TECHNICAL MANUAL

DELTABEAM® Composite Beams

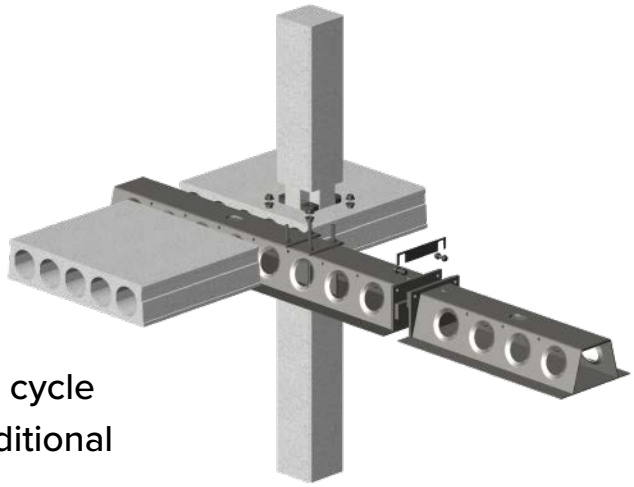
Slim Floor Structure with integrated fireproofing

Version PEIKKO GROUP 03/2021

peikko®

DELTABEAM® Composite Beams

Slim Floor Structure with integrated fireproofing



- Quick and easy installation
- Standardized connections
- Saves construction height
- Easy HVAC installation
- Cost-efficient
- Flexible DELTABEAM® types and details
- Flexible layouts through the whole life cycle
- Fire rating as high as R180 without additional protection
- CE marked
- Low carbon footprint: enables LEED and BREEAM certification points
- Local technical support
- DELTABEAM® design tools available
- EPD certifications for DELTABEAM® and DELTABEAM Green®
- DELTABEAM Green® is made with 90% recycled steel.

DELTABEAM® is a superior composite beam enabling slim-floors for multi-story buildings of any type, whether low-rise or high-rise. Its composite action between steel and concrete allows for creative structures with large open spaces. Multiple fire tests have proven DELTABEAM® to have excellent fire resistance without any additional protection. Its shallow design decreases the building's floor-to-floor height while eliminating conflicts with HVAC systems.

Since 1989 DELTABEAM® Composite Beams have been used in thousands of buildings globally. DELTABEAM® Composite Beams have been subjected to a rigorous testing program and the solution is widely approved in various countries.

Peikko's technical support is always available to help you to find the most suitable solution for your project.

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About DELTABEAM® Composite Beams

1. Product properties

DELTABEAM® is a slim-floor composite beam that is integrated into the floor. The beam is completely filled with concrete on-site. The infill concrete and DELTABEAM® form a composite structure after the concrete has hardened. DELTABEAM® acts as a steel beam before the infill concrete has reached the required strength. DELTABEAM® is made of cut steel plates and welded together at the factory (see *Figure 1*). It can be used with all common floor types. See the ideal floor types in *Figure 2*.

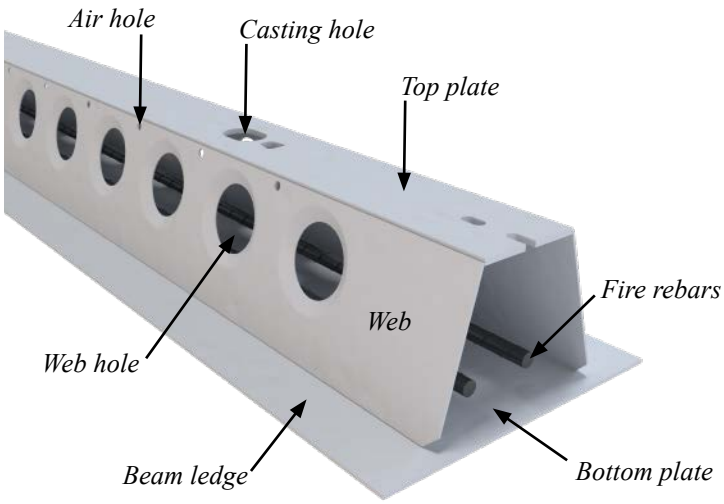


Figure 1. DELTABEAM® parts.

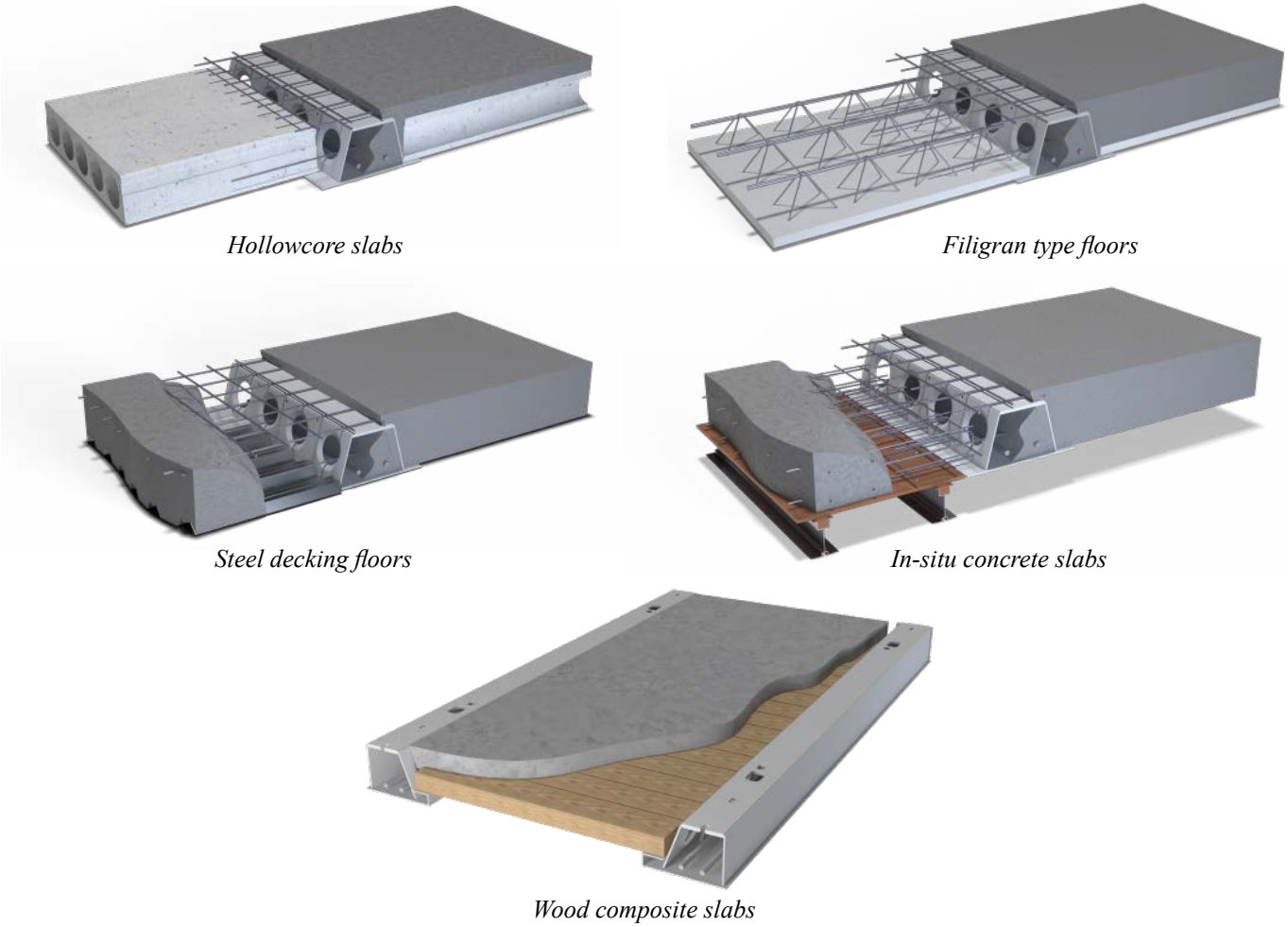
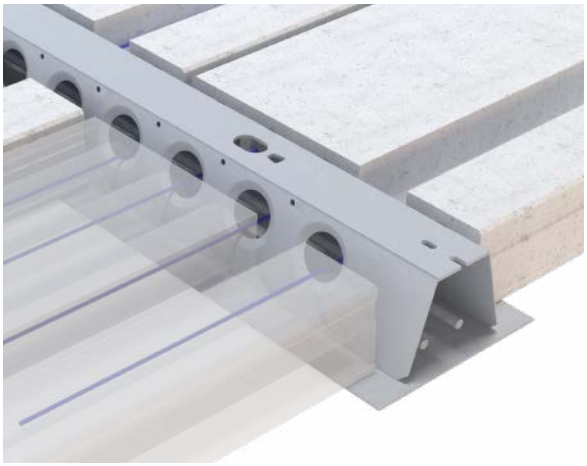
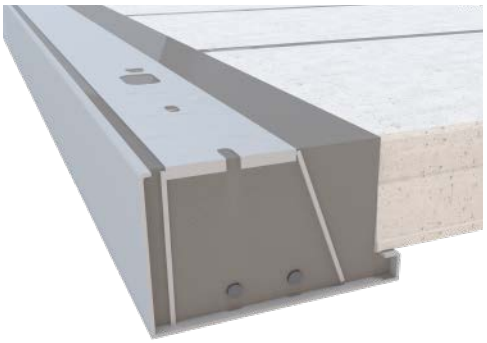
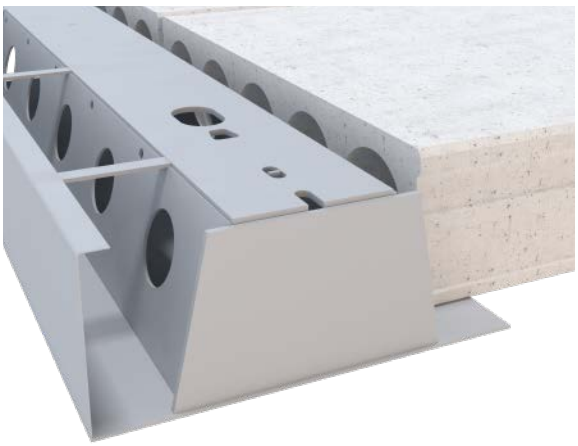


Figure 2. Ideal floor types with DELTABEAM®.

There are two types of DELTABEAM®. The D-type DELTABEAM® has ledges on both sides of the beam. This beam type can carry floor units on both sides of the beam. The DR-type DELTABEAM® has a one vertical web and ledge only on one side. Both types of DELTABEAM® can be used as edge beams to carry floor units at only one side of the beam. Curved floor edges can be made by combining D-type beams with curved formwork. *Table 1* shows the use of DELTABEAM® types.

Table 1. The use of DELTABEAM® types.

D-type DELTABEAM®	DR-type DELTABEAM®
	
Used as an intermediate beam	Used as an edge beam when a narrower beam is needed
	The vertical web is protected against fire with other structure or with separate fire protection. 
Used as an edge beam with formwork sheet	Used on floor openings or floor edges
The free side of DELTABEAM® is protected against fire with concrete. 	Fire protection on the vertical web. 

DELTABEAM® Composite Beams can be used as single-span beams or in multi-span beam construction. DELTABEAM® Composite Beams can also be used for cantilever beam construction. In multi-span beam construction, Gerber connections provide continuity to lines of DELTABEAM® Composite Beams (see *Figure 3*). Peikko designs the locations of the Gerber connections. Shim plates are used by default to allow for installation tolerance.

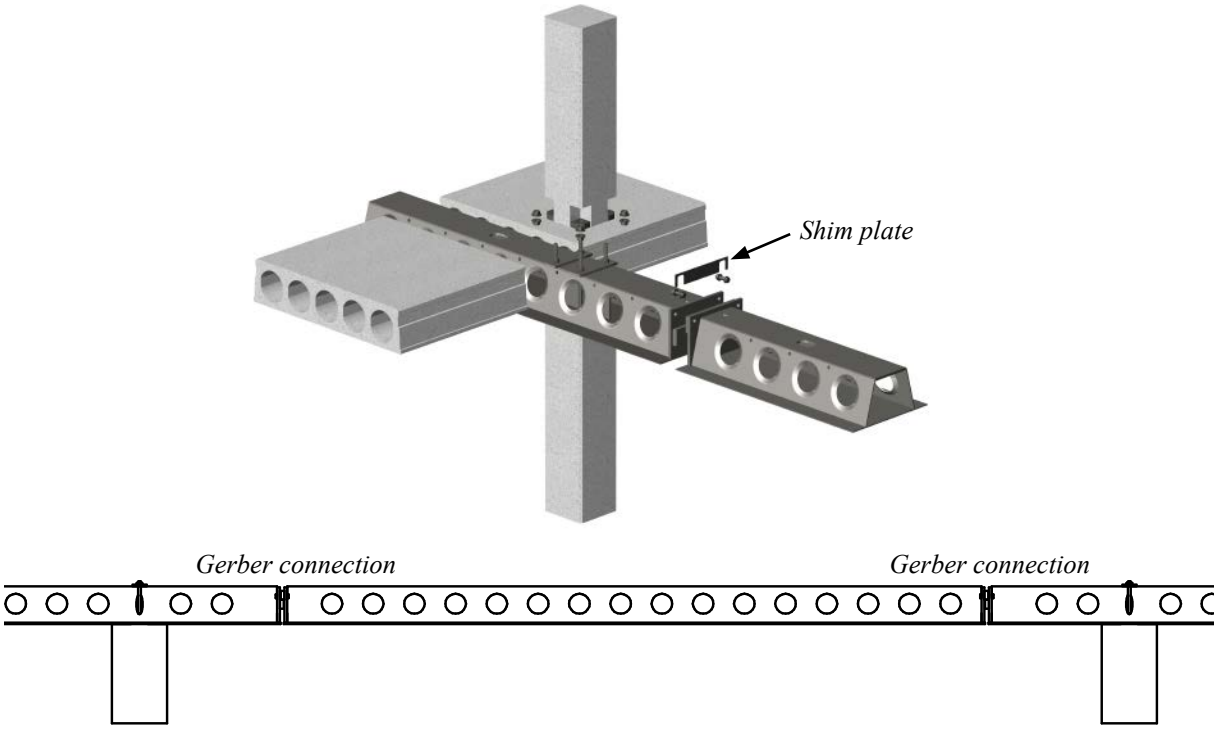


Figure 3. Gerber connections enable the continuity of the DELTABEAM® line.

