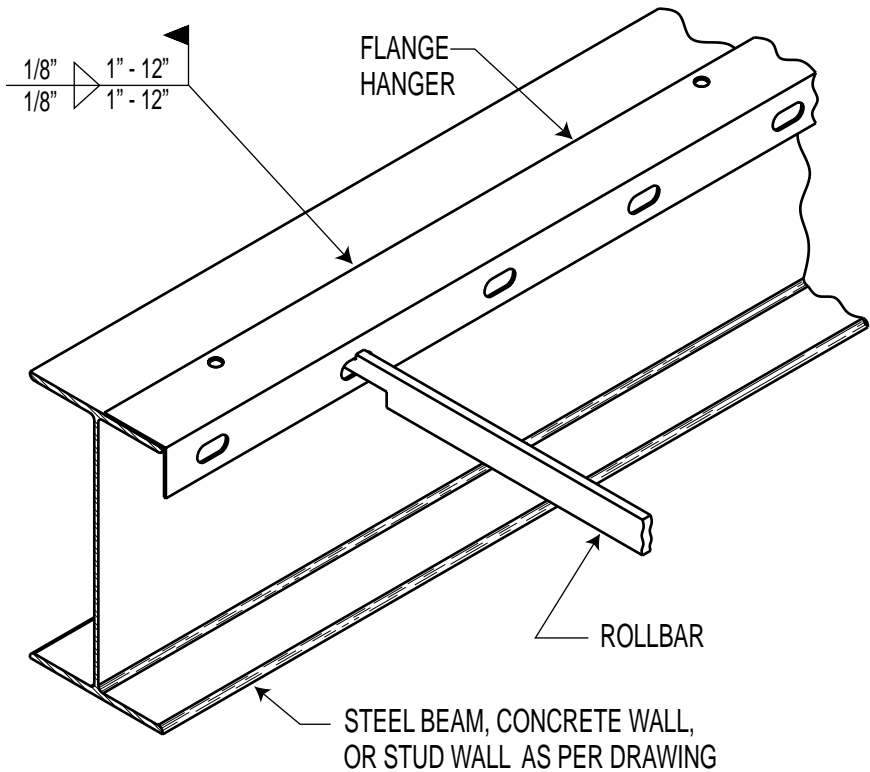


TYPICAL DETAILS

SECTION 30 - 2 HOUR FIRE RATED CORRIDOR ASSEMBLY (4)



SECTION 31 - FLANGE HANGER



MISCELLANEOUS (HAMBRO® SPACING)

Hambro joist spacing is typically 4'-1 1/4" from center line to center line of joists. The first joist parallel to a beam should be spaced 4'-0 5/8" from the edge of the beam flange. This allows for the use of full 4' sheets of plywood and standard roll bars.

NO.	TOTAL	TOTAL + 4'-0 5/8"	NO.	TOTAL	TOTAL + 4'-0 5/8"
1	4'-1 1/4"	8'-1 7/8"	21	86'-2 1/4"	90'-2 7/8"
2	8'-2 1/2"	12'-3 1/8"	22	90'-3 1/2"	94'-4 1/8"
3	12'-3 3/4"	16'-4 3/8"	23	94'-4 3/4"	98'-5 3/8"
4	16'-5"	20'-5 5/8"	24	98'-6"	102'-6 5/8"
5	20'-6 1/4"	24'-6 7/8"	25	102'-7 1/4"	106'-7 7/8"
6	24'-7 1/2"	28'-8 1/8"	26	106'-8 1/2"	110'-9 1/8"
7	28'-8 3/4"	32'-9 3/8"	27	110'-9 3/4"	114'-10 3/8"
8	32'-10"	36'-10 5/8"	28	114'-11"	118'-11 5/8"
9	36'-11 1/4"	40'-11 7/8"	29	119'-0 1/4"	123'-0 7/8"
10	41'-0 1/2"	45'-1 1/8"	30	123'-1 1/2"	127'-2 1/8"
11	45'-1 3/4"	49'-2 3/8"	31	127'-2 3/4"	131'-3 3/8"
12	49'-3"	53'-3 5/8"	32	131'-4"	135'-4 5/8"
13	53'-4 1/4"	57'-4 7/8"	33	135'-5 1/4"	139'-5 7/8"
14	57'-5 1/2"	61'-6 1/8"	34	139'-6 1/2"	143'-7 1/8"
15	61'-6 3/4"	65'-7 3/8"	35	143'-7 3/4"	147'-8 3/8"
16	65'-8"	69'-8 5/8"	36	147'-9"	151'-9 5/8"
17	69'-9 1/4"	73'-9 7/8"	37	151'-10 1/4"	155'-10 7/8"
18	73'-10 1/2"	77'-11 1/8"	38	155'-11 1/2"	160'-0 1/8"
19	77'-11 3/4"	82'-0 3/8"	39	160'-0 3/4"	164'-1 3/8"
20	82'-1"	86'-1 5/8"	40	164'-2"	168'-2 5/8"

