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Canam Buildings and Structures Inc. (“Canam”) specializes in the design and fabrication of steel joists and joist girders, steel deck, purlins and girts and 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. wide by 120 ft. 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. 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.
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.

<table>
<thead>
<tr>
<th>Product</th>
<th>Series</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>D500 system</td>
<td>H</td>
<td></td>
</tr>
<tr>
<td>MD2000 system</td>
<td>MDH</td>
<td></td>
</tr>
<tr>
<td>Composite girder</td>
<td>HJG</td>
<td></td>
</tr>
</tbody>
</table>

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. 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 assumes rigid supports for joist bearing.

If the engineer responsible for the project requires different vibration criteria, he can specify a minimum joist inertia 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. 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
- Hot or cold formed angles and channels: 50 ksi
- Round bars: 50 ksi

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

- ASCE 7-10
- AISC 360-16
- CAN/CSA-S16-14
- CSA-S136-12

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

- ACI 318-14

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 American Welding Society (AWS) or 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

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., a horizontal leg of variable lengths between 3 in., 4 in., 5 in. or 6 in., a thickness of ¼ in. 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.

SPAN AND DEPTH
Span: up to 43 ft.
Depth: between 8 in. and 24 in.

JOIST SPACING
The standard joist spacing is 4 ft.-1¼ in., unless noted otherwise on Canam drawings.

MAXIMUM END REACTION
The maximum non-factored end reaction of the D500 joist is 13 kip 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. 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., 4 ft.-1¼ in. and 5 ft.-1¾ in.).

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. 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).
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. and ⅜ in. are used. Most of the time, standard sheets dimensions (4 ft. x 8 ft.) can be used without cutting due to the standard joist spacing.

**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.

<table>
<thead>
<tr>
<th>Joist depth</th>
<th>P</th>
<th>D</th>
<th>Sq</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>20</td>
<td>3½</td>
<td>3½</td>
<td>6x2½</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>5½</td>
<td>4½</td>
<td>7x3½</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td>7¼</td>
<td>5¼</td>
<td>9x4¼</td>
</tr>
<tr>
<td>14</td>
<td>24</td>
<td>8½</td>
<td>6¼</td>
<td>9½x5½</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11x4¼</td>
</tr>
<tr>
<td>16</td>
<td>24</td>
<td>9½</td>
<td>7½</td>
<td>10½x5½</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12x4</td>
</tr>
<tr>
<td>18</td>
<td>24</td>
<td>10½</td>
<td>8¼</td>
<td>11x6¼</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12½x5</td>
</tr>
<tr>
<td>20</td>
<td>24</td>
<td>11</td>
<td>9</td>
<td>12x6¼</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13x6½</td>
</tr>
<tr>
<td>22</td>
<td>24</td>
<td>12</td>
<td>9½</td>
<td>12x7½</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14x5½</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>12½</td>
<td>10</td>
<td>13x7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14x6</td>
</tr>
</tbody>
</table>

SLAB

The minimum slab thickness is 3 in. and the slab capacity chart tables on pages 22 and 23, show the total allowable load (including the dead load of the slab) based on 3 ksi concrete strength.
Hanger plate

MINI-JOIST

The Hambro D500 top chord section, being 3¼ in., 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.

ACCESSORIES

Accessories are used to accommodate special cases.

1. Hanger plate: for extra slab thickness
   Extra thickness available: 2 in., 3 in., 5 in. and 6 in.


D500 deep shoes

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.

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Assembly detail</th>
<th>Ceiling description</th>
<th>Design No.</th>
<th>Slab (in.)</th>
<th>Fire rating (h)</th>
<th>Beam rating (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gypsum board 1/2 in. Type C or 5/8 in. Type X</td>
<td>I506</td>
<td>2½</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3½</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>I518</td>
<td>2½</td>
<td>1.5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2¼ to 3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G524</td>
<td>Varies</td>
<td>1 to 3</td>
<td>1 to 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gypsum board 5/8 in. Type C</td>
<td>G525</td>
<td>3¼</td>
<td>2 to 3</td>
<td>2 to 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G203</td>
<td>2¼</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3¼</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G213</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G227</td>
<td>2½</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G228</td>
<td>3¼</td>
<td>1.5 to 2</td>
<td>1.5 to 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2½</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spray on</td>
<td>G702</td>
<td>Varies</td>
<td>1 to 3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>I800</td>
<td>2½ to 3¼</td>
<td>1 to 2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G802</td>
<td>Varies</td>
<td>1 to 3</td>
<td>-</td>
</tr>
</tbody>
</table>

\*5/8 in. 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:

<table>
<thead>
<tr>
<th>STC Rating</th>
<th>Practical guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Normal speech easily understood</td>
</tr>
<tr>
<td>30</td>
<td>Normal speech audible, but not intelligible</td>
</tr>
<tr>
<td>35</td>
<td>Loud speech audible, fairly understandable</td>
</tr>
<tr>
<td>40</td>
<td>Loud speech audible, but not intelligible</td>
</tr>
<tr>
<td>45</td>
<td>Loud speech barely audible</td>
</tr>
<tr>
<td>50</td>
<td>Shouting barely audible</td>
</tr>
<tr>
<td>55</td>
<td>Shouting inaudible</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Hambro assemblies</th>
<th>Slab thickness (in.)</th>
<th>Gypsum thickness (in.)</th>
<th># of gypsum layer</th>
<th>STC</th>
<th>IIC</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2½</td>
<td>½</td>
<td>1</td>
<td>53</td>
<td>26</td>
<td>NGC Testing Services Buffalo, NY, USA <a href="http://www.ngctestingservices.com">www.ngctestingservices.com</a></td>
</tr>
<tr>
<td></td>
<td>2½</td>
<td>¼</td>
<td>1</td>
<td>57</td>
<td>30</td>
<td>National Research Concil Ottawa, ON, CA <a href="http://www.nrc-cnrc.gc.ca">http://www.nrc-cnrc.gc.ca</a></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>½</td>
<td>1</td>
<td>N/A</td>
<td>32</td>
<td>NGC Testing Services Buffalo, NY, USA <a href="http://www.ngctestingservices.com">www.ngctestingservices.com</a></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>½</td>
<td>2</td>
<td>63</td>
<td>36</td>
<td>NGC Testing Services Buffalo, NY, USA <a href="http://www.ngctestingservices.com">www.ngctestingservices.com</a></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Floor Finishes</th>
<th>IIC Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpet and pad</td>
<td>50</td>
</tr>
<tr>
<td>Homasote ½ in. ComfortBase® under wood laminate</td>
<td>44</td>
</tr>
<tr>
<td><a href="http://www.homasote.com">www.homasote.com</a></td>
<td></td>
</tr>
<tr>
<td>¼ in. cork under engineer hardwood</td>
<td>47</td>
</tr>
<tr>
<td>QT scu - QT4010</td>
<td>46</td>
</tr>
<tr>
<td>¾ in. underlayment under ceramic tile</td>
<td>46</td>
</tr>
<tr>
<td><a href="http://www.ecoreintl.com">www.ecoreintl.com</a></td>
<td></td>
</tr>
<tr>
<td>QuietWalk® underlayment under laminate flooring</td>
<td>45</td>
</tr>
<tr>
<td><a href="http://www.mpglobalproducts.com">www.mpglobalproducts.com</a></td>
<td></td>
</tr>
<tr>
<td>Insulayment under engineered wood</td>
<td>46</td>
</tr>
<tr>
<td><a href="http://www.mpglobalproducts.com">www.mpglobalproducts.com</a></td>
<td></td>
</tr>
<tr>
<td>1½ in. Maxxon® gypsum underlayment over Enkasonic® sound control mat with quarry tile over NobleSeal® SIS</td>
<td>54</td>
</tr>
<tr>
<td><a href="http://www.maxxon.com">www.maxxon.com</a></td>
<td></td>
</tr>
<tr>
<td>1½ in. Maxxon® gypsum underlayment over Enkasonic® sound control mat with wood laminate floor over Silentstep underlayment</td>
<td>55</td>
</tr>
<tr>
<td><a href="http://www.maxxon.com">www.maxxon.com</a></td>
<td></td>
</tr>
<tr>
<td>1½ in. Maxxon® gypsum underlayment over Enkasonic® sound control mat with Armstrong Commission® Plus Sheet Vinyl</td>
<td>53</td>
</tr>
<tr>
<td><a href="http://www.maxxon.com">www.maxxon.com</a></td>
<td></td>
</tr>
</tbody>
</table>

Notes:

All products tested were on a 2½ in. Hambro slab with a one layer ½ in. 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. 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:

2. Canadian Acoustical Association – www.caa-aca.ca;
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.

<table>
<thead>
<tr>
<th>Vendor 1</th>
<th>Vendor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>625 NW 60th Street, Suite C</td>
<td>Christian Martel, M. Sc. Arch.</td>
</tr>
<tr>
<td>Gainesville, FL</td>
<td>963, chemin Royal</td>
</tr>
<tr>
<td>32607</td>
<td>Saint-Laurent-de-l’île-d’Orléans, QC</td>
</tr>
<tr>
<td>United States</td>
<td>G0A 4N0</td>
</tr>
<tr>
<td>Acousti-Lab</td>
<td>Canada</td>
</tr>
<tr>
<td>Robert Ducharme</td>
<td>Acousti-Tech</td>
</tr>
<tr>
<td>C.P. 5028</td>
<td>Vincent Moreau</td>
</tr>
<tr>
<td>Ste-Anne-des-Plaines, QC</td>
<td>150, rue Léon-Vachon</td>
</tr>
<tr>
<td>J0N 1H0</td>
<td>Saint-Lambert-de-Lauzon, QC</td>
</tr>
<tr>
<td>Canada</td>
<td>G0S 2N0</td>
</tr>
</tbody>
</table>

### 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. and a concrete strength of 3 ksi.

**Loads**

**Live load**

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

<table>
<thead>
<tr>
<th>Use</th>
<th>Uniform load</th>
<th>or</th>
<th>Point load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>40 psf</td>
<td></td>
<td>1.01 kip</td>
</tr>
<tr>
<td>Office</td>
<td>50 psf</td>
<td></td>
<td>2.02 kip</td>
</tr>
<tr>
<td>Corridor/lobby</td>
<td>100 psf</td>
<td></td>
<td>2.02 kip</td>
</tr>
<tr>
<td>Garage</td>
<td>50 psf</td>
<td></td>
<td>4.05 kip</td>
</tr>
</tbody>
</table>
Dead load
The tables have been prepared for different slab thicknesses, therefore different dead loads:

<table>
<thead>
<tr>
<th>Slab thickness</th>
<th>Dead load</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 in.</td>
<td>65 psf</td>
</tr>
<tr>
<td>3½ in.</td>
<td>71 psf</td>
</tr>
<tr>
<td>4 in.</td>
<td>78 psf</td>
</tr>
<tr>
<td>4½ in.</td>
<td>83 psf</td>
</tr>
<tr>
<td>5 in.</td>
<td>89 psf</td>
</tr>
<tr>
<td>5½ in.</td>
<td>95 psf</td>
</tr>
</tbody>
</table>

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 on drawings. For example, H14 means that the joist is 14 in. 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).

<table>
<thead>
<tr>
<th>Imperial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Span</td>
</tr>
<tr>
<td>Slab thickness</td>
</tr>
<tr>
<td>Joists spacing</td>
</tr>
<tr>
<td>Concrete strength</td>
</tr>
<tr>
<td>Concrete density</td>
</tr>
<tr>
<td>Live load</td>
</tr>
<tr>
<td>Dead load</td>
</tr>
<tr>
<td>- Joist</td>
</tr>
<tr>
<td>- Concrete</td>
</tr>
<tr>
<td>- Mechanical</td>
</tr>
<tr>
<td>- Ceiling</td>
</tr>
<tr>
<td>- Partition</td>
</tr>
</tbody>
</table>

Using this information, you can find in the tables that:
1. The optimal joist depth is: 20 in.
2. The minimum joist depth is: 14 in.
<table>
<thead>
<tr>
<th>Slab thickness (in.)</th>
<th>Length (ft.)</th>
<th>Live loads 40 psf</th>
<th>Office</th>
<th>Corridor/lobby</th>
<th>Garage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>40 psf</td>
<td>50 psf</td>
<td>100 psf</td>
<td>50 psf</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>0.06 0.06 0.06 0.06 0.06 0.05 0.05 0.05 0.05 0.05 0.05 0.05 1.08 1.08 1.08 1.08</td>
<td>1.08</td>
<td>1.08 1.10 1.10</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06</td>
<td>1.08</td>
<td>1.08 1.10 1.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06</td>
<td>1.08</td>
<td>1.08 1.10 1.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td>0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06</td>
<td>1.08</td>
<td>1.08 1.10 1.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06</td>
<td>1.08</td>
<td>1.08 1.10 1.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06</td>
<td>1.08</td>
<td>1.08 1.10 1.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06 0.06</td>
<td>1.08</td>
<td>1.08 1.10 1.10</td>
</tr>
</tbody>
</table>

**Notes:**
- Most optimal situation of the live load category
- Most optimal depth according to slab thickness
- End joint reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity

**Hambro D500 Composite Floor System**

**Residential Office Corridor/lobby Garage**

- **Live loads:** 40 psf 50 psf 100 psf 50 psf
- **Slab thickness (in.):** 3 3½ 4 4½ 5
- **Length (ft.):** 12 14 16 18 20
- **Depth (in.):** 1.06 1.10 1.14 1.18 2.00