DELTABEAM® Composite Beams can be used with all common column types. DELTABEAM® Composite Beams are connected to the columns with corbels or fixed to the top of the column with bolts or welds. Peikko's PCs® Corbel is recommended for connecting DELTABEAM® Composite Beams to concrete columns (see *Figure 4*). PCs® Corbel is a modular hidden column corbel designed especially for DELTABEAM®. See PCs® Corbel's technical manual for more information.

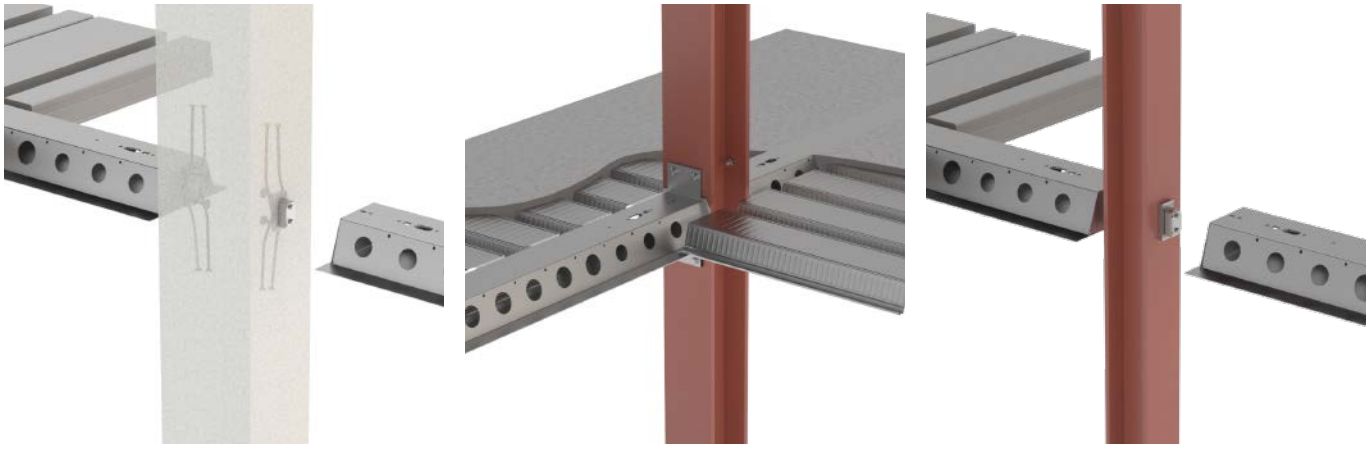


Figure 4. DELTABEAM® connected to steel and concrete columns using Peikko's PCs® Corbel or bolted end plate.

1.1 Structural behavior

1.1.1 Temporary conditions

DELTABEAM® acts as a steel beam before the infill concrete has reached the required strength. During the erection stage, all loads are transferred to DELTABEAM® through the beam ledges (see *Figure 5*). It is important to position the Hollow-core slab end correctly onto the beam ledge because this affects the DELTABEAM®'s design (see section 1.2.2). The erection stage design is carried out in accordance with elastic design principles, with the loads acting in the erection stage. The precamber of DELTABEAM® compensates for the deflection in the erection stage.

The amount of precamber depends on the length of DELTABEAM®, on the loads in the erection stage and on the selected static system.

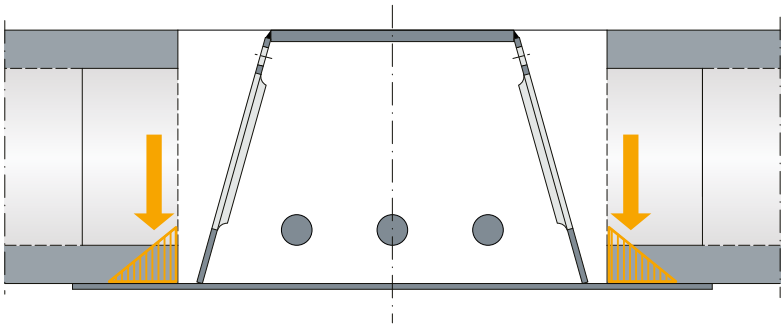


Figure 5. Load transfer in the temporary condition.

The effects of loads such as torsion during the erection stage must be taken into account when designing the connection details and the supporting structures. For example, variable beam spacing, variable load values, or asymmetrically assembled floors can cause torsion.

Propping is used with Hollow-core slabs to prevent DELTABEAM® from rotating at the supports. The function of beam propping is not to prevent deflection. No propping is required provided that the DELTABEAM® Composite Beam's connections and supporting structures are designed for the loads during the erection stage. Temporary props should be designed for temporary erection loads acting to them. DELTABEAM® is capable of transferring the effects of an eccentric load back to the column. More information about propping can be found from section Installation of DELTABEAM®. Peikko's technical support is always available to help with any installation and propping issues.

DELTABEAM® props are located as close to the DELTABEAM® support as possible (see *Figure 6*). Props are placed below the web, on the loaded side. Props should not be removed until the slab cast and the infill concrete of DELTABEAM® have reached the required strength.

Figure 6. Recommended propping method of DELTABEAM®.

In the case of Filigran or other solid slab types that are propped during the construction phase, propping may be necessary along DELTABEAM® to ensure that the beam and the slab do not separate while concrete grouting is done depending on the type of formwork.

Propping is always required when DELTABEAM® is bearing on the end of a narrow wall running parallel with the beam and proper torsionrigid connection to the supporting wall is not possible to be used (see *Figure 7*).

Figure 7. Propping when DELTABEAM® is bearing on the end of a wall.

When the purpose of DELTABEAM® is to transfer floor loads to a wall-type beam above, DELTABEAM® must be correctly propped. DELTABEAM® must be propped according to the project's erection method statement before the floor units are assembled. Props must not be removed until the upper wall is capable of bearing the full floor load. *Figure 8* shows the detail of DELTABEAM® with a wall-type beam above.

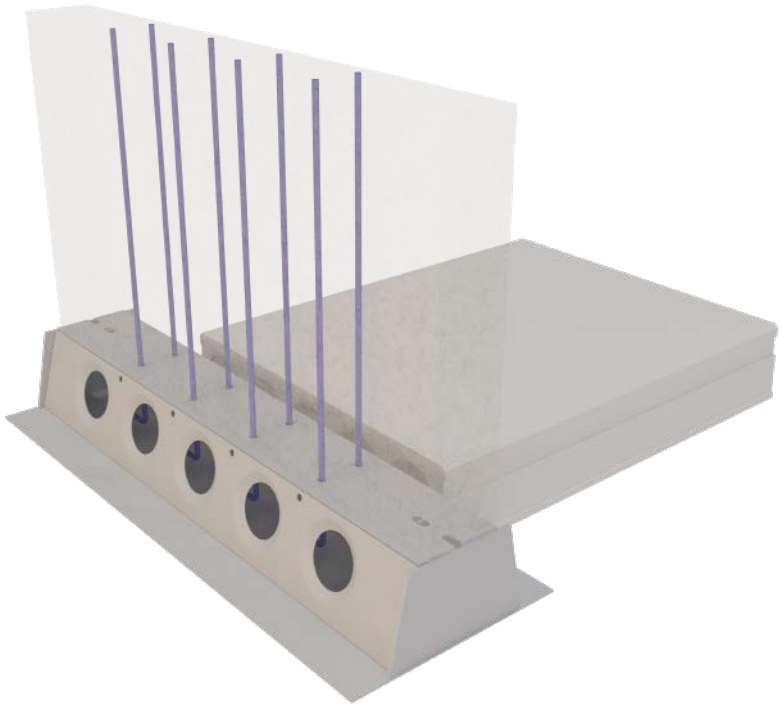


Figure 8. Should vertical reinforcement to tie DELTABEAM® and the wall-type beam together is required, it can be factory fitted as shown above.

NOTE. DELTABEAM® PROPPING IS USED WITH HOLLOW-CORE FLOORS TO PREVENT THE BEAM FROM ROTATING AT ITS SUPPORTS. PROPPING ACCORDING TO THE PROJECT'S INSTALLATION METHOD STATEMENT.

1.1.2 Final conditions

The infill concrete and DELTABEAM® form a composite structure after the concrete has reached the required strength. In the final condition, the loads are transferred to DELTABEAM® through a compression arc against an inclined web (see *Figure 9*). The load transfer is proven by load tests, where DELTABEAM® was tested without the beam ledges. Transverse reinforcement, which is assembled through the DELTABEAM® Composite Beam's web holes, secures load transfer.

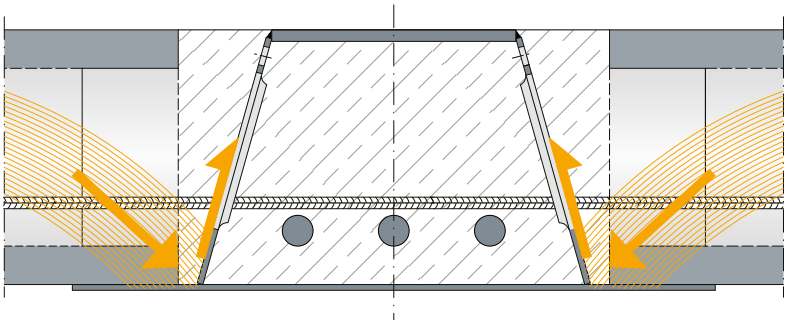


Figure 9. Load transfer in the final condition.

The shear connection between the infill concrete and DELTABEAM® is formed by the dowel action of the web holes. Static loading tests have proven that the composite interaction is full.

The structural engineer designs the connections between DELTABEAM® and the supporting structure. The connection must be designed such that the DELTABEAM® Composite Beam's support reactions are transferred to the supporting structure (e.g., a column, wall, or another beam). This supporting structure must be designed to bear the reactions from DELTABEAM®. Peikko designs DELTABEAM® Composite Beams according to the connection details. Peikko also designs the internal beam-to-beam connections, such as Gerber and Side connections. Indicative connection details can be downloaded from the software download center on Peikko's website www.peikko.com. The appearance of the connection can be finished by cutting the DELTABEAM® Composite Beam's bottom plate according to the connection detail (see *Figure 10*). If necessary, the bottom plate edge can be beveled or arched in the plane of the bottom plate.

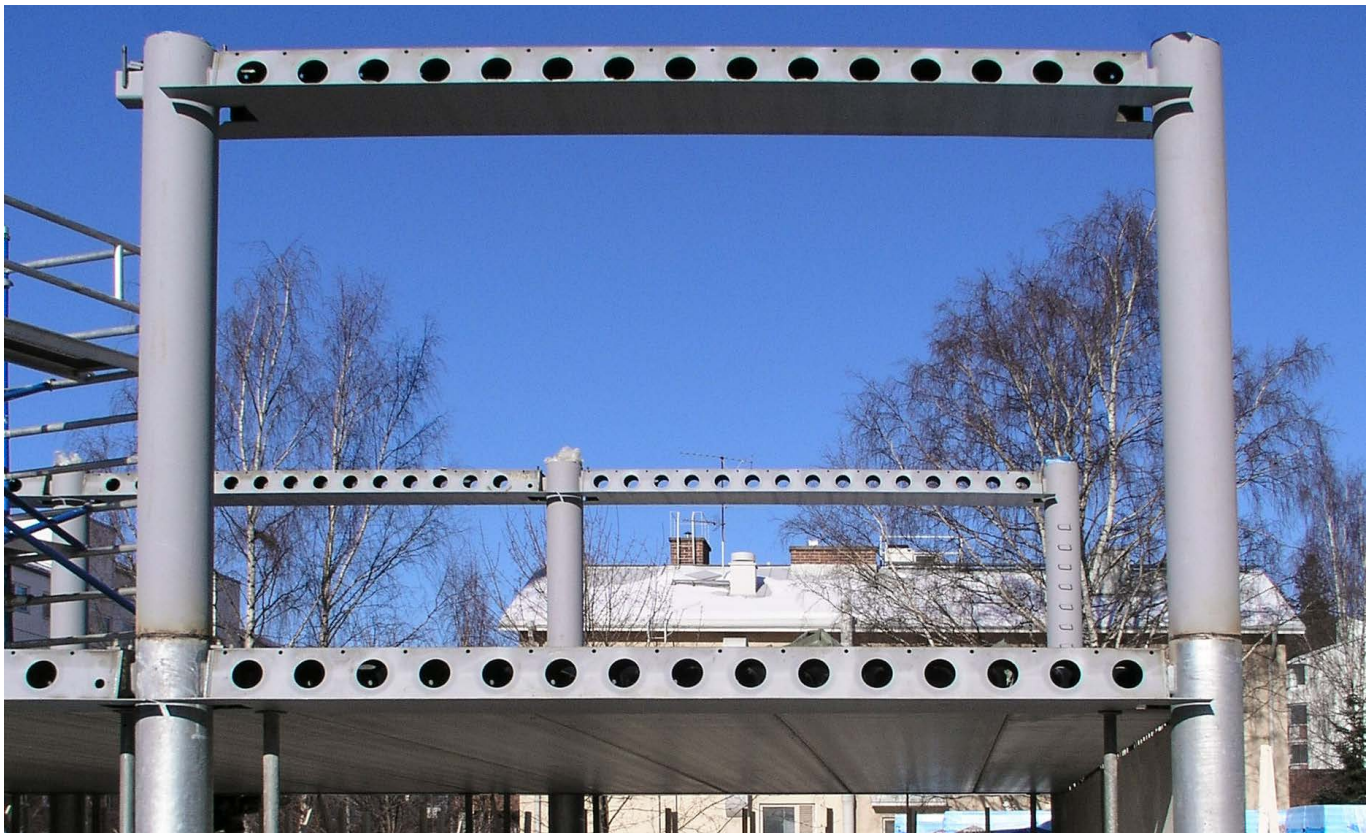


Figure 10. The DELTABEAM® Composite Beam's bottom plate is arched because of the tube column.

1.1.3 In accidental situation

Buildings should be designed to carry the extent of localized failure from an unspecified cause without a disproportionate collapse. The transverse and parallel reinforcement should be therefore designed for a design tensile load defined according to EN 1991-1-7 and its National Annex in the accidental situation.

1.1.4 Extreme load case scenarios

Design against extreme load cases, such as an earthquake or a column loss scenario, demands ductile and flexible structural elements that must have adequate rotational capacity and be able to sustain large deformations without losing their strength. Earthquakes and generally extreme accidental situations are dynamic phenomena that occur rarely and last for only few seconds. It would be uneconomical to design a structure to behave elastically in an extreme scenario and not to take advantage of its ability to acquire a plastic behavior and deform plastically without losing its strength and its stiffness. The seismic design rules for dissipative composite structures aim at local plastic mechanisms (dissipative zones) in the structure and reliable global plastic mechanism dissipating as much energy as possible under the design earthquake action.

When a structural element or a part of it is subjected to compressive axial loads, some plates of the element, if they are too slender, may buckle before the element reaches its full strength. This local buckling is one of the major concerns in the design of steel and composite structures because it essentially defines the strength limit of the elements. Thus, the codes have a classification of steel sections regarding their ability to resist local buckling and subsequently their ability to reach their plastic moment and rotational capacity.

It is proven through an extensive and thorough experimental and analytical investigation that the DELTABEAM®, in conjunction with proper steel reinforcement, offers an extremely ductile behavior making it usable and beneficial for the whole range of buildings and design methods covered by the codes. The reinforcement prevents the failure of the surrounding concrete and thus, subsequently, by the confinement provided to the DELTABEAM®, the local buckling of its web plates is also prevented even for very high deflection values. Furthermore, this structural response indicates that DELTABEAM® can be implemented not only for ultimate state design but also for extreme cases, such as progressive collapse and earthquakes.

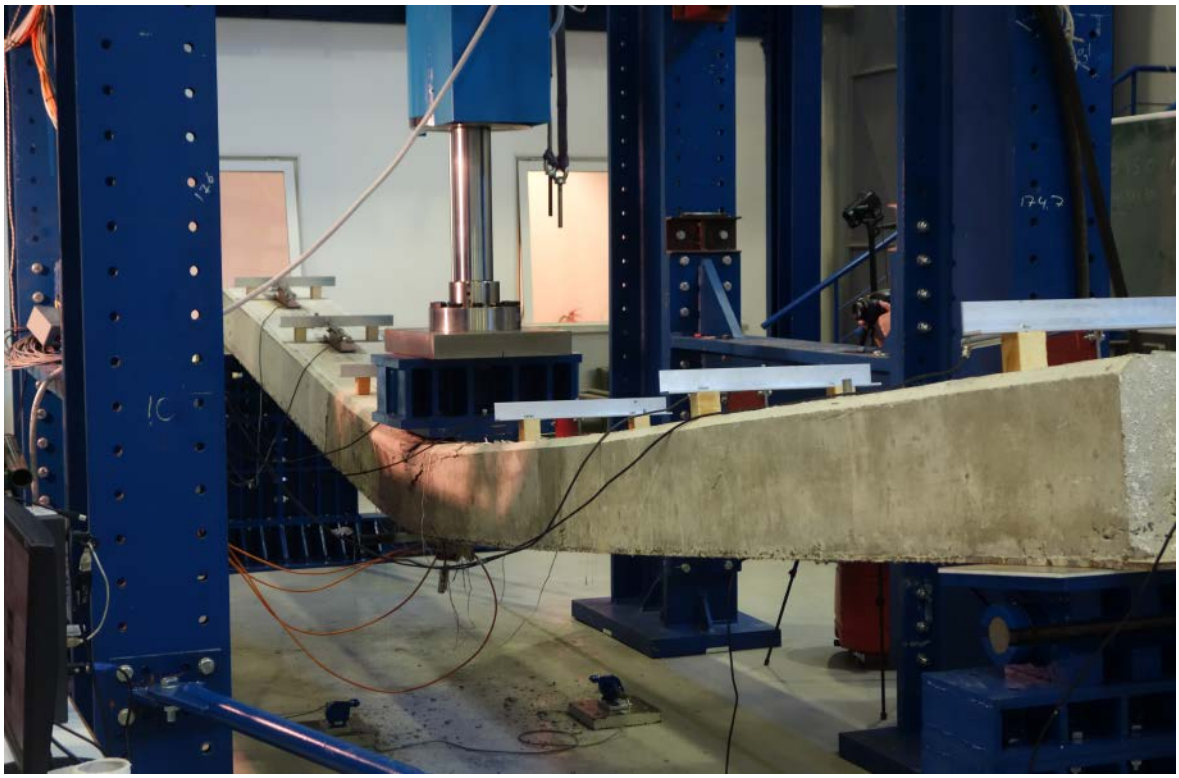


Figure 11. Deflection and Rotation of a DELTABEAM ® during testing.

1.1.5 Fire situation

The evaluation of the fire resistance of DELTABEAM® is based on standard fire tests and design guidelines obtained from tests. DELTABEAM® can have a fire rating as high as R180 depending on local approvals. Check the availability from Peikko's local technical support. DELTABEAM® is dimensioned in compliance with the fire rating requirements of the project.

When needed, the designed number of fire rebars is installed inside DELTABEAM® at the factory (see *Figure 12*). High fire resistance is achieved by fire rebars and infill concrete. The DELTABEAM® Composite Beam's fire rebars and the webs act as tensile reinforcement in the event of a fire. The rebars compensate for the strength that the bottom plate loses, meaning that additional fire protection is not normally needed.

Figure 12. Fire rebars inside DELTABEAM®.

The vertical web of the DR-type DELTABEAM® must be protected against fire by other structures or by protective materials/finishes. Separate fire protection is needed when there is no other structure protecting the vertical web. The material and thickness of the separate fire protection are determined on a case-by-case basis by the responsible structural engineer of the project.

The load transfer in the fire situation behaves similarly as in ambient conditions, see *Figure 13*. Due to the heated bottom plate (reduced stiffness) the resultant is shifted towards the web, however the remaining stiff corner can carry the full reaction. To secure the load transfer transverse horizontal reinforcement is needed to tie the floor slab and the DELTABEAM® together. Also, a special design procedure for the hollow core unit is required.

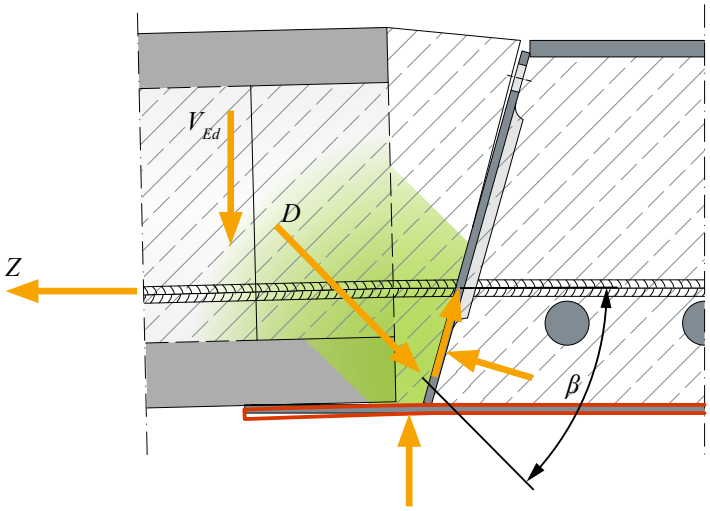


Figure 13. Load transfer in fire situation.

1.2 Application conditions

1.2.1 Loading and environmental conditions

DELTABEAM® Composite Beams are designed by considering the entire loading history. Each DELTABEAM® is designed separately based on the initial information of the project. The initial information is needed for manufacturing and designing DELTABEAM® Composite Beams. The contents of the initial information are presented in *Figure 27*. Appendix A contains the list of required DELTABEAM® details. Every DELTABEAM® has a unique identification code in the project.

The dynamic design in the serviceability limit state is taken into account when designing DELTABEAM® Composite Beams if requested by the structural engineer. The structural engineer analyzes vibrations for the entire project. Peikko's technical support is always available to help with vibration issues.

It is assumed that walls located on DELTABEAM® Composite Beams do not affect the beams unless loading information is provided concerning the walls located on DELTABEAM® Composite Beams. It is also assumed as a default in the DELTABEAM® design that the topping concrete of the flooring is cast in a separate phase after the infill concrete of DELTABEAM® has reached the required strength. If the topping concrete is to be cast simultaneously with the infill concrete, Peikko should be informed. The order of concrete casting significantly affects DELTABEAM® Composite Beam's design. The infill concrete grade in the DELTABEAM® design is C25/30 unless otherwise stated. The minimum infill concrete grade is C20/25 normal-weight structural concrete. DELTABEAM® should always be cast in full in one run.

The HVAC system can be installed below the floor or, in some cases, inside the floor. If the DELTABEAM® Composite Beam's web holes are used for HVAC installation, the impact must be taken into account when DELTABEAM® is designed. Therefore, Peikko must be informed if the DELTABEAM® Composite Beam's web holes are to be used for HVAC installation to find the optimal location for the piping.

DELTABEAM® Composite Beams are either primed or hot-dip galvanized. These surface coating techniques also ensure durability during delivery and installation. The DELTABEAM® Composite Beam's visible bottom parts, web plates from the edge of the bottom surface to height 50 – 100mm, end plates, all connections, formworks, and downstands are primed to a minimum 80 µm. Other surfaces are primed to 40 µm. The customer does the final painting on-site and it is not a part of DELTABEAM® Composite Beams delivery.

The free water in the DELTABEAM® Composite Beam's fresh infill concrete reacts with cement in the normal hardening process, as in other concrete structures. The concrete requires certain drying time and humidity level before the surface materials of the floor can be installed. It is recommended that water-reducing agents be used rather than a high water-cement ratio to make the structural concrete mix for DELTABEAM® casting.

If drying time of the concrete will be reduced, is recommended to use concrete with low water/cement ratio ($v/c < 0.5$) or concrete made with water-reducing agents to higher strength. The water binding coal fly ash is not recommended to use in the concrete mix. To control the concrete's drying time on site, normal guidelines for prevailing environmental conditions and project specific instructions should be followed.

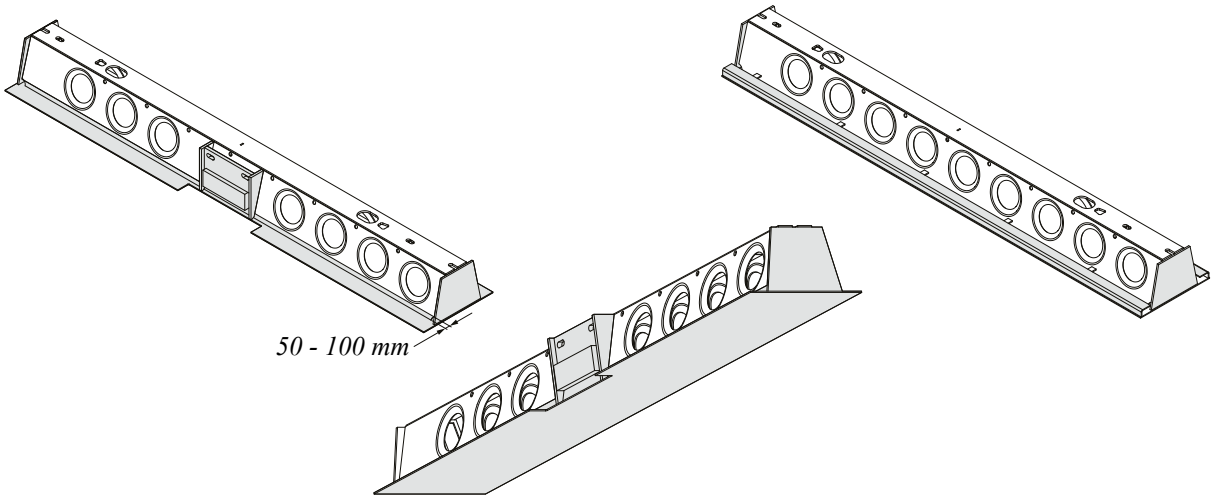


Figure 14. Applied primer 80 µm on visible parts of the DELTABEAM® profile (highlighted by grey color).

1.2.2 Positioning of DELTABEAM®

The bearing length of the Hollow-core slabs or other decks may vary from their standard product requirement. For the standard requirement in the DELTABEAM® Composite Beam's design, see *Figure 15*. Using a smaller bearing length affects the design and the dimensioning of DELTABEAM®. If requested by the supplier of the Hollow-core slabs DELTABEAM® with wider ledges can be delivered.

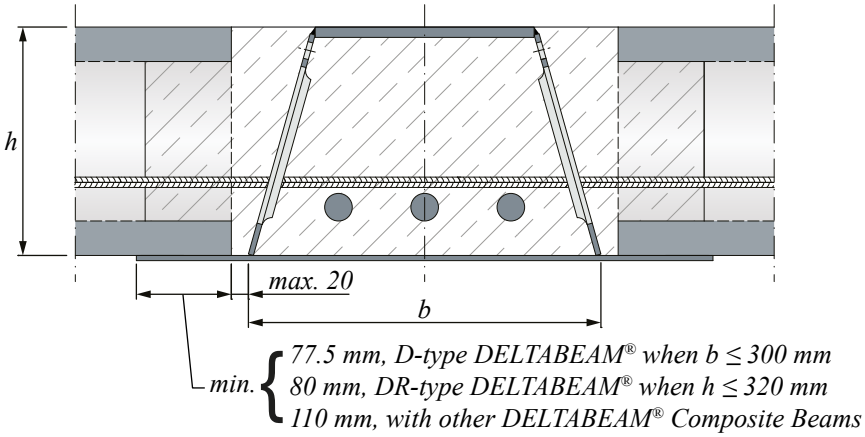


Figure 15. The minimum bearing lengths of standard DELTABEAM® profiles with Hollow-core slabs.