---

**Most optimal situation of the live load category**

**Most optimal depth according to slab thickness**

**End joint reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity**

---

**Hambro D500 span tables**
## Hambro D500 Composite Floor System

### D500 span tables

<table>
<thead>
<tr>
<th>Residential</th>
<th>Office</th>
<th>Corridor/lobby</th>
<th>Garage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live loads</td>
<td>40 psf</td>
<td>50 psf</td>
<td></td>
</tr>
<tr>
<td>Slab thickness (in.)</td>
<td>3</td>
<td>3½</td>
<td>4</td>
</tr>
<tr>
<td>Length (ft.)</td>
<td>Depth (in.)</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>10</td>
<td>1.50</td>
<td>1.27</td>
<td>1.18</td>
</tr>
<tr>
<td>12</td>
<td>1.26</td>
<td>1.07</td>
<td>1.07</td>
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<tr>
<td>14</td>
<td>1.09</td>
<td>1.00</td>
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<tr>
<td>16</td>
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<td>1.17</td>
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<td>1.20</td>
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<tr>
<td>22</td>
<td>1.25</td>
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<td>24</td>
<td>1.39</td>
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<tr>
<td>26</td>
<td>1.21</td>
<td>1.04</td>
<td>1.06</td>
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<tr>
<td>28</td>
<td>1.10</td>
<td>1.00</td>
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</tr>
<tr>
<td>30</td>
<td>1.07</td>
<td>1.02</td>
<td>1.07</td>
</tr>
</tbody>
</table>

- Most optimal situation of the live load category
- 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

**Note:** Live loads are as follows: Residential Office Corridor/lobby Garage

- Live loads: 40 psf, 50 psf, 100 psf, and 50 psf

**Slab thickness in in.**

- 3 in.
- 3½ in.
- 4 in.
- 4½ in.
- 5 in.
## D500 span tables

### Residential Office Corridor/lobby Garage

<table>
<thead>
<tr>
<th>Live loads (psf)</th>
<th>40</th>
<th>50</th>
<th>100</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slab thickness (in.)</td>
<td>3</td>
<td>3½</td>
<td>4</td>
<td>4½</td>
</tr>
<tr>
<td>Length (ft.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth (in.)</td>
<td></td>
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<tr>
<td>14</td>
<td>1.32</td>
<td>1.12</td>
<td>1.13</td>
<td>1.27</td>
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<td>16</td>
<td>1.16</td>
<td>1.02</td>
<td>1.11</td>
<td>1.12</td>
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<td>1.09</td>
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<td>1.08</td>
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<td>1.08</td>
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<td>1.01</td>
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<tr>
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<td>1.07</td>
<td>1.07</td>
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<td>1.05</td>
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<td>1.08</td>
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<td>1.00</td>
</tr>
<tr>
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<td>1.00</td>
<td>1.12</td>
<td>1.13</td>
<td>1.13</td>
</tr>
</tbody>
</table>
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. and the uniform loads presented. The minimum length for the D500 mini-joist is 4 ft.

<table>
<thead>
<tr>
<th>Slab thickness (in.)</th>
<th>3</th>
<th>3½</th>
<th>4</th>
<th>4½</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead load (psf)</td>
<td>65</td>
<td>71</td>
<td>78</td>
<td>83</td>
<td>89</td>
</tr>
<tr>
<td>Live load (psf)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>4’-7”</td>
<td>4’-7”</td>
<td>4’-4”</td>
<td>4’-2”</td>
<td>4’-1”</td>
</tr>
<tr>
<td>RTC</td>
<td>6’-0”</td>
<td>6’-0”</td>
<td>6’-0”</td>
<td>6’-0”</td>
<td>6’-0”</td>
</tr>
<tr>
<td>SRTC</td>
<td>8’-8”</td>
<td>8’-8”</td>
<td>8’-8”</td>
<td>8’-8”</td>
<td>8’-8”</td>
</tr>
<tr>
<td>Live load (psf)</td>
<td>up to 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>4’-2”</td>
<td>4’-2”</td>
<td>4’-1”</td>
<td>4’-0”</td>
<td>N/A</td>
</tr>
<tr>
<td>RTC</td>
<td>6’-0”</td>
<td>6’-0”</td>
<td>6’-0”</td>
<td>6’-0”</td>
<td>6’-0”</td>
</tr>
<tr>
<td>SRTC</td>
<td>8’-8”</td>
<td>8’-8”</td>
<td>8’-8”</td>
<td>8’-8”</td>
<td>8’-8”</td>
</tr>
</tbody>
</table>

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. long at each end, therefore the maximum clear span (without the joist seats) is 8 ft.

SLAB TABLES FOR D500 PRODUCT

Mesh size

The typical wire mesh used has a yield strength of 70,000 psi minimum. The typical sizes used are indicated in the following table:

<table>
<thead>
<tr>
<th>Mesh size (1)</th>
<th>6 in. x 6 in.</th>
<th>4 in. x 4 in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 layers</td>
<td>2 layers</td>
<td>2 layers</td>
</tr>
<tr>
<td>D2.9 x D2.9</td>
<td>D2.9 x D2.9</td>
<td>D2.9 x D2.9</td>
</tr>
<tr>
<td>2 layers</td>
<td>D2.9 x D2.9</td>
<td>D2.9 x D2.9</td>
</tr>
<tr>
<td>D4 x D4</td>
<td>D4 x D4</td>
<td>D4 x D4</td>
</tr>
<tr>
<td>2 layers</td>
<td>D4 x D4</td>
<td>D4 x D4</td>
</tr>
<tr>
<td>D2.9 x D2.9</td>
<td>D2.9 x D2.9</td>
<td>D2.9 x D2.9</td>
</tr>
<tr>
<td>2 layers</td>
<td>D4 x D4</td>
<td>D4 x D4</td>
</tr>
<tr>
<td>2 layers</td>
<td>D4 x D4</td>
<td>D4 x D4</td>
</tr>
<tr>
<td>2 layers</td>
<td>D4 x D4</td>
<td>D4 x D4</td>
</tr>
</tbody>
</table>

Slab capacity under uniform load

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

\[ f'_c = 3,000 \, \text{psi}, \quad \rho = 145 \, \text{pcf}, \quad F_y = 70,000 \, \text{psi} \]

<table>
<thead>
<tr>
<th>Slab thickness (in.)</th>
<th>Chair</th>
<th>Mesh size (in.)</th>
<th>Joist spacing</th>
<th>2’-1¼”</th>
<th>4’-1¼”</th>
<th>5’-1¼”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(6 in. x 6 in.)</td>
<td>Exterior</td>
<td>Interior</td>
<td>Exterior</td>
<td>Interior</td>
</tr>
<tr>
<td>3</td>
<td>N/A</td>
<td>D2.9 x D2.9</td>
<td>1,010</td>
<td>1,150</td>
<td>260</td>
<td>300</td>
</tr>
<tr>
<td>3½</td>
<td>N/A</td>
<td>D4 x D4</td>
<td>1,350</td>
<td>1,580</td>
<td>350</td>
<td>410</td>
</tr>
<tr>
<td>4</td>
<td>N/A</td>
<td>D4 x D4</td>
<td>1,440</td>
<td>1,580</td>
<td>370</td>
<td>410</td>
</tr>
<tr>
<td>4½</td>
<td>N/A</td>
<td>D4 x D4</td>
<td>2,010</td>
<td>2,210</td>
<td>520</td>
<td>580</td>
</tr>
<tr>
<td>5½</td>
<td>3 in.</td>
<td>2 layers D2.9 x D2.9</td>
<td>3,040</td>
<td>3,340</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 layers D4 x D4 (2)</td>
<td>4,130</td>
<td>4,540</td>
<td>1,080</td>
<td>1,190</td>
</tr>
</tbody>
</table>

* Total factored load is taken as 1.2D + 1.6L

Where
\[ D = \text{dead load} \]
\[ L = \text{live load} \]

(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

\[ f'_{c} = 3,000 \text{ psi}, \rho = 145 \text{ pcf}, F_{y} = 70,000 \text{ psi} \]

<table>
<thead>
<tr>
<th>Concentrated load</th>
<th>Slab thickness (in.)</th>
<th>Dead Load (psf)</th>
<th>Mesh size (6 in. x 6 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom/Residential</td>
<td>3</td>
<td>65</td>
<td>D2.9 x D2.9</td>
</tr>
<tr>
<td>Office</td>
<td>3½</td>
<td>71</td>
<td>D4 x D4</td>
</tr>
<tr>
<td>Garage</td>
<td>4</td>
<td>77</td>
<td>D4 x D4</td>
</tr>
<tr>
<td></td>
<td>4½</td>
<td>83</td>
<td>D2.9 x D2.9 (2)</td>
</tr>
</tbody>
</table>

Note:
- Needs to be used in conjunction with uniform load table.
- Mesh size is only a recommendation. A Canam engineer will determine the mesh size.
- (1) 2 layers
- (2) 3 layers

### 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.
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:
   \[ \text{slab thickness} \times \text{concrete density} \]
   Example for a 3 in. slab:
   \[ \left( \frac{3}{12} \right) \times 145 \text{ lb/ft.}^2 = 36.25 \text{ psf} \]
   Formwork and joist:
   5 psf
   Total dead load:
   \[ \text{(concrete + formwork + joist)} \]
   Example:
   \[ (36.25 + 5) = 41.25 \text{ psf} \]

2. Non-composite live load
   Construction live load:
   20 psf

3. Total non-composite load
   Example:
   \[ 41.25 + 20 = 61.25 \text{ psf} \]

Factored moment resistance

\[ M_{nc} = C_e \times T_e \quad \text{i.e.} \]
\[ \frac{W_e L^2}{8} = C_e \times T_e \quad \text{whichever the lesser} \]

Where:

\[ W_e = \frac{61.25 \text{ psf}}{\text{plf}} \times \text{joist spacing} (\text{plf}) \]
\[ L = \text{joist length (ft)} \]
\[ C_e = \text{area of top chord} \times \text{compressive resistance (kip)} \]
\[ T_e = \text{area of bottom chord} \times \text{tensile resistance (kip)} \]
\[ e = \text{effective lever arm at non-composite stage} \]
\[ d = \text{depth of joist (in.)} \]
\[ y_{ne} = \text{neutral axis of bottom chord (in.)} \]

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

\[
\begin{align*}
  t &= 0.09 \text{ in.} \\
  A_{\text{gross}} &= 0.618 \text{ in.}^2 \\
  A_{\text{net}} &= 0.506 \text{ in.}^2 \\
  A_{\text{effective}} &= 0.487 \text{ in.}^2 \\
  I_{x \text{ gross}} &= 0.744 \text{ in.}^4 \\
  I_{y \text{ gross}} &= 0.217 \text{ in.}^4 \\
  I_{x \text{ net}} &= 0.650 \text{ in.}^4 \\
  I_{y \text{ net}} &= 0.185 \text{ in.}^4 \\
  F_{y \text{ top chord}} &= 65 \text{ ksi}
\end{align*}
\]

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:

\[
b_y = \min \left( \frac{I_y}{L^2} \left( \frac{L_2 + L_3}{2} \right) \right)
\]

Where:

\[
L = \text{span of joist}
\]

\[
L_2, \text{ and } L_3 = \text{spacings adjacent to the joist}
\]
The effective width of concrete slab for a perimeter joist:

\[ b_e = \min \left[ L_e + \frac{L_2}{2} ; \frac{L_1}{4} \right] \]

Where:
- \( L \) = span of joist
- \( L_e \) = length of cantilever
- \( L_2 \) = first interior spacing
- \( L_1 \) = second interior spacing

**Effective width of interior D500 joists**

**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 $C' = T_r$. 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. Composite action is considered at 100%.

The simplified concrete stress block is used to find the ultimate tension. The factored resisting moment of the composite section is given by:

$$\phi M_n = \phi A_b F_y e' = T_r e'$$

Where:

- $e' = \text{lever arm at composite stage} = d + \text{slab thickness} - a/2 - y_{nc} \text{ (in.)}$
- $d = \text{joist depth} \text{ (in.)}$
- $y_{nc} = \text{neutral axis of bottom chord} \text{ (in.)}$
- $a = \text{depth of compression block} = \frac{A_c F_y}{0.85 f'c b_e} \text{ (in.)}$
- $\phi = 0.9$
- $A_b = \text{area of bottom chord} \text{ (in.}^2)\text{)}$
- $F_y = \text{yield stress of steel} \text{ (ksi)}$
- $f'c = \text{concrete compressive strength} \text{ (ksi)}$
- $b_e = \text{effective width of concrete} \text{ (in.)}$

The resisting moment can then be compared to the moment:

$$M = \frac{WL^2}{8}$$

Where:

- $W = \text{total factored uniform load (plf)}$
- $L = \text{span of joist (ft.)}$

Web design

Vertical shear

The web of the steel joist is designed to be proportioned to carry the total vertical shear $V$.