1.2.3 Interaction with floor units

The purpose of the transverse reinforcement is to tie DELTABEAM® and the floor together. The transverse reinforcement secures the load transfer from the floor to DELTABEAM®. The minimum transverse reinforcement is described in *Figure 16*. The transverse reinforcement is assembled through the DELTABEAM® Composite Beam's web holes. Deep DELTABEAM® profiles ($h \geq 370\ mm$) may have additional web holes for transverse reinforcement.

The location and the maximum size of the additional web hole can be seen in *Figure 17*. The lower edge of the additional web hole should be 75 mm above the bottom plate to allow a gap for the fire rebars. The additional web holes are always placed between the actual web holes.

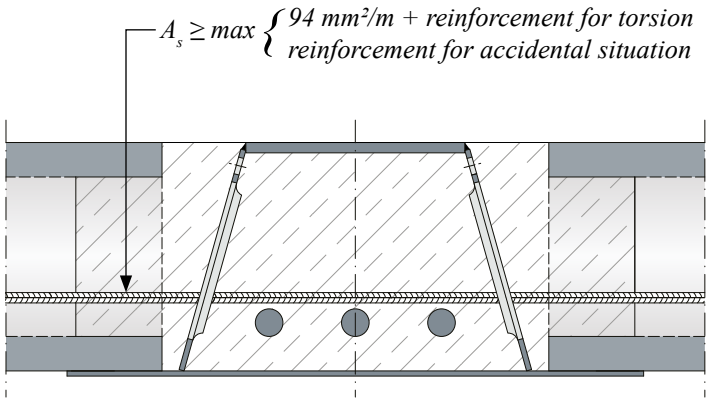


Figure 16. The minimum transverse reinforcement.

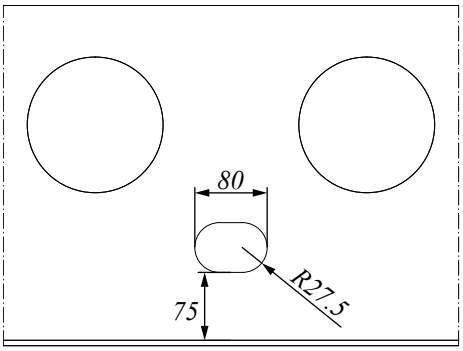


Figure 17. The location and maximum size of an additional web hole.

The location of the web holes/additional web holes is adjusted either to the joints between the Hollow-core units or to the voids of the Hollow-core units. For solid concrete slabs, the exact location of the web holes along the DELTABEAM® Composite Beam's span is normally not important. *Figure 18* shows the minimum distance of DELTABEAM® web holes from the end of the web.

$h < 250 \quad x \geq 160$
or
$h \geq 250 \quad x \geq 195$

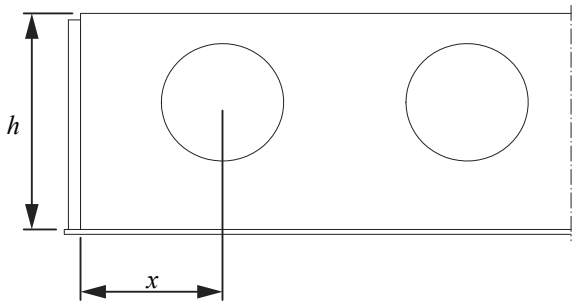


Figure 18. The minimum distance of DELTABEAM® web holes.

With the D-type DELTABEAM®, straight rebars are assembled through the web holes (see *Figure 16*). The reinforcement is anchored with full anchorage length to the slabs on both sides of the D-type DELTABEAM®. The anchorage length of the reinforcement starts from the end of the floor unit. When DELTABEAM® is used as an edge beam, the reinforcement should be anchored inside the beam.

It is recommended that hook ends be assembled inside DELTABEAM®. Mechanical connection is not recommended. If there is ring reinforcement at the edge of the floor and space between the hollow core and DR-type DELTABEAM® is not adequate also the D-type DELTABEAM® may be used as it allows more space for reinforcement between DELTABEAM® and the formwork sheet (see *Figure 19*).

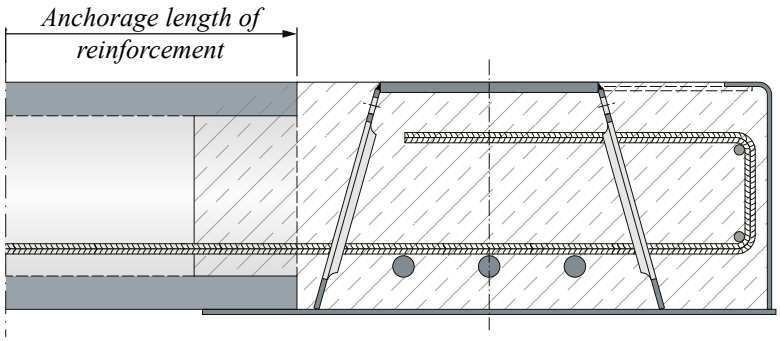


Figure 19. D-type DELTABEAM® used as an edge beam with transverse and ring reinforcement.

Tensile or compression forces acting parallel to the beam axis are usually transferred by ring reinforcement located in the area between the Hollow-core slab end and the inclined web of DELTABEAM®. Peikko must be informed if it is required to transfer normal forces through DELTABEAM® profile.

The structural engineer designs the reinforcement against torsion. Special attention should be paid to edge beams or, when the spans or the loads differ significantly, at the opposite sides of the beam. The magnitude of the torsion varies depending on whether propping is used during the erection stage. *Figure 20* shows the design principal for torsion.

With Hollow-core slabs, dimension hc is the minimum thickness of the top hull. In the case of structural topping on the Hollow-core slabs, the topping may be taken into account in h_c, according to the judgment of the structural engineer. For solid concrete slabs, a normal distribution of compressive stresses may be used. The loads transfer differently in the temporary condition and the final condition as seen in *Figures 5* and *9*. Because of this, the lever arm generating the torsional moment is different in the temporary condition and the final condition.

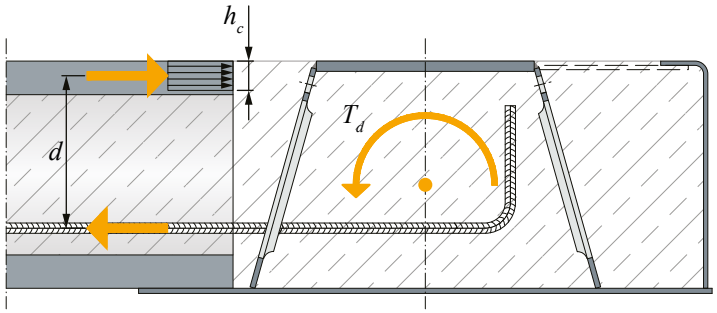


Figure 20. The design principle for torsion.

Peikko does the preliminary check of the interaction rate between the Hollow-core slabs and DELTABEAM® Composite Beams to ensure that the bearing capacity of the hollow-core slabs is sufficient in the final condition, taking into account the composite behavior between the hollow-core slabs and DELTABEAM® Composite Beams. The supplier of the hollow-core slabs is responsible for the design of the hollow-core slabs.

1.2.4 Expansion and construction joints of the slabs

The expansion joints of the slabs allow transverse and longitudinal slab movements (see *Figure 21*). The transverse expansion joint of the slabs allows DELTABEAM® to move in the direction of the beam longitudinal axis It can be built into console coupling. In that case, the end connection inside DELTABEAM® is encased so that there is room for movement after casting. A transverse expansion joint can also exist between DELTABEAM® Composite Beams (see *Figure 22*).

The longitudinal expansion joint of the slabs allows the movement of the flooring. The longitudinal expansion joint may be placed on the beam ledge. An alternative solution is to build double columns and DELTABEAM® Composite Beams.

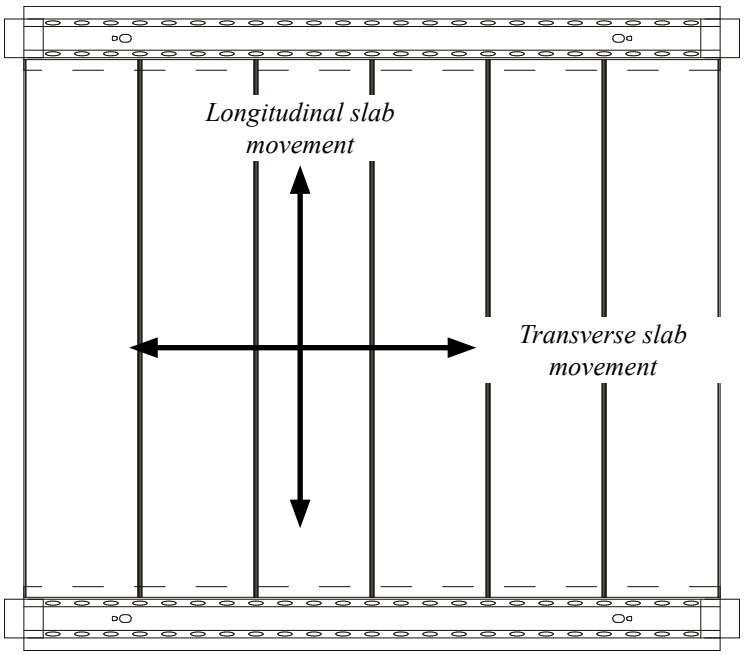


Figure 21. The transverse and longitudinal slab movements.

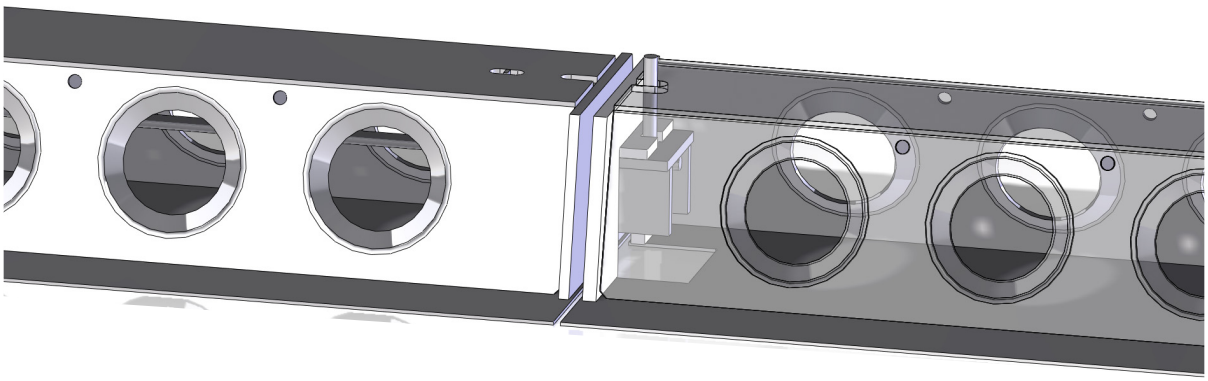


Figure 22. Gerber connection with a transverse slab expansion joint.

When the longitudinal expansion joint is placed on the beam ledge, all the loads are transferred through the beam ledge. The joint grouting of the Hollow-core slabs should be separated from the infill concrete and the DELTABEAM® Composite Beam's web.

DELTABEAM® Composite Beams with expansion joints must be protected against fire from below. When the expansion joint is on the beam ledge, the entire width and length of the beam must be protected against fire (see *Figure 23*). When the expansion joint is at the end connection or the Side connection, the protected length must be evaluated on a case-by-case basis.

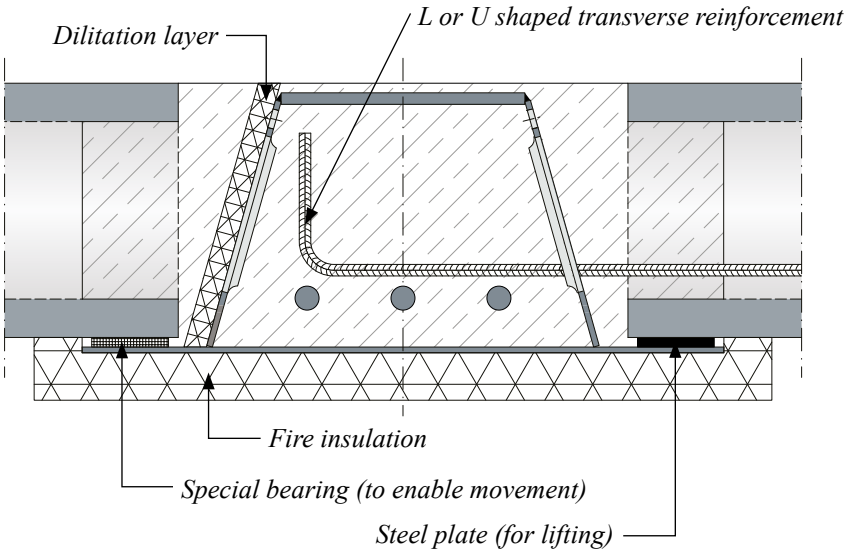


Figure 23. Special bearing to enable movement and fire protection.

The construction joints are placed on a case-by-case basis in co-operation with Peikko so that they can be taken into account when performing strength calculations. The construction joint should not be built inside DELTABEAM® because DELTABEAM® must always be cast full of concrete in one run.

1.2.5 Holes and additional connections

It is preferable to have all the holes made at the factory. Information on holes and attachments should be included in the initial information (see *Figure 27*). Peikko must be always contacted if any changes are to be made. All on-site connections in DELTABEAM® Composite Beams are to be installed in compliance with the instructions provided by the structural engineer. If additional connections are required, Peikko must always be contacted.