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. Dead load plus the appropriate concentrated load 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 $K_l$ is taken as 1.0 time the free distance between the top and bottom chord increased by 1 in.
Hambro D500 Composite Floor System

For webs in tension, the slenderness ratio is not limited, they are dimensioned using:

\[ F_t = 0.6 \times F_y = 30 \text{ ksi} \]

For webs in compression with \( l/r \) less than \( C_c \):

\[
F_a = \left[ 1 - \frac{(l/r)^2}{2C_c^2} \right] \frac{QF_t}{\sqrt{l/f}} \left[ \frac{E}{E_t} \right] \cdot \left[ \frac{f}{f_t} \right]
\]

For webs in compression with \( l/r \) greater than \( C_c \):

\[
F_a = \frac{12\pi^2 E}{23(l/r)}
\]

Where:

\[
C_c = \sqrt{\frac{2\pi^2 E}{QF_t}}
\]
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.

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:

\[ q = \frac{VQ}{I_c} \]
Where:

- \( q \) = horizontal shear flow (lb./in.)
- \( V \) = vertical shear force due to superimposed loads (lb.)
- \( I_s \) = moment of inertia of the composite joist (in.²)
- \( Q \) = statical moment of the effective concrete in compression (hatched area) about the elastic neutral axis of the composite section (in.²)
- \( = (byln) (Y_c - y/2) \) and \( y = y_c \leq t \)
- \( b_r \) = effective concrete width (in.)
- \( n \) = modular ratio
  \[ n = \frac{E_s}{E_c} = 9.4 \text{ (for } f'_c = 3 \text{ ksi)} \]
- \( t \) = slab thickness (in.)
- \( Y_c \) = depth of neutral axis from top of concrete slab (in.)
- \( y \) = neutral axis of composite joist (in.)
  \[ y = \begin{cases} Y_c & \text{when elastic neutral axis lies within slab} \\ t & \text{when elastic neutral axis lies outside slab} \end{cases} \]

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

**Case 2:** N.A. outside the slab \( y = t \)
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. on the length.

1. Horizontal bearing forces
   The test has defined an ultimate value for the end bearing shoe equal to 50 kip for a concrete strength of 3 ksi.

2. Friction between concrete and top chord
   The failure value for the interface shear is 255 lb./in.

**Slab design**

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 ACI 318, Building Code Requirements for Structural Concrete. 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**

ACI 318 provides an approximate method to obtain the moment and shears. If criteria (a) to (e) of section 6.5.1 are satisfied, the following approximate values may be used in the design of one-way slabs. Refer to figure below, for the locations of moments and shear efforts.

![D500 continuous span slab design](image-url)
1. Positive moment
   Exterior span (location 1): \( M_u = W_u L_i^2 / 11 \)
   Interior span (location 3): \( M_u = W_u L_i^2 / 16 \)

2. Negative moment
   First interior support (location 2): \( M_u = W_u L_a^2 / 10 \)
   Other interior support (location 4): \( M_u = W_u L_a^2 / 11 \)

Shear
   Face of first interior support (location 2): \( V_u = 1.15 W_u L_i / 2 \)
   Other interior support (location 4): \( V_u = W_u L_i / 2 \)

Where:

- \( W_u \) = total factored design load = 1.2 x dead load + 1.6 x live load (lb./ft.)
- \( L_1 \) = first exterior span (ft.)
- \( L_i \) = interior spans \( \rightarrow \) joists spacing (ft.)
- \( L_a \) = average of two adjacent spans (ft.)

Single span

However, if at least one of the criteria of ACI 318, 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 31 for location of moment and shear):

1. Positive moment
   All spans (locations 1 and 3): \( M_u = W_u L_i^2 / 8 \)

2. Shear
   All supports: \( V_u = W_u L_i / 2 \)

Concentrated load – load distribution

In addition to the previous verification, the International Building Code (IBC) 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. The following calculations for the effective widths of concentrated load, \( b_e \), are based on the SDI approach.

1. For moment calculation:
   \[ b_e = b_w + (4/3) (1 - x/L_i) x \leq 106.8 \text{ (in./h)} \]

2. For shear calculation:
   \[ b_e = b_w + (1 - x/L_i) x \]

Where:

- \( b_w \) = \( b_2 + 2 t_c \) (in.)
- \( b_2 \) = load width (in.)
- \( t_c \) = slab thickness (in.)
Hambro D500 Composite Floor System

Concentrated load distribution for effective width

Projected width of concentrated load
Moment capacity

The minimum flexural steel is given as a ratio:

\[
\left( \frac{0.0018 \times 60,000}{F_y} \right) \times A_s
\]

Where:

- \( F_y \) = yield strength of reinforcing steel (70,000 psi min.)
- \( A_s \) = area of reinforcing steel in the direction of analysis (in.\(^2\)/ft. width)

In addition, the factored moment resistance (\( M_u \)) of a reinforced concrete section, using an equivalent rectangular concrete stress distribution; and limiting the section to tension controlled (\( \phi = 0.9 \)) is given by:

\[
M_u = \phi_s A_s F_y (d - a/2)
\]

\[
a = \frac{A_s F_y}{\beta_s f'_c b}
\]

Where:

- \( a \) = depth of the equivalent concrete stress block (in.)
- \( \beta_s = 0.85 \)
- \( F_y \) = yield strength of reinforcing steel (70,000 psi min.)
- \( f'_c \) = compressive strength of concrete (3,000 psi min.)
- \( A_s \) = area of reinforcing steel in the direction of analysis (in.\(^2\)/ft. width)
- \( b \) = unit slab width (in.)
- \( d^* \) or \( d \) = distance from extreme compression fiber to centroid of tension reinforcement (in.)
- \( t \) = thickness of the slab (in.)
- \( \phi_s \) = strength reduction factor of reinforcing steel (0.9)
Shear capacity
The shear stress capacity ($V_u$), 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:

$$V_u = V_i = \Phi_c \lambda \sqrt{\frac{V_i}{f'c}} b_u d$$

Where:

- $\lambda = 1$ (for normal density concrete)
- $d'$ or $d$ = distance from extreme compression fiber to centroid of tension reinforcement at the bearing zone (in.)
- $b_u = b$ = width of the slab (in.)
- $\Phi_c$ = strength reduction factor of concrete (0.75)

Serviceability limit states
Crack control parameter
Same as minimum flexural requirement.
**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:

Exterior span: \( t \geq \frac{L_i}{24} \)
Interior span: \( t \geq \frac{L_i}{28} \)

Where:

\( L_i = \text{spacing between joists (in.)} \)

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

**Imperial**

<table>
<thead>
<tr>
<th>Dead load</th>
<th>65 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live load</td>
<td>40 psf</td>
</tr>
<tr>
<td>Concentrated load</td>
<td>1.0 kip on 2.5 ft. x 2.5 ft. area</td>
</tr>
<tr>
<td>Slab thickness (( t ))</td>
<td>3 in.</td>
</tr>
<tr>
<td>Joists spacing (( L_i ))</td>
<td>4 ft.-1¼ in.</td>
</tr>
<tr>
<td>Concrete strength (( f'c ))</td>
<td>3,000 psi</td>
</tr>
<tr>
<td>Wire mesh</td>
<td>D2.9 x D2.9 – 6 x 6</td>
</tr>
<tr>
<td>Area of steel (( A_s ))</td>
<td>0.058 in²/ft.</td>
</tr>
<tr>
<td>Wire mesh diameter</td>
<td>0.192 in.</td>
</tr>
</tbody>
</table>

1. Loads and efforts per foot of slab

**Factored load**

\[ W_f = 1.2 \times 65 \text{ psf} + 1.6 \times 40 \text{ psf} = 142 \text{ psf} \]

**Maximum positive moment at location 1**

\[ M_f = \frac{142 \times 4.1^2}{11} \times 1 \text{ ft.} = 217 \text{ lb.-ft.} \]

**Maximum negative moment at location 2**

\[ M_f = \frac{142 \times 4.1^2}{10} \times 1 \text{ ft.} = 239 \text{ lb.-ft.} \]

**Maximum shear**

\[ V_f = \frac{142 \times 1.15 \times 4.1}{2} = 335 \text{ lb.} \]
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 2½ in. or 2 11/16 in. forming a beam with a span of 24 in. and a depth of 24 in. This beam was loaded with two equal concentrated loads at 6 in. 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 39 illustrates a simple building with a slab in diaphragm. Hambro system values are taken from the slab design example on page 36. Other necessary values are listed below.

<table>
<thead>
<tr>
<th>Imperial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total wind pressure load from leeward and windward faces (W)</td>
</tr>
<tr>
<td>Story height (h₁)</td>
</tr>
<tr>
<td>Span of the beam with the floor slab acting as web (Lt)</td>
</tr>
<tr>
<td>Length of the bearing elements parallel to the horizontal force (B)</td>
</tr>
</tbody>
</table>
Diaphragm example

1. Non-factored moments

The ending moment over the embedded top chord is calculated for one foot width. In using the data from the slab design example, the non-factored moments for a joist with a spacing of 4 ft.-1¼ in. is:

Dead load:

\[ M_d = \frac{65 \text{ psf} \times 4.1042^{\frac{2}{10}} \times 1 \text{ ft.}}{10} = 109.5 \text{ lb.-ft.} \]

Live load:

\[ M_l = \frac{40 \text{ psf} \times 4.1042^{\frac{2}{10}} \times 1 \text{ ft.}}{10} = 67.4 \text{ lb.-ft} \]

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 \( M_r = 466 \text{ lb.-ft.} \).

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.

\[ V = \frac{h W L_t}{2} \]

\[ = \frac{12 \text{ ft.} \times 25 \text{ psf} \times 116.5}{2} \]

\[ = 17,475 \text{ lb.} \]

In our example, the end reaction is distributed along the whole length (60 ft.) of the end wall used to transfer the load.

\[ V = \frac{17,475}{60} \]

\[ = 291.25 \text{ lb./ft.} \]
4. Steel shear capacity

To establish the shear capacity of steel wire mesh for a slab unit width of one foot, we use the following formula from ACI, article 12.5.3.2:

\[
\emptyset V_n = \emptyset A_c \left(2 \sqrt{\frac{f'}{f_y}} + \rho \psi f_y \right)
\]

\[
= 0.75 \times (3 \text{ in.} \times 12 \text{ in.}) \left(2 \times 0 \sqrt{3,000 \text{ psi}} + (3 \text{ in.} \times 12 \text{ in.}) \times 70,000 \text{ psi} \right)
\]

\[
= 3,045 \text{ lb./ft.}
\]

Where \( \rho \) is the area of the wire mesh per linear foot divided by the concrete area.

5. Interaction formulas

According to ASCE 7-10, article 2.3.2, 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:

\[
1.2 \frac{M_f}{M_r} + 0.5 \frac{V}{V_n} \leq 1
\]

\[
1.2 \frac{109.5}{466} + 0.5 \frac{291.25}{3,045} = 0.33 \leq 1 \rightarrow \text{OK (Doesn’t control)}
\]

Load Combination 2:

\[
1.2 \frac{M_f}{M_r} + \frac{V}{V_n} \leq 1
\]

\[
1.2 \frac{109.5}{466} + 67.4 \frac{291.25}{3,045} = 0.52 \leq 1 \rightarrow \text{OK (Controls)}
\]

Load Combination 3:

\[
0.9 \frac{M_f}{M_r} + \frac{V}{V_n} \leq 1
\]

\[
0.9 \frac{109.5}{466} + 291.25 \frac{3,045}{3,045} = 0.31 \leq 1 \rightarrow \text{OK (Doesn’t control)}
\]

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 3 in. is properly held in place by the Hambro joists spaced at a maximum of 61 in. 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

DETAIL 3
BOLTED JOIST
ON STEEL COLUMN
(FLANGE / WEB)

* WHEN DEEP SHOE, THE c/c OF HOLE IS DIFFERENT, CONSULT THE APPROPRIATE DETAILS ON PLAN.
DETAIL 4
BOLTED JOIST ON INTERIOR STEEL BEAM

NOTE:
STAGGERED JOISTS, IF THE FLANGE BEAM IS LESS THAN 8".
* 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+1/4" = SLAB THICKNESS + SHOE THICKNESS

TOST WORONG
**DETAIL 6**

**JOIST BEARING ON INTERIOR MASONRY OR CONCRETE WALL**

- Joist shoe anchored to support with Tapcon concrete screw or equivalent $\frac{1}{4}'' \times \frac{1}{4}''$ length min.
- $3\frac{1}{2}''$ min. bearing for 4'' shoe (typ.)
- Filled masonry or bond beam
- Ceiling extension (typ.)

**NOTE:**
Staggered joists, if the wall is less than 8''.

**T + \frac{1}{2}'' = SLAB THICKNESS + SHOE THICKNESS**

---

**DETAIL 7**

**JOIST BEARING ON EXTERIOR INSULATED CONCRETE WALL**

- Joist shoe anchored to support with Tapcon concrete screw or equivalent $\frac{1}{4}'' \times \frac{1}{4}''$ length min.
- $3\frac{1}{2}''$ min. bearing for 4'' shoe (typ.)
- Ceiling extension (typ.)
- Notch rigid insulation

**T + \frac{1}{2}'' = SLAB THICKNESS + SHOE THICKNESS**
**DETAIL 8**

**JOIST BEARING ON INTERIOR INSULATED CONCRETE WALL**

- **TOp OF BEARING**
- **SLAB**
- **NOTCH RIGID INSULATION (TYP.)**
- **CEILING EXTENSION (TYP.)**

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8”.