Figure 24. Factory-installed sleeve for plumbing penetrations.

1.3 Other properties

DELTABEAM® Composite Beams are fabricated from cut steel plates and welded together at the factory. The required number of fire rebars is also assembled inside DELTABEAM®. The properties of the materials are as follows:

Steel plates	S355J2 + N	EN 10025-2
Ribbed bars	BSt500S / B500B	DIN 488
	A500HW / B500B	SFS 1215 / SFS 1268
	B500B	EN 10080
	K500B-T	SS 212540

Steel plates are cut thermally or mechanically. Rebars are cut mechanically. Welding is done with metal active gas welding (MAG) or with submerged arc welding (SAW). The welding class is C (EN ISO 5817).

Peikko Group's production units are externally controlled and periodically audited based on production certifications and product approvals by various organizations.

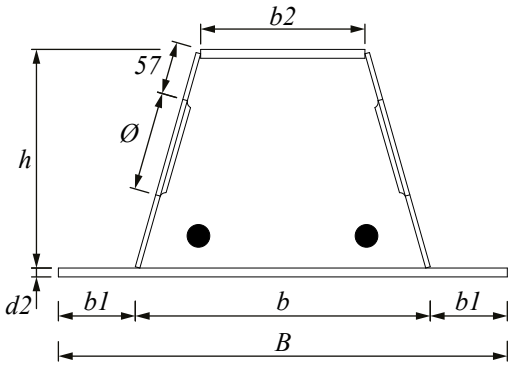
DELTABEAM® has manufacturing tolerances in accordance with EN 1090-2 Annex D.2, Tolerance Class 1. DELTABEAM® Composite Beams are fabricated according to execution class EXC2. If separately agreed with Peikko, DELTABEAM® Composite Beams can also be fabricated according to execution class EXC3.

INFORMATION

The DELTABEAM® product sticker includes the DELTABEAM® Composite Beam's type approval, the project information, the beam type, the weight of the beam, and the length of the beam. DELTABEAM® Composite Beams are CE marked and the CE marking sticker is placed on DELTABEAM® Composite Beams.

The standard D-type DELTABEAM® profiles with dimensions can be seen in *Table 2*. The standard DR-type DELTABEAM® profiles with dimensions can be seen in *Table 3*.

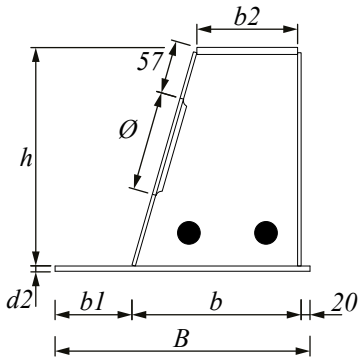
Table 2. The standard D-type DELTABEAM® profiles.



b	B	b1*	b2	d2	h	Ø**
			[mm]			
D20-200	395	97.5	100	5 – 30	200	80
D20-300	495	97.5	180	5 – 30	200	80
D20-400	660	130	278	5 – 30	200	80
D22-300	495	97.5	170	5 – 30	220	80
D22-400	660	130	270	5 – 30	220	80
D25-300	495	97.5	155	5 – 30	250	150
D25-400	660	130	255	5 – 30	250	150
D26-300	495	97.5	148	5 – 30	265	150
D26-400	660	130	245	5 – 30	265	150
D30-300	495	97.5	130	5 – 30	300	150
D30-400	660	130	230	5 – 30	300	150
D32-300	495	97.5	110	5 – 30	320	150
D32-400	660	130	210	5 – 30	320	150
D37-400	660	130	180	5 – 30	370	150
D37-500	760	130	278	5 – 30	370	150
D40-400	660	130	180	5 – 30	400	150
D40-500	760	130	278	5 – 30	400	150
D50-500	760	130	230	5 – 30	500	150
D50-600	860	130	330	5 – 30	500	150

* standard size unless the customer otherwise defines (minimum 20 mm).
** *c/c* distribution for web holes is always 300 mm.

Table 3. The standard DR-type DELTABEAM® profiles.



b	B	b1*	b2	d2	h	Ø**
			[mm]			
DR20-215	335	100	148	5 – 30	200	80
DR20-245	365	100	180	5 – 30	200	80
DR22-250	370	100	180	5 – 30	220	80
DR25-260	380	100	180	5 – 30	250	150
DR26-230	350	100	148	5 – 30	265	150
DR26-260	380	100	180	5 – 30	265	150
DR26-290	410	100	210	5 – 30	265	150
DR26-325	445	100	245	5 – 30	265	150
DR30-270	390	100	180	5 – 30	300	150
DR32-250	370	100	148	5 – 30	320	150
DR32-285	405	100	180	5 – 30	320	150
DR32-310	430	100	210	5 – 30	320	150
DR32-365	485	100	245	5 – 30	320	150
DR37-325	475	130	210	5 – 30	370	150
DR40-295	445	130	180	5 – 30	400	150
DR50-350	500	130	210	5 – 30	500	150

* standard size unless the customer otherwise defines (minimum 20 mm).
** *c/c* distribution for web holes is always 300 mm.

2. Resistances

DELTABEAM® Composite Beams are CE marked through harmonized standard EN 1090-1. Eurocodes and National Annexes are taken into account in the designs of DELTABEAM® Composite Beams. The resistances of DELTABEAM® Composite Beams are determined by a design concept that refers to the following standards:

- EN 1990
- EN 1991
- EN 1992
- EN 1993
- EN 1994

In general, it is more economical to use DELTABEAM® Composite Beams for the short span and floor slabs in the direction of the long span.

Selecting DELTABEAM®

The preliminary DELTABEAM® profile selection is made based on *Tables 2* and *3* and the basis of Peikko Designer® DELTABEAM SELECT software. If a special DELTABEAM® profile is needed, please contact Peikko's technical support.

The standard depth of DELTABEAM® is 200 – 500 mm. DELTABEAM® profiles are usually with beam depths equal to the depth of the flooring units. If a deeper DELTABEAM® profile is needed, it is possible to use a downstand on the beam ledge (see *Figure 25*). DELTABEAM®'s downstand depth may vary to accommodate differing slab profiles (see *Figure 26*.

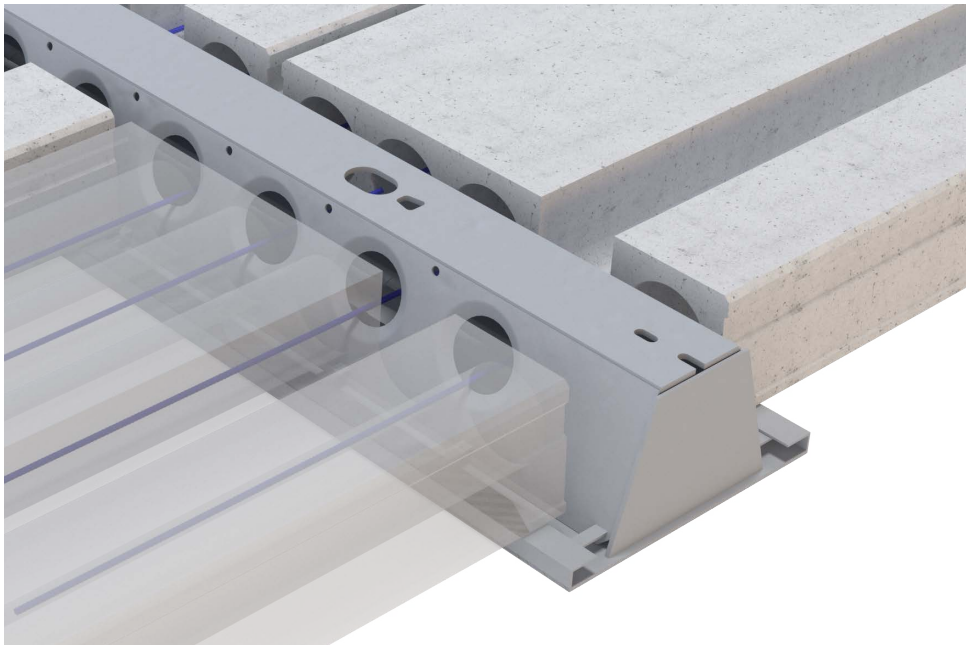


Figure 25. DELTABEAM® with downstands on the beam ledge.

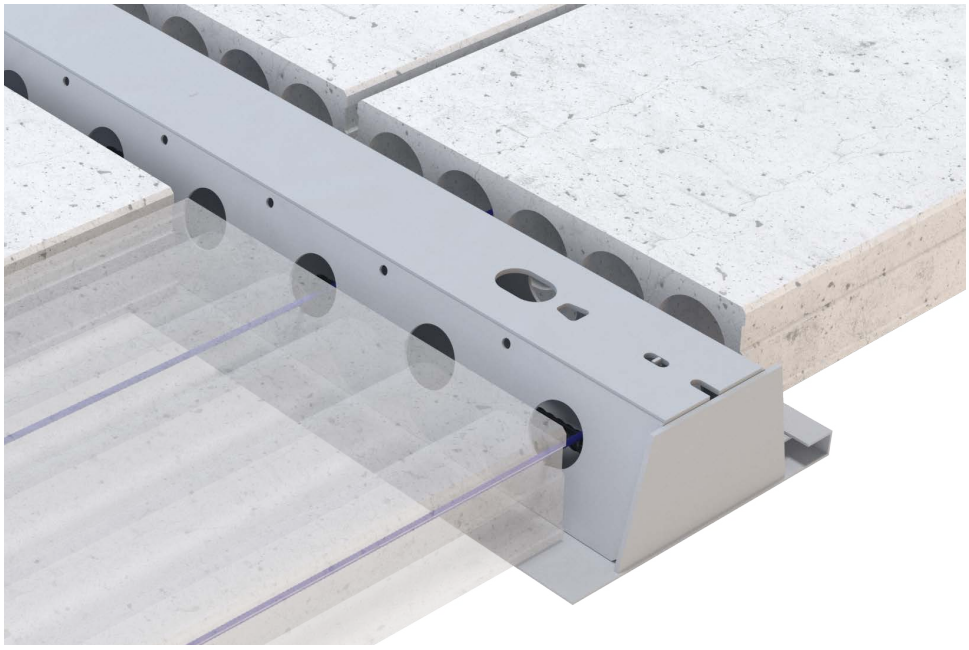


Figure 26. DELTABEAM® with a single downstand on the beam ledge to accommodate varying slab depths.

The standard maximum DELTABEAM® length is 13.5 m. If DELTABEAM® Composite Beams longer than 13.5 m are needed, please contact Peikko's technical support. Longer DELTABEAM® Composite Beams usually require special shipping arrangements.

Peikko Designer® DELTABEAM SELECT Software

Peikko Designer® DELTABEAM SELECT software is a free dimensioning software. It can be used to select DELTABEAM® profiles for a request for a quotation. Peikko Designer® DELTABEAM SELECT is available online on Peikko's website (www.peikko.com) and included in Peikko Designer® software as well. The procedure is typical as follows:

USER INPUT

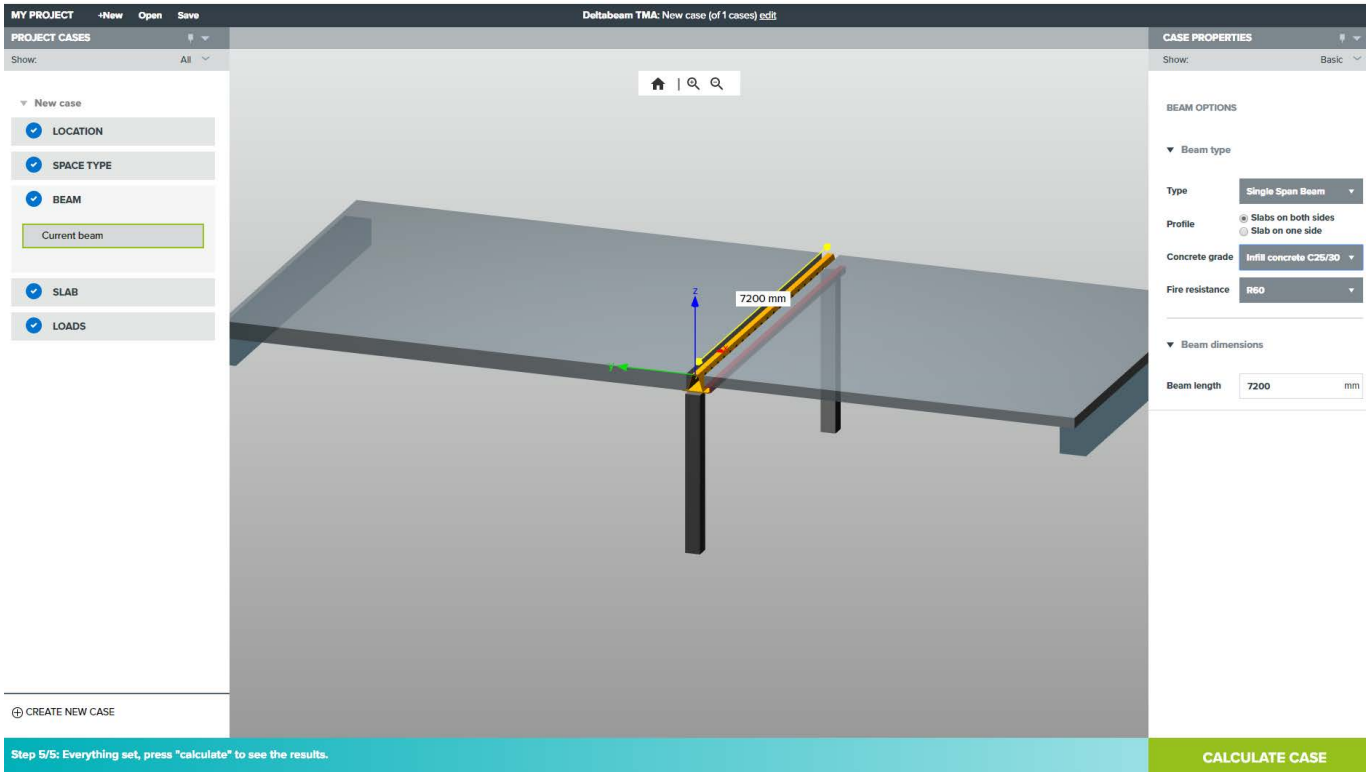
- Project data
- DELTABEAM® data
- Slab data
- Loads
- Fire resistance.