**DETAIL 9**

**JOIST BEARING ON EXTERIOR STEEL BEAM**

- **POUR STOP**
- **CEILING EXTENSION**

T+1/4” = SLAB THICKNESS + SHOE THICKNESS
**DETAIL 10**

**JOIST BEARING ON INTERIOR STEEL BEAM**

\[ T + \frac{1}{4}'' = \text{SLAB THICKNESS + SHOE THICKNESS} \]

**NOTE:**
Staggered joists, if the flange beam is less than 8”.

**DETAIL 11**

**JOIST BEARING ON INTERIOR STEEL STUD WALL**

\[ T + \frac{1}{4}'' = \text{SLAB THICKNESS + SHOE THICKNESS} \]

**MECHANICAL FASTENERS**
According to the materials thickness.
DETIAL 12
JOIST BEARING ON INTERIOR STEEL STUD WALL

T-3/4" = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8'.

DETIAL 13
JOIST BEARING ON EXTERIOR STEEL STUD WALL

T-3/4" = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8'.
DETAIL 14

JOIST BEARING ON
EXTERIOR WOOD STUD
WALL

JOIST SHOE ANCHORED
TO PLANK WITH TWO WOOD
SCREWS #12 OR NAILS

3½" MIN. BEARING FOR 4" SHOE (TYP.)

T+1" = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8".

DETAIL 15

JOIST BEARING ON
INTERIOR WOOD STUD
WALL

JOIST SHOE ANCHORED
TO PLANK WITH TWO WOOD
SCREWS #12 OR NAILS

½" MIN. BEARING FOR 4" SHOE (TYP.)

T+1" = SLAB THICKNESS + SHOE THICKNESS
DETAIL 16

EXPANSION JOINT AT ROOF
(STEEL BEAM)

DETAIL 17

EXPANSION JOINT AT ROOF
MINIMUM CLEARANCE OPENING AND HOLE IN THE SLAB

IF SLAB OPENING IS:
- LESS THAN 1'-5", REINFORCE THE AREA WITH AN ADDITIONAL LAYER OF WIRE MESH LAPPED 1'-0" ALL AROUND OPENING
- 1'-5" OR MORE, FOLLOW THE ENGINEER OF RECORD'S DETAIL

STANDARD REINFORCEMENT FOR SLAB OPENING
**DETAIL 19**

**JOIST PARALLEL TO EXPANSION JOINT**

- **NOMINAL JOIST DEPTH**
- **SLAB**
- **T + 1/4" = SLAB THICKNESS + SHOE THICKNESS**

- **ø3/16" TAPCON CONCRETE FASTENERS OR EQUIVALENT @ 24" c/c (MAX.) ANCHORED 1/4" DEEP**
- **CONCRETE, ICF, WOOD OR MASONRY WALL**
- **EXPANSION JOINT DETAILS ACCORDING TO CONSULTING ENGINEER SPECIFICATIONS**

**DETAIL 20**

**JOIST PARALLEL TO A MASONRY OR CONCRETE WALL**

- **NOMINAL JOIST DEPTH**
- **SLAB**
- **T + 1/4" = SLAB THICKNESS + SHOE THICKNESS**

- **ø3/16" TAPCON CONCRETE FASTENERS OR EQUIVALENT @ 24" c/c (MAX.) ANCHORED 1/4" DEEP**
- **CONCRETE, ICF, WOOD OR MASONRY WALL**
- **FLANGE HANGER (TYPE F.H.)**
**Hambro D500 Composite Floor System**

**DETAIL 21**

**JOIST PARALLEL TO INSULATED CONCRETE WALL**

- T+\( \frac{1}{4} \)" = SLAB THICKNESS + SHOE THICKNESS

**DETAIL 22**

**JOIST PARALLEL TO A STEEL BEAM**

- HILTI STEEL DECK FASTENERS:
  - HSN24 FOR \( \frac{1}{8} " < t < \frac{3}{8} " \)
  - EPN19 FOR \( t > \frac{1}{4} " \)

\( t = \) MINIMUM THICKNESS OF THE SUPPORTING STEEL

- SELF-TAPPING FASTENERS @ 12" c/c

- OR

- \( \frac{3}{4} " \) DEEP TAPCON CONCRETE FASTENERS OR EQUIVALENT @ 24" c/c (MAX.) ANCHORED \( \frac{3}{4} " \) DEEP

**SPECIAL NOTE:**

IF THE FLANGE THICKNESS IS MORE THAN \( \frac{1}{16} " \), INSTALL THE FLANGE HANGER AT \( \frac{1}{2} " \) TO THE FACE OF FLANGE.
Hambro D500 Composite Floor System

DETAIL 23
JOIST PARALLEL TO A STEEL STUD WALL

HILTI STEEL DECK FASTENERS:
- HSN24 FOR $\frac{1}{4}'' < t < \frac{3}{4}''$
- EPN19 FOR $t > \frac{3}{4}''$

$t = \text{MINIMUM THICKNESS OF THE SUPPORTING STEEL}$

Screwed or Self Tapping Fasteners
@ 12'' c/c OR

HILTI STEEL DECK FASTENERS:
- HSN24 FOR $\frac{1}{4}'' < t < \frac{3}{4}''$
- EPN19 FOR $t > \frac{3}{4}''$

$t = \text{MINIMUM THICKNESS OF THE SUPPORTING STEEL}$

FLANGE HANGER (TYPE F.H.)

$T+\frac{1}{2}'' = \text{SLAB THICKNESS + SHOE THICKNESS}$

DETAIL 24
JOIST PARALLEL TO A WOOD WALL

$\frac{3}{16}''$ Tapcon Concrete Fasteners
OR EQUIVALENT @ 24'' c/c (MAX.)

ANCHORED $\frac{3}{4}''$ DEEP

FLANGE HANGER (TYPE F.H.)

$T+\frac{1}{2}'' = \text{SLAB THICKNESS + SHOE THICKNESS}$
DETAIL 25
DEEP SHOE TO SUIT SLAB THICKNESS

\[ (T+TS) + 1 = (\text{SLAB THICKNESS} + \text{THicker SLAB}) + \text{SHOE THICKNESS} \]

DETAIL 26
THICKER SLAB

NOTES
- The hanger plate is used to thicken the underside of the concrete slab.
- Four different standards thickness slab can be considered with the hanger plate (see detail).
Hambro D500 Composite Floor System

DETAIL 27
MINI-JOIST AT CORRIDOR

3½" MIN. BEARING FOR 4" SHOE (TYP.)
BEARING DETAILS ACCORDING TO CANAM SPECIFICATIONS

CONCRETE, ICF, WOOD, MASONRY WALL, STEEL BEAM OR STEEL STUD WALL

NOTE:
STAGGERED JOISTS, IF THE SUPPORT ELEMENT IS LESS THAN 8".

DETAIL 28
MINI-JOIST WITH HANGER PLATE AT CORRIDOR

3½" MIN. BEARING FOR 4" SHOE (TYP.)
BEARING DETAILS ACCORDING TO CANAM SPECIFICATIONS

HANGER PLATE TO THICKEN SLAB 2" MORE THAN BASE SLAB

T+1 4" = SLAB THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE SUPPORT ELEMENT IS LESS THAN 8".
DETAIL 29
HEADER SUPPORT

NOTE:
If there is a joist sitting on the header beam, the dimension $\frac{1}{2}"$ will become $\frac{1}{2}"$ and 
"T" will become "T+$\frac{1}{2}" = slab thickness + shoe thickness".

DETAIL 30
FLANGE HANGER FOR
BEAM AND WALL

HILTI STEEL DECK FASTENERS:
- HSN24 for $\frac{3}{8}" < t < \frac{3}{8}"
- EPN19 for $t > \frac{3}{4}"
$t = \text{minimum thickness of the supporting steel}$

SELF TAPPING FASTENERS OR
@ 12" c/c
OR

CONCRETE, ICF, WOOD, MASONRY WALL,
STEEL BEAM OR STEEL STUD WALL

SPECIAL NOTE:
If the flange thickness is more than $\frac{1}{8}"$, install the flange hanger at $\frac{1}{2}"$ to the face of flange.
DETAIL 31
FLANGE HANGER FOR INSULATED CONCRETE WALL

ø3/8" TAPCON CONCRETE FASTENERS OR EQUIVALENT @ 24" c/c (MAX.)
ANCHORED 3/4" DEEP

FLANGE HANGER (TYPE M.H.)

1/2"

DETAIL 32
CANTILEVERED BALCONY (SHALLOW JOIST PARALLEL TO BALCONY)

CONCRETE, ICF, WOOD, MASONRY WALL, STEEL BEAM OR STEEL STUD WALL

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)

(SEE SPECIFICATIONS OF ARCHITECT)  VARIABLE (SEE PLAN)  (SEE PLAN)

CONCRETE, ICF, WOOD, MASONRY WALL, STEEL BEAM OR STEEL STUD WALL

SLOPE

TEMPORARY SUPPORT FOR CANTILEVER

FLANGE HANGER (TYPE F.H.)

HANGER PLATE TO THICKEN SLAB MORE 2", 3", 5" OR 6" THAN BASE SLAB

BRIDGING (INSTALLED AS SHOWN) MAY BE NECESSARY IF UPLIFT, DUE TO CANTILEVERED SLAB, EXCEEDS GRAVITY LOADS (IF REQUIRED BY CONSULTING ENGINEER OR CANAM).

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

NOMINAL JOIST DEPTH (D)

SLAB (T)

1"

SLOPE

DETAIL 34

CANTILEVERED BALCONY
(JOIST PERPENDICULAR TO BALCONY)

(SEE SPECIFICATIONS OF ARCHITECT)

DEEP SHOE TO SUIT THE THICKER SLAB

3/4" MIN. BEARING FOR 4" SHOE (TYP.)

2/3" MIN. BEARING FOR 3" SHOE (TYP.)

TOP OF BEARING

OR BOLTED (SEE DETAIL 4)

1/4" 1/2"

STEEL BEAM

TORSIONAL BRACING SYSTEM TO BE COORDINATED WITH ENGINEER OF RECORDS

CEILING EXTENSION

HANGER PLATE (SEE DETAIL 28)

THICKER SLAB TO SUIT BALCONY

(T+TS)/2 = (SLAB THICKNESS + THICKER SLAB) + SHOE THICKNESS
Hambro D500 Composite Floor System

ENGINEERING TYPICAL DETAILS – HAMBRO D500 ON GIRDER

DETAIL 35
JOIST BEARING ON GIRDER

\[ T+\frac{1}{4} = \text{SLAB THICKNESS} + \text{SHOE THICKNESS} \]

DETAIL 36
JOIST BEARING ON GIRDER

\[ T+\frac{1}{4} = \text{SLAB THICKNESS} + \text{SHOE THICKNESS} \]

NOTE:
KNEE BRACING, IF REQUIRED, SEE ON DRAWING. SIZE TO BE DETERMINED.
DETAIL 37
BOLTED JOIST
ON GIRDER

T+1/4" = 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

HILTI STEEL DECK FASTENERS:
- HSN24 FOR \( \frac{3}{8}" < t < \frac{3}{4}" \)
- EPN19 FOR \( t > \frac{3}{4}" \)

\( t = \text{MINIMUM THICKNESS OF THE SUPPORTING STEEL} \)

SELF TAPPING FASTENERS
@ 12" c/c

\( \frac{3}{4} \) 24" OR

\( T + \frac{1}{4}" = \text{SLAB THICKNESS + SHOE THICKNESS} \)

DETAIL 39

JOIST PARALLEL TO A GIRDER WITH SHEAR CONNECTORS

\( \frac{3}{8}" \right 1\frac{1}{2}" - 12" \)

\( T + \frac{1}{4}" = \text{SLAB THICKNESS + SHOE THICKNESS} \)
ARCHITECTURAL TYPICAL DETAILS – HAMBRO D500 (H SERIES)

Hambro D500 Composite Floor System

HAMBRO D500 TYPICAL FLOOR ASSEMBLY
- CONCRETE SLAB
- WELDED WIRE MESH 6"x6"
- HAMBRO D500 STEEL JOISTS
- GALVANIZED STEEL FURRING CHANNEL 7/8"
- 25 GAUGE @ 24" O.C.
- FIRECODE C GYPSUM PANEL 1/2"

SECTION - TYPICAL FLOOR

FURRING CHANNELS ATTACHED TO JOISTS WITH 18 GAUGE GALVANIZED STEEL TIE WIRE

HAMBRO D500 FIRE RESISTANT RATED FLOOR ASSEMBLY AS PER UL/ULC DESIGN NO. G524
Hambro D500 Composite Floor System

CONCRETE WALL (PERPENDICULAR)

CONCRETE WALL (PARALLEL)
LOAD BEARING STEEL STUD WALL (PERPENDICULAR)

LOAD BEARING STEEL STUD WALL (PARALLEL)
Hambro D500 Composite Floor System

- Pour stop angle
- Cavity filled with mineral wool insulation
- Joist shoe fastened to steel beam
- Galvanized steel studs
- Wall composition per project specifications
- Steel beam
- Extension for ceiling
- Double top track with 1" deflection
- Cavity filled with mineral wool

Structural steel (perpendicular)
Hambro D500 Composite Floor System

- POUR STOP ANGLE
- FLANGE HANGER
- CAVITY FILLED WITH MINERAL WOOL INSULATION
- CALVANIZED STEEL STUDS
- WALL COMPOSITION PER PROJECT SPECIFICATIONS
- STEEL BEAM
- DOUBLE TOP TRACK WITH 1" DEFLECTION, CAVITY FILLED WITH MINERAL WOOL
- HAMBRO D500 TYPICAL FLOOR ASSEMBLY

STRUCTURAL STEEL (PARALLEL)
Hambro D500 Composite Floor System

INSULATED CONCRETE FORMS WALL (PERPENDICULAR)

CONCRETE ANCHOR

1/2"

HAMBRO D500 TYPICAL FLOOR ASSEMBLY

REINFORCING STEEL BARS (BY ENGINEER)

PERIMETER BLOCKING ANGLE

INSULATED FORMS

GYPSUM PANEL (BY ARCHITECT)

FLANGE HANGER

HAMBRO D500 TYPICAL FLOOR ASSEMBLY

REINFORCING STEEL BARS (BY ENGINEER)

PERIMETER BLOCKING ANGLE

INSULATED FORMS

GYPSUM PANEL (BY ARCHITECT)
Hambro D500 Composite Floor System

LOAD BEARING MASONRY WALL (PERPENDICULAR)

LOAD BEARING MASONRY WALL (PARALLEL)
Hambro D500 Composite Floor System

LOAD BEARING WOOD STUD WALL (PERPENDICULAR)

LOAD BEARING WOOD STUD WALL (PARALLEL)
Hambro MD2000 Composite Floor System

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.

JOIST SHOE
The Hambro joist shoe consists of an angle with a vertical leg of 3½ in., a horizontal leg of variable lengths between 3 in., 4 in., 5 in. or 6 in., a thickness of ¼ in. and a variable width depending on the fastening method.
Bolted shoe - Option 1
Bolts ½ in.

Bolted shoe - Option 2
Bolts ¾ in.

Welded or mechanically anchored shoe

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

**SPAN AND DEPTH**
Span: up to 43 ft.
Depth: between 8 in. and 24 in.

**JOIST SPACING**
The standard joist spacing is 4 ft., unless noted otherwise on Canam drawings.

**MAXIMUM END REACTION**
The maximum non-factored end reaction of the MD2000 joist is 17.0 kip at the composite stage.

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

<table>
<thead>
<tr>
<th>Joist depth</th>
<th>P</th>
<th>D</th>
<th>Sq</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>20</td>
<td>4</td>
<td>4</td>
<td>6 x 3</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>6</td>
<td>5</td>
<td>7 x 4</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td>8</td>
<td>6</td>
<td>9 x 5</td>
</tr>
<tr>
<td>14</td>
<td>24</td>
<td>9</td>
<td>7</td>
<td>9½ x 6</td>
</tr>
<tr>
<td>16</td>
<td>24</td>
<td>10</td>
<td>8</td>
<td>10½ x 6½</td>
</tr>
<tr>
<td>18</td>
<td>24</td>
<td>11</td>
<td>8½</td>
<td>11 x 7</td>
</tr>
<tr>
<td>20</td>
<td>24</td>
<td>11½</td>
<td>9</td>
<td>12 x 7</td>
</tr>
<tr>
<td>22</td>
<td>24</td>
<td>12</td>
<td>9½</td>
<td>12 x 8</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>12½</td>
<td>10</td>
<td>13 x 8</td>
</tr>
</tbody>
</table>
SLAB
The minimum slab thickness is 4½ in. and the slab capacity chart tables on page 84, show the total allowable load (including the dead load of the slab) based on a 3 ksi concrete.

ACCESSORIES
Accessories are used to accommodate special cases.
1. Deep shoe: for height variation of joist bearing

MINI-JOIST
The Hambro MD2000 top chord section, being 3½ in., 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.
## 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](http://www.ul.com) or ULC website at [www.ulc.ca](http://www.ulc.ca).

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Assembly detail</th>
<th>Ceiling description</th>
<th>Design No.</th>
<th>Slab (in.)</th>
<th>Fire rating (h)</th>
<th>Beam rating (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gypsum board ½ in. Type C or ⅝ in. Type X</td>
<td>I522</td>
<td>4½</td>
<td>2</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G524</td>
<td>Varies</td>
<td>1 to 3</td>
<td>1 to 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gypsum board 1½ in. Type C or ⅞ in. Type X</td>
<td>G203</td>
<td>4¾</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G213</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G227</td>
<td>4¼</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G228</td>
<td>4</td>
<td>1.5 to 2</td>
<td>1.5 to 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G229</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spray on</td>
<td>G702</td>
<td>Varies</td>
<td>1 to 3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>I800</td>
<td>4 to 5</td>
<td>1 to 2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>G802</td>
<td>Varies</td>
<td>1 to 3</td>
<td>-</td>
</tr>
</tbody>
</table>

½ in. 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:

<table>
<thead>
<tr>
<th>STC Rating</th>
<th>Practical guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>Normal speech easily understood</td>
</tr>
<tr>
<td>30</td>
<td>Normal speech audible, but not intelligible</td>
</tr>
<tr>
<td>35</td>
<td>Loud speech audible, fairly understandable</td>
</tr>
<tr>
<td>40</td>
<td>Loud speech audible, but not intelligible</td>
</tr>
<tr>
<td>45</td>
<td>Loud speech barely audible</td>
</tr>
<tr>
<td>50</td>
<td>Shouting barely audible</td>
</tr>
<tr>
<td>55</td>
<td>Shouting inaudible</td>
</tr>
</tbody>
</table>

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.

### Hambro assemblies

<table>
<thead>
<tr>
<th>Assembly</th>
<th>Total slab thickness (in.)</th>
<th>Steel deck</th>
<th>Gypsum thickness (in.)</th>
<th># of gypsum layer</th>
<th>STC</th>
<th>IIC</th>
<th>Laboratory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P-3606 gage 22</td>
<td>½</td>
<td>1</td>
<td>52</td>
<td>27</td>
<td>NGC Testing Services</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Buffalo, NY, USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><a href="http://www.ngctestingservices.com">www.ngctestingservices.com</a></td>
</tr>
</tbody>
</table>
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:

2. Canadian Acoustical Association – www.caa-aca.ca;

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.**
  - 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. and a concrete strength of 3 ksi.
Loads

Live load

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

<table>
<thead>
<tr>
<th>Use</th>
<th>Uniform load</th>
<th>or</th>
<th>Point load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>40 psf</td>
<td></td>
<td>1.01 kip</td>
</tr>
<tr>
<td>Office</td>
<td>50 psf</td>
<td></td>
<td>2.02 kip</td>
</tr>
<tr>
<td>Corridor/lobby</td>
<td>100 psf</td>
<td></td>
<td>2.02 kip</td>
</tr>
<tr>
<td>Garage</td>
<td>50 psf</td>
<td></td>
<td>4.05 kip</td>
</tr>
</tbody>
</table>

Dead load

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

<table>
<thead>
<tr>
<th>Total slab thickness</th>
<th>Dead load</th>
</tr>
</thead>
<tbody>
<tr>
<td>4½ in.</td>
<td>73 psf</td>
</tr>
<tr>
<td>5 in.</td>
<td>79 psf</td>
</tr>
<tr>
<td>5½ in.</td>
<td>85 psf</td>
</tr>
<tr>
<td>6 in.</td>
<td>91 psf</td>
</tr>
<tr>
<td>6½ in.</td>
<td>97 psf</td>
</tr>
</tbody>
</table>

Note:
The total slab thickness includes the steel deck.
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 on drawings. For example, MDH14 means that the joist is 14 in. 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).

Using this information, you can find in the tables that:
1. The optimal joist depth is: 20 in.
2. The minimum joist depth is: 14 in.
### MD2000 span tables

<table>
<thead>
<tr>
<th>Slab thickness (in.)</th>
<th>Live loads 40 psf</th>
<th>Live loads 50 psf</th>
<th>Live loads 100 psf</th>
<th>Live loads 50 psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>4½</td>
<td>5</td>
<td>5½</td>
<td>6</td>
<td>6½</td>
</tr>
<tr>
<td>5</td>
<td>5½</td>
<td>6</td>
<td>6½</td>
<td>6½</td>
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<tr>
<td>5½</td>
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<td>6½</td>
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<tr>
<td>6½</td>
<td>6½</td>
<td>6½</td>
<td>6½</td>
<td>6½</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Length (ft.)</th>
<th>Depth (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1.04 1.04 1.04 1.06 1.06 1.06 1.08 1.08 1.08 1.08 1.07</td>
</tr>
<tr>
<td>10</td>
<td>1.06 1.08 1.08 1.08 1.08 1.09 1.10 1.10 1.10 1.10 1.10</td>
</tr>
<tr>
<td>12</td>
<td>1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.06</td>
</tr>
<tr>
<td>14</td>
<td>1.00 1.01 1.01 1.01 1.01 1.00 1.01 1.01 1.01 1.01 1.00</td>
</tr>
<tr>
<td>16</td>
<td>1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.02</td>
</tr>
<tr>
<td>18</td>
<td>1.09 1.09 1.13 1.13 1.13 1.11 1.10 1.14 1.14 1.14 1.12</td>
</tr>
<tr>
<td>20</td>
<td>1.15 1.15 1.15 1.15 1.15 1.16 1.16 1.16 1.16 1.16 1.19</td>
</tr>
<tr>
<td>16</td>
<td>1.02 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.09</td>
</tr>
<tr>
<td>18</td>
<td>1.10 1.12 1.12 1.12 1.12 1.11 1.13 1.13 1.13 1.13 1.15</td>
</tr>
<tr>
<td>20</td>
<td>1.15 1.15 1.15 1.15 1.15 1.16 1.16 1.16 1.16 1.16 1.18</td>
</tr>
<tr>
<td>18</td>
<td>1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00</td>
</tr>
<tr>
<td>20</td>
<td>1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00</td>
</tr>
<tr>
<td>16</td>
<td>1.02 1.02 1.02 1.02 1.02 1.04 1.03 1.03 1.03 1.03 1.03</td>
</tr>
<tr>
<td>18</td>
<td>1.13 1.13 1.16 1.16 1.16 1.16 1.16 1.16 1.16 1.16 1.18</td>
</tr>
<tr>
<td>20</td>
<td>1.15 1.15 1.15 1.15 1.15 1.16 1.16 1.16 1.16 1.16 1.19</td>
</tr>
<tr>
<td>18</td>
<td>1.07 1.01 1.02 1.02 1.02 1.03 1.04 1.04 1.04 1.04 1.04</td>
</tr>
<tr>
<td>20</td>
<td>1.22 1.05 1.05 1.12 1.16 1.25 1.14 1.16 1.16 1.16 1.15</td>
</tr>
<tr>
<td>16</td>
<td>1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03</td>
</tr>
<tr>
<td>18</td>
<td>1.10 1.10 1.10 1.10 1.10 1.10 1.10 1.10 1.10 1.10 1.10</td>
</tr>
<tr>
<td>20</td>
<td>1.13 1.13 1.13 1.14 1.16 1.14 1.14 1.14 1.14 1.14 1.17</td>
</tr>
</tbody>
</table>

**Most optimal situation of the live load category**

**Most optimal depth according to slab thickness**

**End joint reaction not acceptable and/or compression into top chord is higher than the maximum factored capacity**

---

**Hambro MD2000 Composite Floor System**

80
### MD2000 span tables

<table>
<thead>
<tr>
<th><strong>Live loads</strong></th>
<th><strong>40 psf</strong></th>
<th><strong>50 psf</strong></th>
<th><strong>100 psf</strong></th>
<th><strong>50 psf</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slab thickness (in.)</strong></td>
<td><strong>4½</strong></td>
<td><strong>5</strong></td>
<td><strong>6</strong></td>
<td><strong>6½</strong></td>
</tr>
<tr>
<td><strong>Length (ft.)</strong></td>
<td><strong>Depth (in.)</strong></td>
<td><strong>1.23</strong></td>
<td><strong>1.12</strong></td>
<td><strong>1.13</strong></td>
</tr>
<tr>
<td>10</td>
<td>1.08</td>
<td>1.03</td>
<td>1.03</td>
<td>1.06</td>
</tr>
<tr>
<td>12</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.02</td>
</tr>
<tr>
<td>14</td>
<td>1.11</td>
<td>1.11</td>
<td>1.11</td>
<td>1.13</td>
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<tr>
<td>16</td>
<td>1.13</td>
<td>1.13</td>
<td>1.16</td>
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<td>18</td>
<td>1.17</td>
<td>1.19</td>
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<tr>
<td>20</td>
<td>1.18</td>
<td>1.07</td>
<td>1.10</td>
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<td>22</td>
<td>1.00</td>
<td>1.00</td>
<td>1.05</td>
<td>1.05</td>
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<td>24</td>
<td>1.00</td>
<td>1.00</td>
<td>1.05</td>
<td>1.05</td>
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<tr>
<td>26</td>
<td>1.01</td>
<td>1.04</td>
<td>1.05</td>
<td>1.06</td>
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<tr>
<td>28</td>
<td>1.02</td>
<td>1.04</td>
<td>1.05</td>
<td>1.05</td>
</tr>
<tr>
<td>30</td>
<td>1.03</td>
<td>1.05</td>
<td>1.06</td>
<td>1.08</td>
</tr>
</tbody>
</table>

- **Most optimal situation of the live load category**
- **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**

### Notes
- **Hambro MD2000 Composite Floor System**
### MD2000 span tables

<table>
<thead>
<tr>
<th>Slab thickness (in.)</th>
<th>4½</th>
<th>5</th>
<th>5½</th>
<th>6</th>
<th>6½</th>
<th>4½</th>
<th>5</th>
<th>5½</th>
<th>6</th>
<th>6½</th>
<th>4½</th>
<th>5</th>
<th>5½</th>
<th>6</th>
<th>6½</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 psf</td>
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<td>50 psf</td>
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<td>100 psf</td>
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<td>50 psf</td>
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</tr>
</tbody>
</table>

**Notes:**
- Most optimal situation of the live load category
- 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

---

**Hambro MD2000 Composite Floor System**
**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. and the uniform loads presented. The minimum length for the MD2000 mini-joist is 4 ft.