SOFTWARE OUTPUT

- Result of the analysis (Two to three recommended DELTABEAM® profiles)
- The bending moment values and diagrams in the erection stage, final stage, and fire design
- The shear force values and diagrams in the erection stage, final stage, and fire design
- Deflections with DELTABEAM® precambering
- Economically efficient solution.

Peikko Designer® DELTABEAM SELECT software calculations are based on basic Eurocode design taking into account both ultimate and serviceability limit state. Some special designs are excluded (e.g accidental design, frequency and flexible shear). The calculation of forces, moments and deformations of the beam structure is based on FEM (Finite Element Method).

Peikko always makes the final design for DELTABEAM® Composite Beams based on exact information from the project.



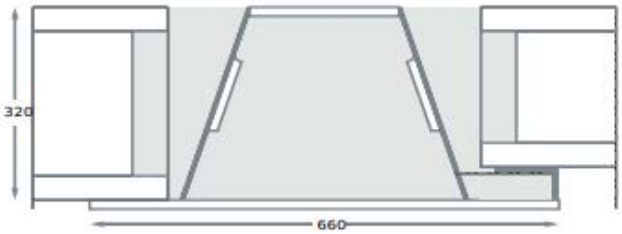
Peikko Designer® **DELTABEAM SELECT**

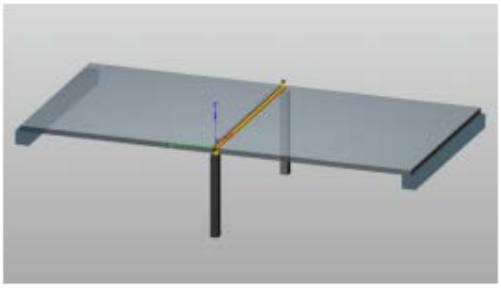
Printed on: 19.7.2018

Project: Deltabeam TMA
Location: Slovakia
Designer: Stanislav Pitek
Company: Deltabeam Slovakia
Email:

DESIGN REPORT

DELTABEAM №/ID: New case **DESIGN STATUS:** ✓ PASS





D32-400

Fire resistance: R60
Materials: Steel S355
Infill concrete C25/30
Fire rebars B500B
Execution class: EXC2
Finishing: Epoxy primer 80µm
Comment:

Applied standards, safety factors and combinations

- ENs 1990; 1991-1-1; 1991-1-6; 1994-1-1; 1994-1-2no National Annexes, ULS (STR, SET B) and SLS
- Safety factors for materials in installation and normal use: yc = 1,5 , ys = 1,15 , yM = 1
- ULS - EQU Load factors: yG,sup = 1,1 , yG,inf = 0,9 , yQ = 1,5; Combination expression 6.10
- ULS - STR Load factors: yG,sup = 1,35, yG,inf = 1 , yQ = 1,5; Combination expression 6.10
- SLS Load factors: yG = 1 , yQ = 1; Combination expression 6.14b for deflections during installation; Combination expression 6.16b for total deflections
- Fire situation safety factors for materials: yc = 1, ys = 1, yM = 1

STRUCTURE

Structure	ID	Type	Length [mm]	Span [mm]	Supports at [mm]
Deltabeam	New case	single-span	7200		0; 7200
Slab	left	HC32		9000	
Slab	right	HC27		7200	

CHARACTERISTIC LOADS

Load case	Stage	Action	Load name	Acts on	Intensity	Position [mm]	On beam
Temporary (automatic)	Installation	Q_T	Temporary load		0.5 kN/m²	full area	4.0 kN/m
Permanent	Final	G_1	Permanent load		4.0 kN/m²	full area	32.4 kN/m
Variable load	Final	Q_B	Variable load		5.0 kN/m²	full area	40.5 kN/m

DESIGN RESULTS FOR THE BEAM

Limit State	Stage	Restrictions/min/max [kN]		Ratios [kNm] and [kN]		Deformation [mm]	
		Support 1	Support 2	M_{Ed} / M_{Rd} (%)	V_{Ed} / V_{Rd} (%)	Deflection W_{max} (%)	Displacement
ULS	Installation	130.3 / 197.8	130.3 / 197.8	356 / 735.2 (48)	197.8 / 574.2 (34)		
ULS	Final	246.9 / 552.1	246.9 / 552.1	993.7 / 996.5 (100)	552.1 / 776.3 (66)		
ULS_{FI}	Final	246.9 / 319.8	246.9 / 319.8	575.7 / 957.2 (60)	319.8 / 557.3 (41)		
SLS	Final	116.6 / 160.4	116.6 / 160.4			24; L/305 (122)	24

The precamber of DELTABEAM® compensates for the deflection in the erection stage (applied EN 1990 eq. 6.16b).

NOTES:
Final design and optimization will be made by Peikko.

www.peikko.com

Design phases and delivery processes

Peikko's website www.peikko.com contains DELTABEAM® information for designers. *Figure 27* shows a typical workflow. Delivery dates are agreed with the project manager/engineer of the local Peikko unit.

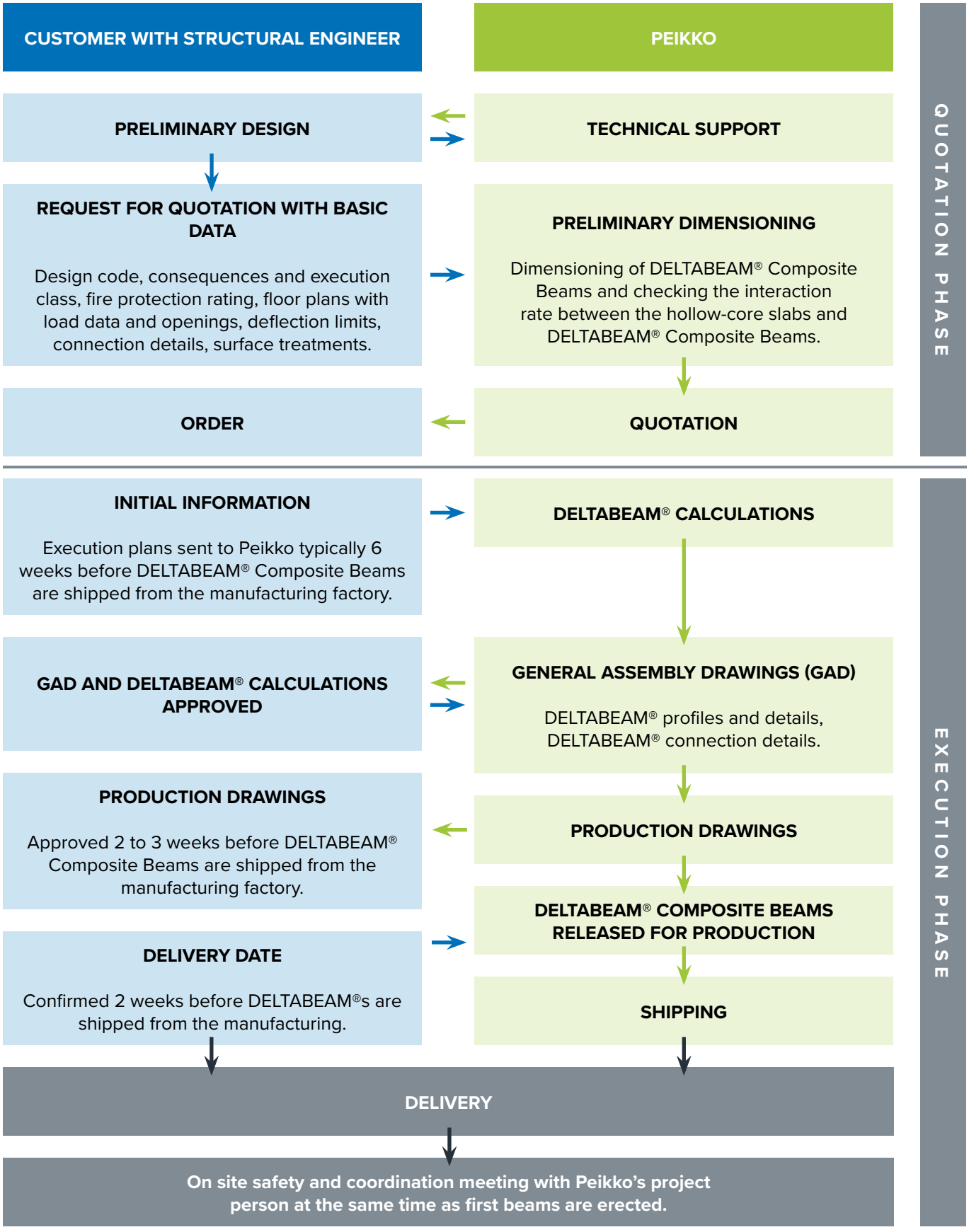


Figure 27. The typical workflow.

Annex A – Initial information

The following information is required for manufacturing DELTABEAM® Composite Beams and making design calculations:

- Structural drawings in DWG (floorplan and section drawings) Design code and load data
  - Loads
  - Loading class
  - Fire rating
- DELTABEAM®
- Connection details DELTABEAM® special requirement (i.e. extra holes, surface treatment etc...)
- Project & contact information (Project Manager, location, preliminary schedule).

Annex B – The possibilities DELTABEAM® offers

DELTABEAM® Composite Beams have been successfully used in close to 10,000 projects around the world. Demanding façade shapes, curves, and cantilevers can be made with DELTABEAM® Composite Beams using in-built formwork and also prefabricated elements. See the following examples:

Example 1. The frame of the curved external wall was built using DELTABEAM® Composite Beams with formwork sheets (Patient hotel, Denmark).

Example 2. A unique façade shape was built using concrete slab elements with DELTABEAM® Composite Beams (Metsätapiola, Finland).

Example 3. DELTABEAM® Composite Beams could be used even though the columns had a tilt of ten degrees (Saxo Bank, Denmark).

DELTABEAM® Composite Beam installation instructions

These instructions are valid in the following countries: Czech Republic, Denmark, Finland, France, Hungary, Italy, Lithuania, Netherlands, Norway, Poland, Russia, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

These DELTABEAM® installation instructions are intended to complement the project's erection method statement. Peikko's technical support is available to assist with the erection method statement if required. If there are differences between the erection method statement and this document, the differences should be approved by the structural engineer.

NOTE: IF THE INSTALLATION TOLERANCES OF DELTABEAM® ARE EXCEEDED, PEIKKO MUST BE CONTACTED. DELTABEAM® OR CONNECTIONS BETWEEN DELTABEAM® COMPOSITE BEAMS CAN NOT BE MODIFIED WITHOUT PERMISSION FROM PEIKKO.

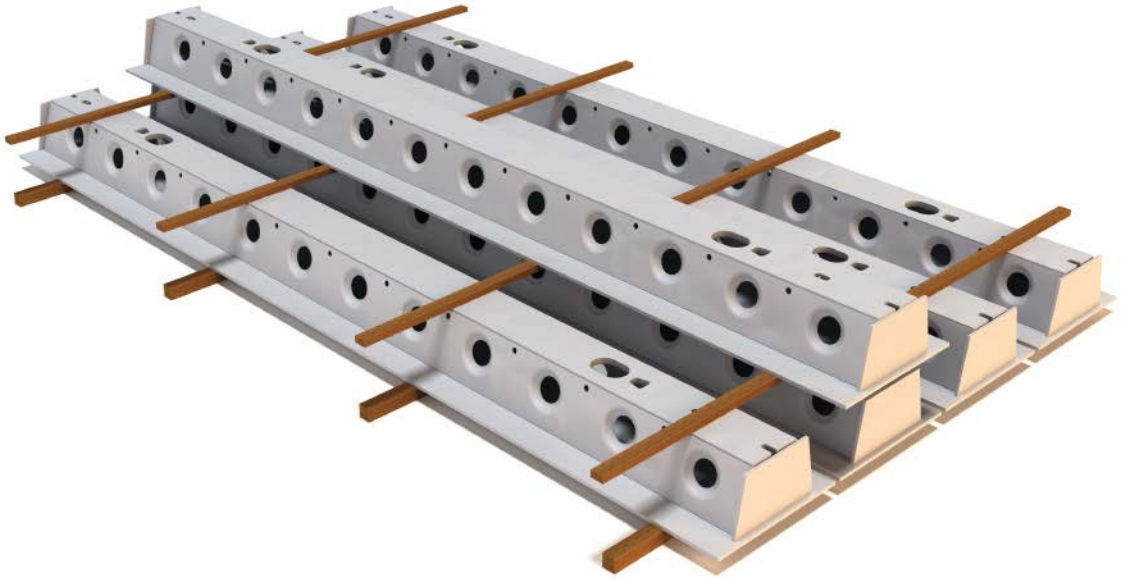
Deliveries

DELTABEAM® Composite Beams are delivered to the site in accordance with the agreed project schedule. The delivery of each shipment should be confirmed with Peikko two weeks before shipping. At the factory, DELTABEAM® Composite Beams of different lengths are not loaded in the order of installation because that would not be economical or practical. The beams are marked with identification codes in accordance with the drawings.

Storage on-site

The visible bottom parts of DELTABEAM®, web plates from the edge of the bottom surface to height 50 – 100mm, end plates, all connections, formworks, and downstands are primed to a minimum 80 µm of anticorrosive primer. Other surfaces are primed to 40 µm. The customer does the final painting on-site and it is not a standard part of DELTABEAM® delivery.

For long-term storage, the beams must be covered. Piling strips are used under the beams to protect surface treatment. Piling strips should be free from grease or other substances that may damage surface treatment. When storing beams in piles, the bearing capacity and the level of the surface should be verified.