<table>
<thead>
<tr>
<th>Slab thickness (in.)</th>
<th>4½</th>
<th>5</th>
<th>5½</th>
<th>6</th>
<th>6½</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead load (psf)</td>
<td>73</td>
<td>79</td>
<td>85</td>
<td>91</td>
<td>97</td>
</tr>
<tr>
<td>Live load (psf)</td>
<td>up to 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MD</td>
<td>RMD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5'-9''</td>
<td>8'-0''</td>
<td>7'-8''</td>
<td>7'-4''</td>
<td>7'-1''</td>
</tr>
<tr>
<td>Live load (psf)</td>
<td>up to 100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MD</td>
<td>RMD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5'-2''</td>
<td>7'-2''</td>
<td>7'-1''</td>
<td>6'-11''</td>
<td>6'-10''</td>
</tr>
</tbody>
</table>

**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. long at each end, therefore the maximum clear span (without the joist seats) is 8 ft.

**SLAB TABLES FOR MD2000 PRODUCT**

**Mesh size**
The typical wire mesh used has a yield strength of 70,000 psi minimum. The typical sizes used are indicated in the following table:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Area (in.²/lin. ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.192</td>
<td>0.058</td>
</tr>
<tr>
<td>0.226</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**Slab capacity under uniform load**

**MD2000 - Maximum unshored deck for single spans**

\[
 f'_c = 3,000 \text{ psi}, \rho = 145 \text{ pcf}, F_y = 40,000 \text{ psi}
\]

<table>
<thead>
<tr>
<th>Effective slab thickness (total slab) (in.)</th>
<th>22</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (4½)</td>
<td>5'-7&quot;</td>
<td>6'-5&quot;</td>
</tr>
<tr>
<td>3½ (5)</td>
<td>5'-4&quot;</td>
<td>6'-1&quot;</td>
</tr>
<tr>
<td>4 (5½)</td>
<td>5'-2&quot;</td>
<td>5'-11&quot;</td>
</tr>
<tr>
<td>4½ (6)</td>
<td>5'-0&quot;</td>
<td>5'-8&quot;</td>
</tr>
<tr>
<td>5 (6½)</td>
<td>4'-10&quot;</td>
<td>5'-6&quot;</td>
</tr>
</tbody>
</table>

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

\( f'_{c} = 3,000 \text{ psi}, \rho = 145 \text{ pcf}, F_y = 70,000 \text{ psi} \)

<table>
<thead>
<tr>
<th>Effective slab thickness** (total slab) (in.)</th>
<th>Chair</th>
<th>Mesh size(2) (6 in. x 6 in.)</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4'-0&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exterior</td>
</tr>
<tr>
<td>3 (4½)</td>
<td>N/A</td>
<td>D2.9 x D2.9</td>
<td>280</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D4 x D4</td>
<td>370</td>
</tr>
<tr>
<td>3½ (5)</td>
<td>N/A</td>
<td>D4 x D4</td>
<td>390</td>
</tr>
<tr>
<td>4 (5½)</td>
<td>N/A</td>
<td>D4 x D4</td>
<td>390</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 layers D2.9 x D2.9</td>
<td>550</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 layers D4 x D4</td>
<td>750</td>
</tr>
<tr>
<td>4½ (6)</td>
<td>N/A</td>
<td>2 layers D2.9 x D2.9</td>
<td>550</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 layers D4 x D4</td>
<td>750</td>
</tr>
<tr>
<td>5 (6½)</td>
<td>3 in.</td>
<td>2 layers D2.9 x D2.9(2)</td>
<td>840</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 layers D4 x D4(2)</td>
<td>1,140</td>
</tr>
</tbody>
</table>

** Total factored load is taken as 1.2D + 1.6L
Where D = dead load
L = live load

Notes:
- Only slab portion over the deck is considered for effective slab thickness, concrete in deck flute cannot be considered due to UL ratings.
- Mesh size is only a recommendation. A Canam engineer will determine the mesh size.
- 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

\( f'_{c} = 3,000 \text{ psi}, \rho = 145 \text{ pcf}, F_y = 70,000 \text{ psi} \)

<table>
<thead>
<tr>
<th>Concentrated load</th>
<th>Effective slab thickness (total slab) (in.)</th>
<th>Dead Load (psf)</th>
<th>Mesh size(2) (6 in. x 6 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4'-0&quot;</td>
<td>4'-6&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exterior</td>
<td>Interior</td>
</tr>
<tr>
<td>Classroom/Residential 1 kip on 30 in. x 30 in.</td>
<td>3 (4½)</td>
<td>73</td>
<td>D2.9 x D2.9</td>
</tr>
<tr>
<td></td>
<td>3½ (5)</td>
<td>79</td>
<td>D4 x D4</td>
</tr>
<tr>
<td></td>
<td>4 (5½)</td>
<td>85</td>
<td>D4 x D4</td>
</tr>
<tr>
<td></td>
<td>4½ (6)</td>
<td>91</td>
<td>D2.9 x D2.9(2)</td>
</tr>
<tr>
<td></td>
<td>5 (6½)</td>
<td>91</td>
<td>D2.9 x D2.9(2)</td>
</tr>
<tr>
<td>Office 2 kip on 30 in. x 30 in.</td>
<td>3 (4½)</td>
<td>73</td>
<td>D2.9 x D2.9(2)</td>
</tr>
<tr>
<td></td>
<td>3½ (5)</td>
<td>79</td>
<td>D4 x D4</td>
</tr>
<tr>
<td></td>
<td>4 (5½)</td>
<td>85</td>
<td>D4 x D4</td>
</tr>
<tr>
<td></td>
<td>4½ (6)</td>
<td>91</td>
<td>D2.9 x D2.9(2)</td>
</tr>
<tr>
<td>Garage 3 kip on 4.5 in. x 4.5 in.</td>
<td>4 (5½)</td>
<td>85</td>
<td>D4 x D4(2)</td>
</tr>
<tr>
<td></td>
<td>4½ (6)</td>
<td>91</td>
<td>D4 x D4(2)</td>
</tr>
</tbody>
</table>

Notes:
- Needs to be used in conjuncture with uniform load table.
- Only slab portion over the deck is considered for effective slab thickness, concrete in deck flute cannot be considered due to UL ratings.
- Mesh size is only a recommendation. A Canam engineer will determine the mesh size.
- 2 layers
- 3 layers
**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.

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: \( \text{slab thickness over the steel deck \times concrete density} + 0.33 \times \text{steel deck thickness \times concrete density} \)
   
   ’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. total slab thickness:
   
   \[ \left( \frac{4.5}{12} \right) \times 145 \text{ lb./ft.}^3 + 0.33 \times \left( \frac{4.5}{12} \right) \times 145 \text{ lb./ft.}^3 = 42.23 \text{ psf} \]

   Formwork and joist: \( 5 \text{ psf} \)

   Total dead load: \( \text{concrete + formwork + joist} \)

   Example:

   \[ 42.23 + 5 = 47.23 \text{ psf} \]

2. Non-composite live load
   
   Construction live load: \( 20 \text{ psf} \)

3. Total non-composite load
   
   Example:

   \[ 47.23 + 20 = 67.23 \text{ psf} \]
Factored moment resistance

\[ M_{rc} = C_r e \text{ or } T_e \text{ i.e.} \]

\[ \frac{W_e L^2}{8} = C_r e \text{ or } T_e \text{ whichever the lesser} \]

Where:

\[ W_e = 67.23 \text{ psf} \times \text{joist spacing (plf)} \]
\[ L = \text{joist length (ft.)} \]
\[ C_r = \text{area of top chord} \times \text{compressive resistance (kip)} \]
\[ T_e = \text{area of bottom chord} \times \text{factored tensile resistance (kip)} \]
\[ e = \text{effective lever arm at non-composite stage} \]
\[ = (d - 0.192 \text{ in.} - y_{ne}) \text{ (in.)} \]
\[ d = \text{depth of joist (in.)} \]
\[ y_{ne} = \text{neutral axis of bottom chord (in.)} \]

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.

\[ t = 0.09 \text{ in.} \]
\[ A_{gross} = 0.690 \text{ in.}^2 \]
\[ A_{net} = 0.634 \text{ in.}^2 \]
\[ A_{effective} = 0.565 \text{ in.}^2 \]
\[ I_{x \text{ gross}} = 0.761 \text{ in.}^4 \]
\[ I_{y \text{ gross}} = 0.575 \text{ in.}^4 \]
\[ I_{x \text{ net}} = 0.707 \text{ in.}^4 \]
\[ I_{y \text{ net}} = 0.537 \text{ in.}^4 \]
\[ F_{y \text{ top chord}} = 65 \text{ ksi} \]

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:

\[ b_e = \min \left( \frac{L}{4} ; \frac{L_2 + L_3}{2} \right) \]

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:

\[ b_e = \min \left( L ; L_2/2 ; L/4 \right) \]

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 \( C' = T_r \). 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. Composite action is considered at 100%.

The simplified concrete stress block is used to find the ultimate tension. The factored resisting moment of the composite section is given by:

\[
\varnothing M_n = \varnothing A_b F_y' = T_r e' 
\]

Where:

- \( e' \) = lever arm at composite stage = \( d + \text{slab thickness} - a/2 - y_{nc} \) (in.)
- \( d \) = joist depth (in.)
- \( y_{nc} \) = neutral axis of bottom chord (in.)
- \( a \) = depth of compression block = \( \frac{A_b F_y}{0.85 f_c' b_e} \) (in.)
- \( \varnothing_s = 0.9 \)
- \( A_b \) = area of bottom chord (in.\(^2\))
- \( F_y \) = yield stress of steel (ksi)
- \( f_c' \) = concrete compressive strength (ksi)
- \( b_e \) = effective width of concrete (in.)

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

\[
M = \frac{WL^2}{8}
\]

Where:

- \( W \) = total uniform load (plf)
- \( L \) = span of joist (ft.)

**Web design**

**Vertical shear**

The web of the steel joist is designed to be proportioned to carry the total vertical shear \( V \).

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. Dead load plus the appropriate concentrated load 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.
**Length “l” of MD2000 web member**

For webs in tension, the slenderness ratio is not limited, they are dimensioned using:

$$F_t = 0.6 F_y = 30 \text{ ksi}$$

For webs in compression with $l/r$ less than $C_c$:

$$F_a = \frac{1}{\gamma^2} \left[ \frac{1}{l} - \frac{\gamma F_y}{2C_c^2} \right] QF, \quad \frac{1}{\gamma^2} \left[ \frac{\gamma}{C_t} \right] ^2 - \frac{1}{\gamma^2} \left[ \frac{\gamma}{C_t} \right] ^3$$

For webs in compression with $l/r$ greater than $C_c$:

$$F_a = \frac{12 \pi^2 E}{23 (\gamma^2 l^2)}$$

Where:

$$C_c = \sqrt{\frac{2\pi E}{QF}}$$
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.

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:

\[ q = \frac{VQ}{I} \]
Where:

\( q \) = horizontal shear flow (lb./in.)
\( V \) = vertical shear force due to superimposed loads (lb.)
\( I_c \) = moment of inertia of the composite joist (in.\(^2\))
\( Q \) = statical moment of the effective concrete in compression
   (hatched area) about the elastic neutral axis of the composite
   section (in.\(^3\))
   \[ = (b/n) \left( Y_c - \frac{y}{2} \right) \text{ and } y = \frac{y_c}{2} \leq t \]
\( b_e \) = concrete width (in.)
\( n \) = modular ratio
   \[ = \frac{E_s}{E_c} = 9.4 \text{ (for } f'_c = 3 \text{ ksi)} \]
\( t \) = slab thickness (in.)
\( Y_c \) = depth of neutral axis from top of concrete slab (in.)
\( y \) = neutral axis of composite joist (in.)
   \[ = Y_c \rightarrow \text{ when elastic neutral axis lies within slab} \]
   \[ = t \rightarrow \text{ when elastic neutral axis lies outside slab} \]

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

Case 2: N.A. outside the slab \((y = t)\)
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. on the length.

1. Horizontal bearing forces
   The test has defined an ultimate value for the end bearing shoe equal to 50 kip for a concrete strength of 3 ksi.

2. Friction between concrete and top chord
   The failure value for the interface shear is 255 lb./in.

Slab Design
The slab component of the MD2000 Hambro composite floor system behaves as a one-way slab carrying loads transversely to the joists. The slab design is based on ACI 318, Building Code Requirements for Structural Concrete. 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
ACI 318 provides an approximate method to obtain the moment and shears. If criteria (a) to (e) of section 6.5.1 are satisfied, the following approximate values may be used in the design of one-way slabs. Refer to the figure below, for the locations of moments and shear.

![MD2000 continuous span slab design](image-url)
Positive moment
Exterior span (location 1): \[ M_u = \frac{W_u L_1^2}{11} \]
Interior span (location 3): \[ M_u = \frac{W_u L_i^2}{16} \]

Negative moment
First interior support (location 2): \[ M_u = \frac{W_u L_a^2}{10} \]
Other interior support (location 4): \[ M_u = \frac{W_u L_a^2}{11} \]

Shear
Face of first interior support (location 2): \[ V_u = 1.15 \frac{W_u L_1}{2} \]
Other interior support (location 4): \[ V_u = \frac{W_u L_i}{2} \]

Where:
- \( W_u \) = total factored design load = 1.2 x dead load + 1.6 live load (lb/ft.)
- \( L_1 \) = first span (exterior span) (ft.)
- \( L_i \) = interior spans → joist spacing (ft.)
- \( L_a \) = average of two adjacent spans (ft.)

Single span
However, if at least one of the criteria of ACI 318, 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 92 for location of moment and shear):

1. Positive moment
   All spans (locations 1 and 3): \[ M_u = \frac{W_u L^2}{8} \]
2. Shear
   All supports: \[ V_u = \frac{W_u L}{2} \]

Concentrated load – load distribution
In addition to the previous verification, the International Building Code (IBC) 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. The following calculations for the effective widths of concentrated load, \( b_e \), are based on the SDI approach.

1. For moment calculation:
   \[ b_e = b_m + (4/3) (1 - x/L_i) x \leq 106.8 (t/f) \]
2. For shear calculation:
   \[ b_e = b_m + (1 - x/L_i) x \]

Where:
- \( b_m \) = load width (in.)
- \( b_e \) = load width (in.)
- \( t_e \) = slab thickness (in.)

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2. For shear calculation:
   \[ b_e = b_m + (1 - x/L_i) x \]

Where:
- \( b_m \) = load width (in.)
- \( b_e \) = load width (in.)
- \( t_e \) = slab thickness (in.)
Hambro MD2000 Composite Floor System

Concentrated load distribution for effective width

Projected width of concentrated load
Moment capacity
The minimum flexural steel is given as a ratio:
\[
\left( \frac{0.0018 \times 60,000}{Fy} \right) \times A_s
\]
Where:
\( Fy \) = yield strength of reinforcing steel (70,000 psi min.)
\( A_s \) = area of reinforcing steel in the direction of analysis (in.\(^2\)/ft. width)

In addition, the factored moment resistance \( M_u \) of a reinforced concrete section, using an equivalent rectangular concrete stress distribution; and limiting the section to tension controlled \((\phi = 0.9)\) is given by:

\[
M_u = \phi_s A_s F_y (d - a/2)
\]

\[
a = \frac{A_s F_y}{\beta_1 f'_c b}
\]

Where:
\( a \) = depth of the equivalent concrete stress block (in.)
\( \beta_1 = 0.85 \)
\( F_y \) = yield strength of reinforcing steel (70,000 psi min.)
\( f'_c \) = compressive strength of concrete (3,000 psi min.)
\( A_s \) = area of reinforcing steel in the direction of analysis (in.\(^2\)/ft. width)
\( b \) = unit slab width (in.)
\( d^o \) or \( d \) = distance from extreme compression fiber to centroid of tension reinforcement (in.)
\( t \) = thickness of the slab (in.)
\( \phi \) = strength reduction factor of reinforcing steel (0.9)
Shear capacity

The shear stress capacity \( (V_u) \), 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:

\[
V_u = V_e = \varnothing_c \lambda \sqrt{f''} b_w d
\]

Where:

- \( \lambda = 1 \) (for normal density concrete)
- \( d^* \) or \( d^- \) = distance from extreme compression fiber to centroid of tension reinforcement at the bearing zone (in.)
- \( b_w = b = \) width of the slab (in.)
- \( \varnothing_c = \) strength reduction factor of concrete (0.75)

Serviceability limit states

Crack control parameter

Same as minimum flexural requirement.
Crack control parameter

**Deflection control**
For one-way slabs not supporting or attached to partitions likely to be damaged by large deflections, deflection criteria are considered to be satisfied if the following span/depth ratios are met:

- Exterior span: \( t \geq \frac{L_i}{24} \)
- Interior span: \( t \geq \frac{L_i}{28} \)

Where:
\( L_i \) = spacing between joists (in.)

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

<table>
<thead>
<tr>
<th>Imperial</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dead load</td>
<td>73 psf</td>
</tr>
<tr>
<td>Live load</td>
<td>40 psf</td>
</tr>
<tr>
<td>Concentrated load</td>
<td>1.0 kip on 2.5 ft. x 2.5 ft. area</td>
</tr>
<tr>
<td>Total slab thickness</td>
<td>4.5 in.</td>
</tr>
<tr>
<td>Slab thickness (( t ))</td>
<td>3 in.</td>
</tr>
<tr>
<td>Joists spacing (( L_i ))</td>
<td>4 ft.</td>
</tr>
<tr>
<td>Concrete strength (( f'_c ))</td>
<td>3,000 psi</td>
</tr>
<tr>
<td>Wire mesh</td>
<td>D2.9 x D2.9 – 6 x 6</td>
</tr>
<tr>
<td>Area of steel (( \lambda ))</td>
<td>0.058 in²/ft.</td>
</tr>
<tr>
<td>Wire mesh diameter</td>
<td>0.192 in.</td>
</tr>
</tbody>
</table>

1. Loads and efforts per foot of slab

   Factored load
   \( W'_f = 1.2 \times 73 + 1.6 \times 40 = 151.6 \text{ psf} \)

   Maximum positive moment at location 1
   \( M'_f^+ = \frac{151.6 \times 4^2}{11} \times 1 \text{ ft.} = 220.5 \text{ lb.-ft.} \)

   Maximum negative moment at location 2
   \( M'_f^- = \frac{151.6 \times 4^2}{10} \times 1 \text{ ft.} = 242.6 \text{ lb.-ft.} \)

   Maximum shear
   \( V'_f = \frac{1.15 \times 151.6 \times 4}{2} = 348.7 \text{ lb.} \)
2. Resistance under uniform load
Check minimum flexural and shrinkage steel ratio

\[ A_{s, \min} \geq \left( \frac{0.0018 \times 60,000}{F_y} \right) A_y \rightarrow \frac{A_s}{A_y} \geq \left( \frac{0.0018 \times 60,000}{70,000} \right) \rightarrow 0.058 \text{ in}^2/\text{ft.} \geq \left( \frac{0.0018 \times 60,000}{70,000} \right) \rightarrow 0.0016 \geq 0.00154 \rightarrow \text{OK} \]

Positive moment capacity

\[ d^+ = t - 1.5 - \frac{Q_{aux}}{2} \]

\[ d^+ = 3 - 1.5 - \frac{0.192}{2} = 1.404 \text{ in.} \]

\[ a = \frac{A_s F_y}{0.85 f'c_b} = \frac{0.058 \times 70,000}{0.85 \times 3,000 \times 12} = 0.133 \text{ in.} \]

\[ M^+ = \frac{\varnothing A_s F_y (d^+ - a)}{2} = 0.9 \times 0.058 \times 70,000 (1.404 - 0.133/2) = 4,887 \text{ lb.-in.} > M_f = 348.7 \text{ lb.-ft.} \rightarrow \text{OK} \]

Negative moment capacity

\[ d^- = 1.5 + \frac{Q_{aux}}{2} \]

\[ d^- = 1.5 + \frac{0.192}{2} = 1.596 \text{ in.} \]

\[ a = \frac{A_s F_y}{0.85 f'c_b} = \frac{0.058 \times 70,000}{0.85 \times 3,000 \times 12} = 0.133 \text{ in.} \]

\[ M^- = \frac{\varnothing A_s F_y (d^- - a)}{2} = 0.9 \times 0.058 \times 70,000 (1.596 - 0.133/2) = 5,589 \text{ lb.-in.} > M_f = 242.6 \text{ lb.-ft.} \rightarrow \text{OK} \]

Shear capacity

\[ V_r = 0.22 \sqrt{f'c_b d} \]

\[ V_r = 0.75 \times 2 \times 1 \times \sqrt{3,000 \times 12} \times 1 = 985 \text{ lb.} > V_f = 348.7 \text{ lb.} \]

3. Resistance under concentrated load
Refer to table Slab capacity under concentrated load on page 84.
The reinforcement is ok, so that the slab can carry the specified load.

4. Serviceability

Deflection control

\[ \frac{\text{span}}{\text{depth}} = \frac{48}{3} = 16 \]

Exterior span: \( t \geq \frac{L}{24} \rightarrow t \geq \frac{48}{24} = 2 > 16 \rightarrow \text{OK} \)

Interior span: \( t \geq \frac{L}{28} \rightarrow t \geq \frac{48}{28} = 1.71 > 16 \rightarrow \text{OK} \)
DIAPHRAGM

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 2½ in. or 2 11/16 in. forming a beam with a span of 24 in. and a depth of 24 in. This beam was loaded with two equal concentrated loads at 6 in. 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 below) illustrates a simple building with a slab in diaphragm. Hambro system values are taken from the slab design example on page 97. Other necessary values are listed below.

<table>
<thead>
<tr>
<th>Imperial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total wind pressure load from leeward and windward faces ( W )</td>
</tr>
<tr>
<td>Story height ( h_s )</td>
</tr>
<tr>
<td>Span of the beam with the floor slab acting as web ( L_t )</td>
</tr>
<tr>
<td>Length of the walls parallel to the horizontal force ( B )</td>
</tr>
</tbody>
</table>

1. Non-factored moments
The ending moment over the embedded top chord is calculated for one-foot width. In using the data from the slab design example, the non-factored moments for a joist with a spacing of 4 ft. is:

Dead load:
\[ M_d = \frac{73 \text{ psf} \times (4 \text{ ft.})^2}{10} \times 1 \text{ ft.} = 116.8 \text{ lb.-ft.} \]

Live load:
\[ M_L = \frac{40 \text{ psf} \times (4 \text{ ft.})^2}{10} \times 1 \text{ ft.} = 64 \text{ lb.-ft} \]

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 \( M_f = 466 \text{ lb.-ft.} \).

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.

\[ V = h_s W \frac{L_t}{2} \]
\[ = 12 \text{ ft.} \times 25 \text{ psf} \times \frac{116.5}{2} \]
\[ = 17,475 \text{ lb.} \]

In our example, the end reaction is distributed along the whole length (60 ft.) of the end wall used to transfer the load.

\[ V = \frac{17,475}{60} \]
\[ = 291.25 \text{ lb./ft.} \]
4. Steel shear capacity

To establish the shear capacity of steel wire mesh for a slab unit width of one foot, we use the following formula from ACI, article 12.5.3.2:

\[ V_n = \frac{A_w}{(2\lambda f'_c + \rho_f f_y)} \times 0.058 \text{ in.}^2 \]

\[ = 0.75 \times (3 \text{ in.} \times 12 \text{ in.}) \left( 2 \times 0 \sqrt{3,000 \text{ psi}} + \frac{0.058 \text{ in.}^2}{(3 \text{ in.} \times 12 \text{ in.}) \times 70,000 \text{ psi}} \right) \]

\[ = 3,045 \text{ lb./ft.} \]

Where \( \rho_f \) is the area of the wire mesh per linear foot divided by the concrete area.

5. Interaction formulas

According to ASCE 7-10, article 2.3.2, 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:

\[ 1.2 \left( \frac{M_x}{M_y} + 0.5 \frac{V}{V_n} \right) \leq 1 \]

\[ 1.2 \frac{116.68}{466} + 0.5 \frac{291.25}{3,045} = 0.35 \leq 1 \rightarrow \text{OK (Doesn't control)} \]

Load Combination 2:

\[ 1.2 \left( \frac{M_x}{M_y} + \frac{M_x}{M_y} + \frac{V}{V_n} \right) \leq 1 \]

\[ 1.2 \frac{116.68}{466} + \frac{64}{466} + \frac{291.25}{3,045} = 0.53 \leq 1 \rightarrow \text{OK (Controls)} \]

Load Combination 3:

\[ 0.9 \left( \frac{M_x}{M_y} + \frac{V}{V_n} \right) \leq 1 \]

\[ 0.9 \frac{116.68}{466} + \frac{291.25}{3,045} = 0.32 \leq 1 \rightarrow \text{OK (Doesn't control)} \]

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 3 in. plus deck of 1.5 in. are properly held in place by the Hambro joists spaced at a maximum of 61 in. 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+1/4" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 41
BOLTED JOIST ON STEEL COLUMN (FLANGE, WEB)

T+1/4" = 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**

- 2 - ½" BOLTS ASTM A307
- ½" x ½" SLOTS @ 4½" c/c (HAMBRO SHOE)
- ¼" Ø HOLES @ 4½" c/c (SUPPORT) U.N.O. OR
- 2 - ⅝" BOLTS ASTM A325
- ⅝" x ⅝" SLOTS @ 5" c/c (HAMBRO SHOE)
- ½" Ø HOLES @ 5" c/c (SUPPORT) U.N.O.

STEEL DECK (TYP.)

T+¼" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

**NOTE:**

- STAGGERED JOISTS, IF THE FLANGE BEAM IS LESS THAN 8".
- *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**

- 3½" MIN. BEARING FOR 4" SHOE (TYP.)

JOIST SHOE ANCHORED TO SUPPORT WITH TAPCON CONCRETE SCREW OR EQUIVALENT ⅛" x 1¼" LENGTH MIN.