Lifting and moving

DELTABEAM® can be lifted and moved using ordinary lifting equipment, such as cranes or forklifts. The weight of each DELTABEAM® is displayed on the product sticker on the beam and in the fabrication drawings. The CE marking sticker, QR-Code sticker which will link to these installation instructions, and DELTABEAM® trademark can also be found on the beam.

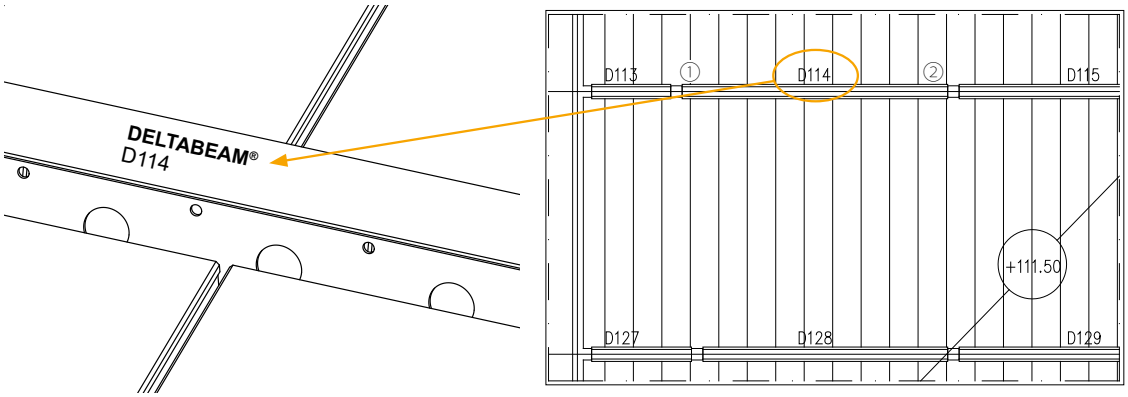
DELTABEAM® must be lifted using the lifting holes on the top plate symmetrically to the axis of the center of mass. The maximum allowed lifting angle of the chains must be observed. In special cases, when there are no lifting holes,

DELTABEAM® can be lifted with chains attached to the web holes. In some cases, a third chain is needed to lift DELTABEAM® and maintain its balance. For example, DELTABEAM® with wide formwork sheets should be lifted using the lifting holes and a third chain should be attached to the formwork structure.

NOTE: ALWAYS USE APPROVED LIFTING CHAINS AND LOCK THE CHAIN HOOKS. NO LIFTING STRAPS OR CHAINS AROUND DELTABEAM® AS THIS WILL INVOLVE A RISK TO HEALTH AND SAFETY!.

Assembling DELTABEAM®

The project's erection method statement must be followed. Every DELTABEAM® has the DELTABEAM® trademark and identification code on the top plate near the beam end ①. The beams are installed in such a way that the identification code on the top plate of DELTABEAM® can be read in the same direction as marked in the element layout drawing.



Connecting DELTABEAM®

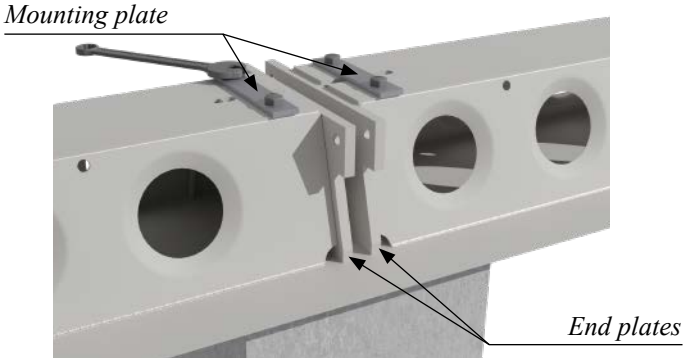
DELTABEAM® Composite Beams are connected in accordance with the project's erection method statement, the installation plans, and the connection details. The connection details are specified in the construction plan for each project. Shim plates and steel packs should be placed in accordance with the project related erection method statement. The DELTABEAM® delivery only includes installation material for the connections between DELTABEAM® (Gerber and Side connections).

Important

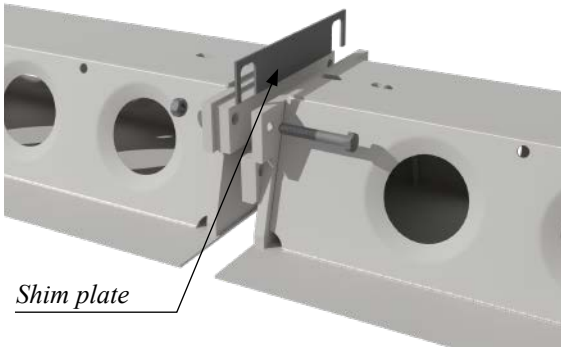
During the installation of the slabs, maintaining the frame stability requires connecting DELTABEAM® before assembling the props and floor units. This prevents the beams from moving. If on-site welding is required, the process and the qualification of the welders should be in accordance with the erection method statement.

Shim plates in Gerber and side connections are used by default to allow installation tolerance. Installation tolerance is +5 mm / -10 mm, and the maximum thickness of the shim plates is 15 mm. DELTABEAM® lengths have been designed including a shim plate; a 5 mm shim plate is set to every connection after DELTABEAM® is installed and before the bolts are tightened. Any variations to the designed total length of the beam line are taken into account by adding or removing the number of shim plates from other connections within the allowed tolerances.

Connection with HPM® anchor bolts

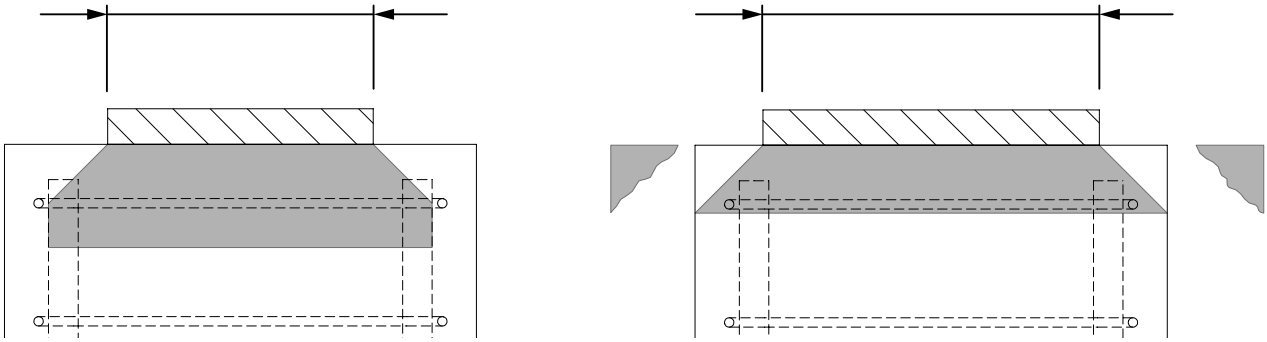


Gerber connection



When assembling continuous DELTABEAM® Composite Beams, the location of each DELTABEAM® and the total length of the beam line should be confirmed before tightening the bolts in the Gerber connections and other connections. The ends of the continuous beam lines must be prevented from uplifting during installation.

Steel packs are placed on the reinforced concrete structure so that the effect of the contact stress remains inside the perimeter of the stirrup reinforcement. The risk of spalling can be reduced by applying chamfers to the edges of the concrete structure. The usage of neoprene is not recommended between DELTABEAM® and the support.



NOTE: DELTABEAM® CUTTING, OPENING OUT BOLT HOLES, ETC. REQUIRES A PERMISSION AND INSTRUCTIONS FROM PEIKKO.

Propping DELTABEAM®

Propping needs to be carried out in accordance with the project's erection method statement before assembling the floor units. DELTABEAM® must be connected in accordance with the erection method statement, the installation plans, and the connection details before propping. Only certified props are to be used. Their quantity and placing must be in accordance with the propping plan made by a structural engineer.

The stability of the props must be confirmed when they are assembled. The foundation for the props must also be secure and solid. The props shall be assembled as close to the beam support as possible. The props are placed at the loaded side of the beam, below the web. The props may be removed only when the joint concrete and the infill concrete of DELTABEAM® have reached the required strength.

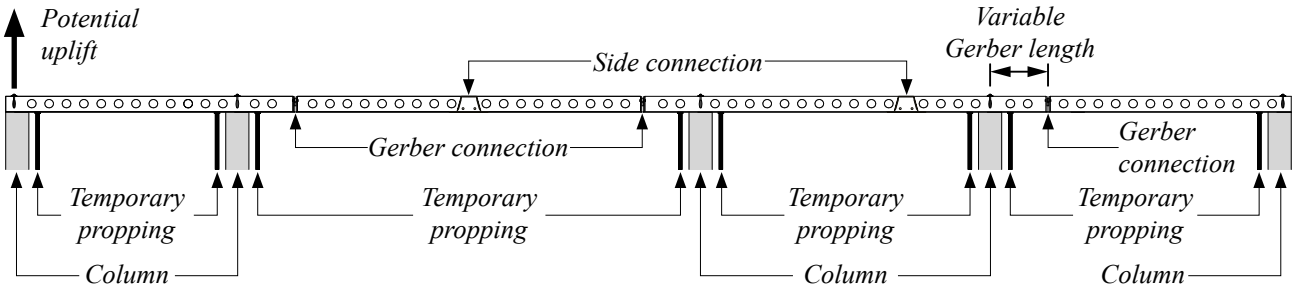
With hollow-core slabs, DELTABEAM® propping is only used to prevent the rotation of the beam at the supports. The function of DELTABEAM® propping is not to prevent deflection. Hollow-core slabs cannot be propped without permission from the hollow-core units manufacturer.

The role of propping is crucial when DELTABEAM® is bearing on the end of a wall running parallel with the beam. The propping plan prepared by a structural engineer shall be followed.

Support for PCs® console connection

Wall support

Propping of continuous DELTABEAM® line and potential uplift.



- Propping in the position of Gerber and Side connection is not required.
- Both Gerber and Side connections are designed to take the torsion from loads acting in the erection stage.
- The possible uplift effects of loads during the erection or final stage must be considered when designing the connection details and supporting structures of DELTABEAM® by the structural engineer responsible for the project. E.g. Peikko's PCs® LOCK Corbel is designed to uplift. See PCs® Corbels technical manual for more information.

The DELTABEAM® wide formwork sheet must always be supported. If this is not possible – special agreement with Peikko technical support is needed. The continuous support is placed along the edge of under the corner of the wide formwork sheet. The continuous support is supported with props, and it shall be the same length as the supported formwork sheet.

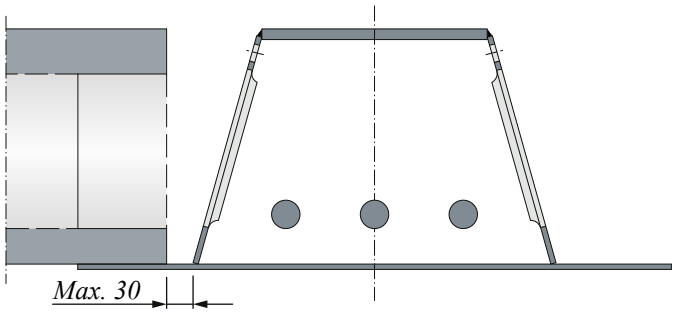
Special attention should be paid to asymmetrically support beams, long beam spans, or tall propping heights. When the propping heights are tall, traditional methods such as temporary columns or towers are used. Peikko´s technical support helps with demanding propping issues.

NOTE: DELTABEAM® PROPPING IS USED WITH HOLLOW-CORE FLOORS ONLY TO PREVENT THE BEAM FROM ROTATING AT ITS SUPPORTS.

Assembling floor units

The DELTABEAM® connections and the props must be securely installed, tightened, or welded before assembling the floor units. To minimize the rotation of the beam, the floor units should be assembled alternately on different sides of the beam. If one side is loaded, erection props must be designed accordingly. After the slabs are installed the necessary formwork, edge forming, and slab reinforcement will be carried out.

Floor units should be assembled directly on the beam ledge. The use of neoprene is not recommended. Floor units should be assembled so that there is a gap of a maximum of 30 mm between the web of the DELTABEAM® and the end of the floor unit. If this gap is exceeded, contact Peikko or the structural engineer. Finally, all holes on the bottom side of DELTABEAM® (locations of consoles, Side connections, and Gerber connections) should be blocked. The joint and ring reinforcement are also assembled.

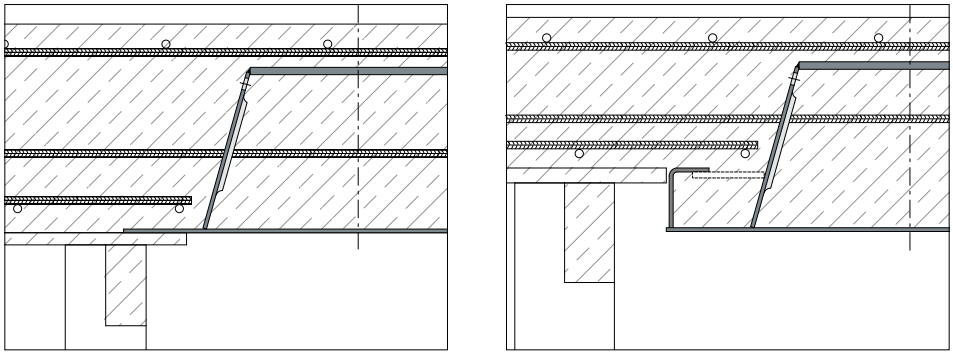


Metal decking and filigran type slabs are installed to the nominal elevation according to the plans. DELTABEAM® precamber is designed so that it will deflect horizontally due to the weight of the floor.

NOTE: MATERIAL MUST NOT BE STORED ON THE FLOOR BEFORE THE INFILL CONCRETE HAS HARDENED. THE FLOOR ABOVE MUST NOT BE BUILT UNTIL THE INFILL CONCRETE HAS HARDENED.

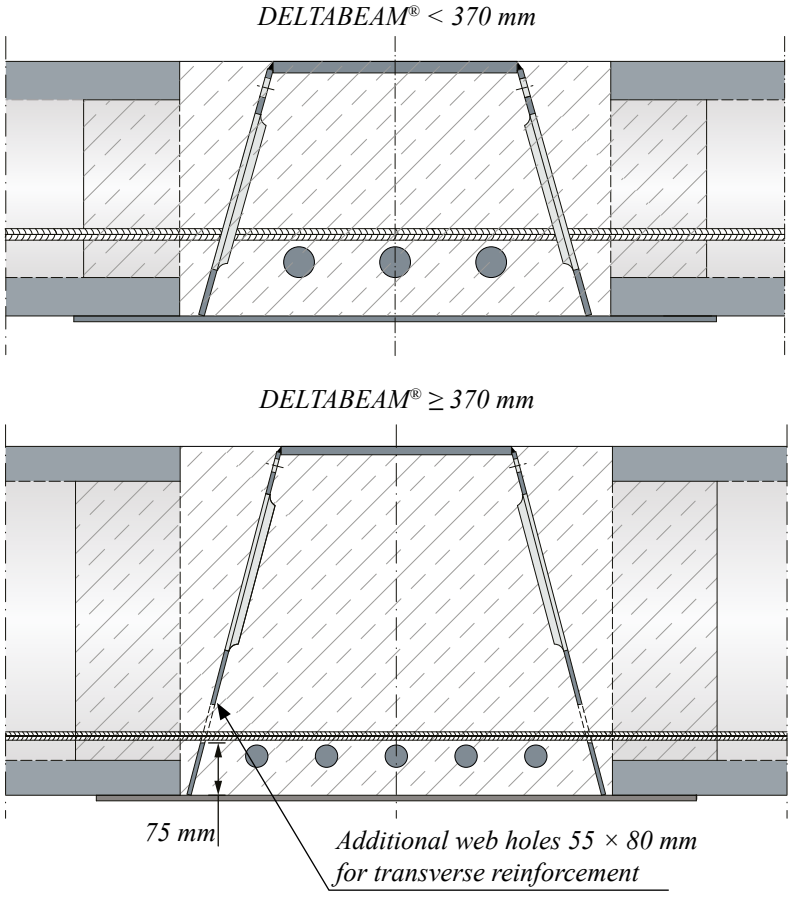
In-situ concrete slab

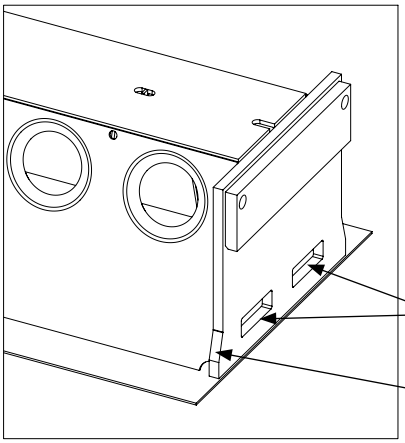
In-situ concrete slabs are built to the nominal level. To achieve a flush bottom surface with an in-situ slab, it is recommended that the formwork be built under the bottom plate. With the downstand on the beam ledge, the formwork is built against the web of the downstand.



Reinforcement

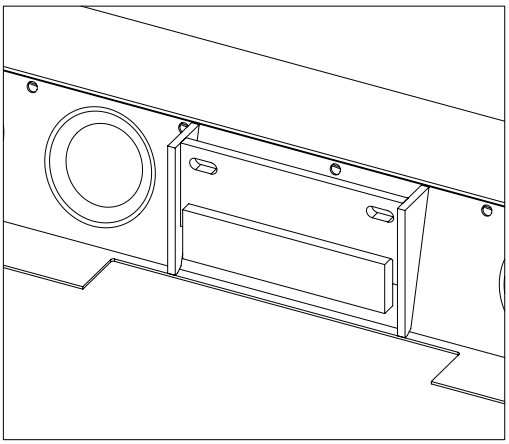
Reinforcement is installed in accordance with the erection method statement. The minimum transverse reinforcement of the DELTABEAM® is 94 mm^2/m. The transverse reinforcement must be installed even if rebars are being bent over DELTABEAM®. The transverse reinforcement should pass through the web holes ($h < 370\ mm$) or additional web holes ($h \geq 370\ mm$) of the DELTABEAM®. Gerber end plate has a modified shape that allows installing ring reinforcement between DELTABEAM® ($h \geq 300\ mm$) and Hollow-core unit. Cut-outs in Gerber plate serves for purpose of concreting of joint. There are two cut-outs in DELTABEAM® with width $b \geq 600\ mm$ (see Figures below).

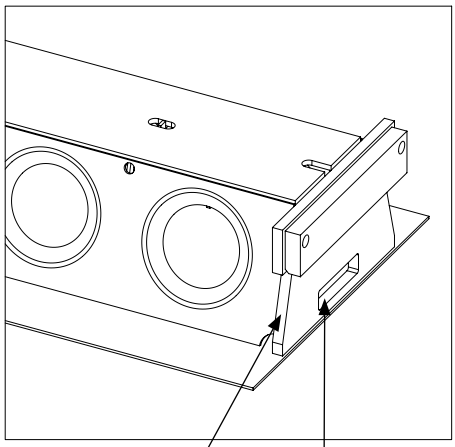




Two cut-outs for DELTABEAM® b ≥ 600 mm

End plate shape for DELTABEAM® h ≥ 300 mm





End plate shape for DELTABEAM® h < 300 mm

Cut-out for DELTABEAM® b < 600 mm

Casting the concrete

DELTABEAM® is cast with concrete simultaneously with the slab or the joints of the Hollow-core slabs. DELTABEAM® must be filled with concrete in one run. DELTABEAM® must be cast completely for it to secure the properties of a composite beam. DELTABEAM® is designed for temporary live load according to EN 1991-1-6 and its National Annex.

Structural concrete is always used when casting concrete. The concrete grade is in accordance with the project's erection method statement. The concrete's properties are determined in accordance with the project's concreting plan.

The recommended maximum aggregate size is 8 mm (in any case, no more than 16 mm). The drying time of concrete can be reduced by reducing the amount of water required. This can be done by using concrete with low water/cement ration ($v/c < 0.5$), or stronger concrete made with water-reducing agents. It is not recommended to use water-binding coal fly in the concrete mix. On-site drying time can be influenced by following the guidelines for prevailing environmental conditions and project specific instructions.

The lower parts of Gerber and side connections must be properly filled with concrete. Topping concrete is cast in accordance with the erection method statement.

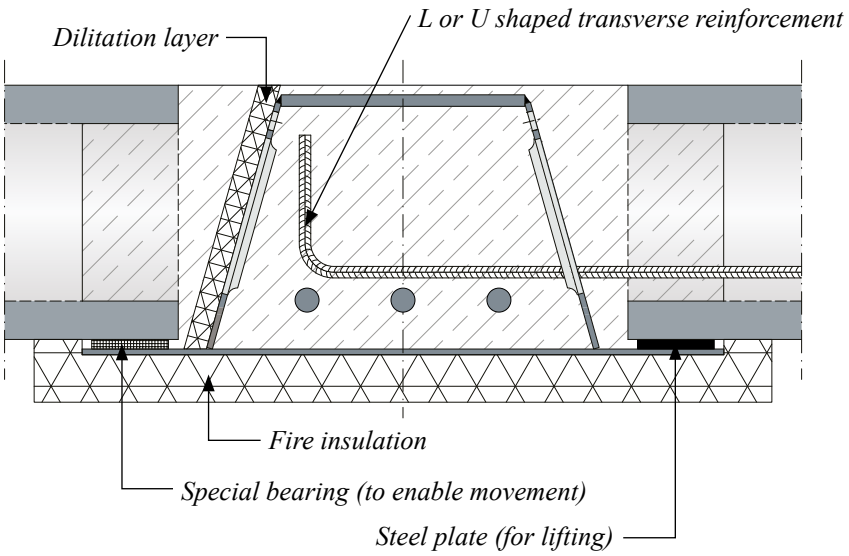
Process of casting the concrete:

1. Use only the concrete mix defined by the structural engineer responsible for the project.
2. Ensure that there is no water in the beam and that water drainage holes are open.
3. Ensure that DELTABEAM® is clean for casting.
4. If there are pre-installed heating wires inside the DELTABEAM®, ensure that the socket of the wire is taken out of the beam before casting the concrete.
5. Ensure that the formwork and the reinforcement are in accordance with the design.
6. Initial infill may be done through the casting holes in the top plate. DELTABEAM® is filled with concrete up to the bottom edge of the web holes.
7. After the initial infill, the final concreting is done only from one side of DELTABEAM®.
8. Ensure that DELTABEAM® is filled with concrete by checking the air holes on the opposite side of DELTABEAM®. The beam is full when concrete runs through the air holes. Concrete spillage over the beam must be avoided as this will make it harder to observe whether the beam is full.
9. Compact the concrete with poker or vibrator while concreting. The entire infill process may be done through the casting holes in the top plate, but it will be slower and require more work with the poker to run the concrete. Mind the formwork plate and the vertical web when using a poker.



Additional fire protection

Additional fire protection is done according to the project's erection method statement. The DELTABEAM® with expansion joints must be protected against fire from below. When the expansion joint is on the beam ledge the entire width and length of the beam must be protected against fire. The expansion joint can also be located at the end connection or the Side connection.



The vertical web of the DR-type DELTABEAM® must be protected against fire on-site if the vertical web is not protected against fire by permanent structures such as walls. A wall would act as permanent structural fire protection.

If DELTABEAM® is being connected to a fire-protected steel structure, the extent of fire protection must be done according to the erection method statement. Unprotected DELTABEAM® will conduct heat to the steel structure through the connection.

After installation

Any damage to the surface treatment should be repaired as soon as possible. The surface treatment should be completed with the top layers as soon as possible.

Safety

All valid health and safety rules must be followed during installation. Fixing points for handrails and other safety products can be ordered separately.

On-site checklist

1. **Storage on-site**
   - Use piling strips or timber boards to protect surface treatment.
   - Cover DELTABEAM® Composite Beams when long-term storage on-site.

2. **Lifting and moving**
   - DELTABEAM® is lifted by using the lifting holes located on the top plate. Always lock the chains.
   - Note the maximum allowed lifting angle of the chains.
   - DELTABEAM® self-weight is given on a product sticker.

   NO LIFTING STRAPS OR CHAINS AROUND DELTABEAM® AS THIS IS A HEALTH AND SAFETY RISK!

3. **Assembling DELTABEAM®**
   - First, check the instructions and the requirements in the erection method statement.
   - The direction of the identification codes of the installed beams should be the same as in the element layout drawing.
   - The beams must be connected (with bolts or welds) to supports before the assembly of the floor units.
   - When assembling DELTABEAM® Composite Beams on reinforced concrete columns, use either one wide steel pack or two smaller packs: one small pack in the middle is not sufficient.
   - Before tightening the bolts on the Gerber connections, check the location of each DELTABEAM® and the total length of the beam line.
   - Propping
   - With Hollow-core slabs as close to the DELTABEAM® support as possible, at the loaded side of the beam, below the web.
   - With other floor types, the erection method statement is followed.
   - Remove only after the concrete has hardened.

4. **Assembling floor units**
   - Assemble the floor units directly on the beam ledge without any layers between.
   - Maximum 30 mm gap between the web of the DELTABEAM® and the end of the floor unit.
   - To minimize the rotation of the beam, assemble floor units alternately on different sides of the beam.

5. **Reinforcement**
   - The minimum transverse reinforcement through DELTABEAM® is 94 mm^2/m, from slab to slab in joints or voids.
   - In edge, beams use L or U-shaped rebars.

6. **Casting the concrete**
   - Concrete fullfills the specification given in the project-related erection method statement.
   - Fill in one run, fill only from one side, observe from the other side. The beam is full when concrete starts to run through the small air holes in the upper part of the web. Mind the formwork plates when using a poker/vibrator.
   - Ensure that concrete fills the gap between Gerber and Side connections.

DELTABEAM® CUTTING, OPENING OUT BOLT HOLES, ETC. REQUIRES A PERMISSION AND INSTRUCTIONS FROM PEIKKO.

MATERIALS SHOULD NOT BE STORED ON THE FLOOR BEFORE THE INFILL CONCRETE HAS REACHED THE REQUIRED STRENGTH.

THE FLOOR ABOVE MUST NOT BE BUILT BEFORE THE INFILL CONCRETE HAS REACHED THE REQUIRED STRENGTH.

Revisions

Version: PEIKKO GROUP 03/2021. Revision: 002

- New information regarding extreme load cases scenarios.
- New information regarding fire situation.
- Updated figures related to propping, floor types, installation, etc.
- New information on Peikko's latest pre selection software DELTABEAM Select®.
- Rewording of many paragraphs for easier understanding.
- Document brought up to date with current styles.

Version: PEIKKO GROUP 08/2014. Revision: 001*

- New cover design for 2018 added.

Resources

DESIGN TOOLS

Use our powerful software every day to make your work faster, easier and more reliable. Peikko design tools include design software, 3D components for modeling programs, installation instructions, technical manuals and product approvals of Peikko's products.

peikko.com/design-tools

TECHNICAL SUPPORT

Our technical support teams around the world are available to assist you with all of your questions regarding design, installation etc.

peikko.com/technical-support

APPROVALS

Approvals, certificates and documents related to CE-marking (DoP, DoC) can be found on our websites under each products' product page.

peikko.com/products

EPDS AND MANAGEMENT SYSTEM CERTIFICATES

Environmental Product Declarations and management system certificates can be found at the quality section of our websites.

peikko.com/qehs

CE

MANAGEMENT SYSTEM CERTIFICATION
DNV·GL
ISO 9001 = ISO 14001
ISO 45001 = ISO 3834-2