STEEL DECK

FILLED MASONRY OR BOND BEAM

CEILING EXTENSION

T+½" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETIAL 44

JOIST BEARING ON
INTERIOR MASONRY OR CONCRETE WALL

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8”

T+1/4” = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETIAL 45

JOIST BEARING ON
EXTERIOR INSULATED CONCRETE WALL

T+1/4” = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETAIL 46

JOIST BEARING ON
INTERIOR INSULATED
CONCRETE WALL

JOIST SHOE ANCHORED TO SUPPORT
WITH TAPCON CONCRETE SCREW OR
EQUIVALENT 6/2x1 1/4" LENGTH MIN.

T+1/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8".

DETAIL 47

JOIST BEARING ON
EXTERIOR STEEL BEAM

T+1/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETAIL 48

JOIST BEARING ON INTERIOR STEEL BEAM

3/8" MIN. BEARING FOR 4" SHOE (TYP.)

JOIST SHOE ANCHORED TO SUPPORT WITH TAPCON CONCRETE SCREW OR EQUIVALENT 1/4" x 3" LENGTH MIN.

STEEL DECK (TYP.)

NOTCH RIGID INSULATION (TYP.)

CEILING EXTENSION (TYP.)

T+1/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8".

DETAIL 49

JOIST BEARING ON EXTERIOR STEEL STUD WALL

3/8" MIN. BEARING FOR 4" SHOE (TYP.)

2/8" MIN. BEARING FOR 3" SHOE (TYP.)

MECHANICAL FASTENERS OR ACROSS THE MATERIALS THICKNESS

STEEL DECK

CEILING EXTENSION

T+1/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETAIL 50

JOIST BEARING ON INTERIOR STEEL STUD WALL

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8”.

DETAIL 51

JOIST BEARING ON EXTERIOR WOOD STUD WALL

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8”.

T+1/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETAIL 52

JOIST BEARING ON INTERIOR WOOD STUD WALL

NOTE:
STAGGERED JOISTS, IF THE WALL IS LESS THAN 8".

DETAIL 53

EXPANSION JOINT AT ROOF

NOTE:
EXPANSION JOINT DETAILS ACCORDING TO THE SPECIFICATIONS OF THE CONSULTING ENGINEER
BEARING DETAILS ACCORDING TO CANAM SPECIFICATIONS

T+1/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETAIL 54
EXPANSION JOINT
AT ROOF (STEEL BEAM)

T + 17/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 55
JOIST PARALLEL TO
EXPANSION JOINT

T + 17/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETAIL 56
JOIST PARALLEL TO MASONRY OR CONCRETE WALL

STEEL DECK ANCHORED TO THE WALL WITH TAPCON CONCRETE SCREW
\[ \phi \frac{1}{4''} \times \frac{1}{2''} \text{ LENGTH MIN.} \]

\[ T + \frac{1}{8''} = \text{TOTAL SLAB THICKNESS} + \text{DECK THICKNESS} + \text{TOP CHORD THICKNESS} + \text{SHOE THICKNESS} \]

DETAIL 57
JOIST PARALLEL TO INSULATED CONCRETE WALL

STEEL DECK ANCHORED TO THE WALL WITH TAPCON CONCRETE SCREW
\[ \phi \frac{1}{4''} \times \frac{1}{2''} \text{ LENGTH MIN.} \]

\[ T + \frac{1}{8''} = \text{TOTAL SLAB THICKNESS} + \text{DECK THICKNESS} + \text{TOP CHORD THICKNESS} + \text{SHOE THICKNESS} \]
Hambro MD2000 Composite Floor System

DETAIL 58
JOIST PARALLEL TO A STEEL BEAM

HILTI STEEL DECK FASTENERS:
- HSN24 FOR \( \frac{3}{8}'' < t < \frac{3}{4}'' \)
- EPN19 FOR \( t > \frac{3}{4}'' \) OR
\[ t = \text{MINIMUM THICKNESS OF THE SUPPORTING STEEL} \]
#12 SELF TAPping FASTENERS OR @ 12'' c/c

\[ T+\frac{1}{8}'' = \text{TOTAL SLAB THICKNESS} + \text{DECK THICKNESS} + \text{TOP CHORD THICKNESS} + \text{SHOE THICKNESS} \]

DETAIL 59
JOIST PARALLEL TO A STEEL STUD WALL

HILTI STEEL DECK FASTENERS:
- HSN24 FOR \( \frac{3}{8}'' < t < \frac{3}{4}'' \)
- EPN19 FOR \( t > \frac{3}{4}'' \) OR
\[ t = \text{MINIMUM THICKNESS OF THE SUPPORTING STEEL} \]
#12 SELF TAPping FASTENERS OR @ 12'' c/c

\[ T-\frac{1}{4}'' = \text{TOTAL SLAB THICKNESS} + \text{DECK THICKNESS} + \text{TOP CHORD THICKNESS} + \text{SHOE THICKNESS} \]
Hambro MD2000 Composite Floor System

DETAIL 60

MINIMUM CLEARANCE OPENING AND HOLE IN THE SLAB

NO ADDITIONAL REINFORCEMENT REQUIRED IF:
- MINIMUM DISTANCE C/C OF DRILLED HOLES IS 2'-0" AND;
- ONLY ONE STRAND OF STEEL PERPENDICULAR TO JOISTS IS CUT PER HOLE.
IF NOT: SEE STANDARD REINFORCEMENT FOR SLAB OPENING

STANDARD REINFORCEMENT FOR SLAB OPENING

- LESS THAN 1'-5", REINFORCE THE AREA WITH AN ADDITIONAL LAYER OF WIRE MESH LAPPED 1'-0" ALL AROUND OPENING.
- 1'-5" OR MORE, FOLLOW THE ENGINEER OF RECORDS' DETAIL.
DETAIL 61

JOIST PARALLEL TO A WOOD WALL

STEEL DECK ANCHORED TO THE PLANK WITH TWO WOOD SCREWS #12 OR NAILS @ 12" c/c

T + 1/8" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 62

THICKER SLAB

ADDITIONAL ANGLE WELDED TO THE TOP CHORD TO GET A THICKER SLAB OF 2" AND MORE (SEE DETAIL 65)
DETAIL 63
HEADER SUPPORT

NOTE:
IF THERE IS A JOIST SITTING ON THE HEADER BEAM, THE DIMENSION 31/4" WILL BECOME 33/8" AND “T” WILL BECOME “T+17/8” = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS”.

DETAIL 64
CANTILEVERED BALCONY
(JOIST PERPENDICULAR TO BALCONY)

T+17/8 = (SLAB THICKNESS + THICKER SLAB) + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
DETAIL 65
CANTILEVERED BALCONY (SHALLOW JOIST PARALLEL TO BALCONY)

SEE SPECIFICATIONS OF ARCHITECT
VARIABLE (SEE PLAN) (SEE PLAN)
3'' MIN. (TYP.) T+1/2'' TOP OF BEARING
8-1/4'' WALL
SLOPE

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

CONCRETE, ICF, WOOD, MASONRY WALL, STEEL BEAM OR STEEL STUD WALL
STEEL DECK ANCHORED TO THE WALL WITH TAPCON CONCRETE SCREW
∅ 1/4'' x 13/4'' LENGTH MIN.

BRIDGING CLIP WITH STUD (CENTERED) WITH THREADED ROD 3/8'' (BY CANAM) (TYP.)

HORIZONTAL AND DIAGONAL BRIDGING
THICKER SLAB (TS)
SLAB (T)
TOTAL SLAB (S)

DETAIL 66
CANTILEVERED BALCONY (JOIST PARALLEL TO BALCONY)

SEE SPECIFICATIONS OF ARCHITECT
VARIABLE (SEE PLAN) (SEE PLAN)
3'' MIN. (TYP.) T+1/2'' TOP OF BEARING
8-1/4'' WALL
SLOPE

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

CONCRETE, ICF, WOOD, MASONRY WALL, STEEL BEAM OR STEEL STUD WALL
STEEL DECK ANCHORED TO THE WALL WITH TAPCON CONCRETE SCREW
∅ 1/4'' x 13/4'' LENGTH MIN.

BRIDGING CLIP WITH STUD (CENTERED) WITH THREADED ROD 3/8'' (BY CANAM) (TYP.)
ENGINEERING TYPICAL DETAILS – HAMBRO MD2000 ON GIRDER

DETAIL 67
JOIST BEARING
ON GIRDER

T + 1/4" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS

DETAIL 68
JOIST BEARING
ON GIRDER

T + 1/4" = 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

2 1/2' BOLTS ASTM A307
3/8" x 1/2" SLOTS @ 4" c/c (HAMBRO SHOE)
5/8" Ø HOLES @ 4 1/2" c/c (SUPPORT) U.N.O.

OR

2 - 3/4" BOLTS ASTM A325
1/2" x 1/2" SLOTS @ 5" c/c (HAMBRO SHOE)
5/8" Ø HOLES @ 6 1/2" c/c (SUPPORT) U.N.O.

STEEL DECK (TYP.)
T+1/2" = 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

HILTI STEEL DECK FASTENERS:
- HSN24 FOR 1/8" < t < 1/4"
- EPN19 FOR t > 1/4"

t = MINIMUM THICKNESS OF THE SUPPORTING STEEL

#12 SELF TAPPING FASTENERS @ 12" c/c OR

1/2" MIN. (TYP.)

T+1/4" = TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
Hambro MD2000 Composite Floor System

DETAIL 71

JOIST PARALLEL TO A GIRDER WITH SHEAR CONNECTORS

HILTI STEEL DECK FASTENERS:
- HSN24 FOR $\frac{3}{8}'' < t < \frac{4}{8}''$
- EPN19 FOR $t > \frac{3}{8}''$
  $t =$ MINIMUM THICKNESS OF THE SUPPORTING STEEL

#12 SELF TAPPING FASTENERS @ 12'' c/c

OR

HILTI STEEL DECK FASTENERS:
- HSN24 FOR $\frac{3}{8}'' < t < \frac{4}{8}''$
- EPN19 FOR $t > \frac{3}{8}''$
  $t =$ MINIMUM THICKNESS OF THE SUPPORTING STEEL

#12 SELF TAPPING FASTENERS @ 12'' c/c

OR

$T + \frac{1}{2}'' =$ TOTAL SLAB THICKNESS + DECK THICKNESS + TOP CHORD THICKNESS + SHOE THICKNESS
ARCHITECTURAL TYPICAL DETAILS – HAMBRO MD2000 (MDH SERIES)

HAMBRO MD2000 TYPICAL FLOOR ASSEMBLY
- CONCRETE SLAB
- WELDED WIRE MESH 6” x 8”
- 22 GAUGE STEEL DECK 1/8”
- HAMBRO MD2000 STEEL JOISTS
- GALVANIZED STEEL FURRING CHANNEL 7/8”
- 25 GAUGE 3/8” C.C.
- 4” FIRECODE CA GYPSUM PANEL 1/2”

SECTION - TYPICAL FLOOR
Hambro MD2000 Composite Floor System

CONCRETE WALL
(PERPENDICULAR)

CONCRETE WALL
(PARALLEL)
Hambro MD2000 Composite Floor System

LOAD BEARING STEEL STUD WALL (PERPENDICULAR)

LOAD BEARING STEEL STUD WALL (PARALLEL)
Hambro MD2000 Composite Floor System

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**INSULATED CONCRETE FORMS WALL (PERPENDICULAR)**

---

**INSULATED CONCRETE FORMS WALL (PARALLEL)**
Hambro MD2000 Composite Floor System

LOAD BEARING MASONRY WALL (PERPENDICULAR)

LOAD BEARING MASONRY WALL (PARALLEL)
LOAD BEARING WOOD STUD WALL
(Perpendicular)

LOAD BEARING WOOD STUD WALL
(Parallel)
Hambro MD2000 Composite Floor System

UL RATED FIRE/SMOKE STOP SEALANT, ON EACH SIDE OF PARTITION

GALVANIZED STEEL HANGER CLIP

STEEL BEAM FOR LOAD DISTRIBUTION

PERIMETER BLOCKING ANGLE

12 GAUGE MIN. GALVANIZED STEEL HANGER WIRE

COLD ROLLED GALVANIZED STEEL CHANNELS

HAMBRO MD2000 MINI-JOISTS AND SUSPENDED GYPSUM CEILING
- CONCRETE SLAB
- WELDED WIRE MESH 8"x6"
- HAMBRO MD2000 MINI-JOISTS
- COLD ROLLED GALVANIZED STEEL CHANNELS
- GALVANIZED STEEL FLUILLING CHANNEL 7/8"
- 25 GAUGE @ 24" O.C.
- "FIRECODE C" GYPSUM PANEL 1/2"

SHADIED AREA: MINI-JOIST

LOAD BEARING STEEL STUD WALL

VARIIES - MAXIMUM 8'-3"

HAMBRO MD2000 TYPICAL FLOOR ASSEMBLY

WALL COMPOSITION PER PROJECT SPECIFICATIONS

MINI-JOISTS
Hambro Composite Girder

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. We have better cost control for material purchases (angles) on the US market compared to importing the beam sections.

2. The open web girders are lighter than the full web beams of the same depth.

3. The speed and ease of site erection improves jobsite coordination.

4. The girders can be used to facilitate the installation of ventilation ducts and plumbing as compared to a beam.
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. and 1 ¾ in.
2. Diagonals: u-shaped channels or two angles back-to-back.
3. Verticals: u-shaped channels, boxed angles, plates or HSS.

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.
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 opening 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.