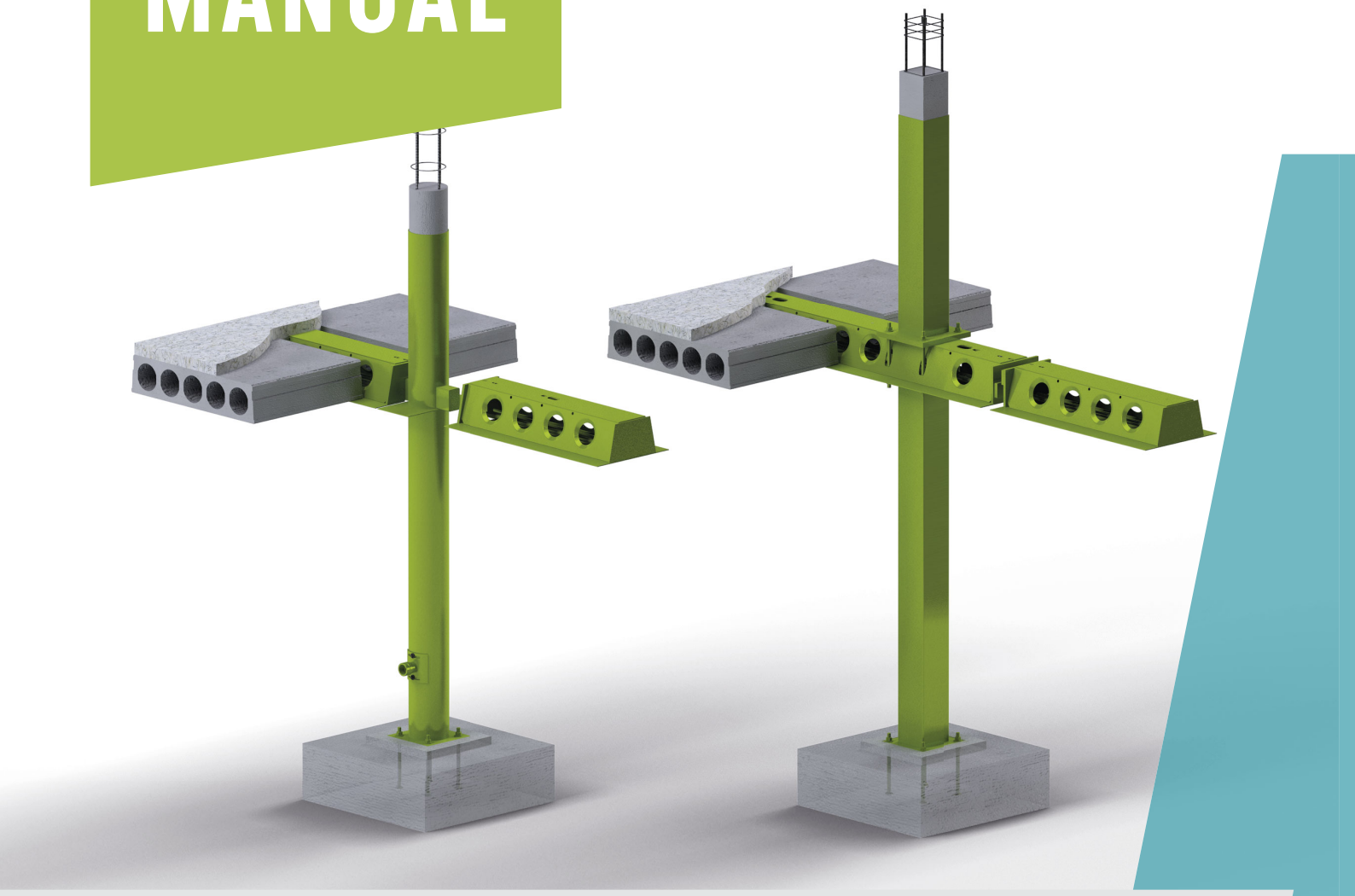
TECHNICAL MANUAL



DELTABEAM® Frame

Structural Solution

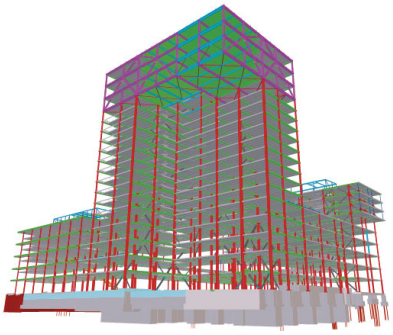
Version Peikko Group 11/2017

peikko®

DELTABEAM® Frame

Save time – fast frame erection

The frame components do not restrict design. All components are light, which makes transportation , storage, and installation easy and keeps costs low.



DELTABEAM® COMPOSITE BEAMS

- Slim floors and grids up to 16 meters
- Integrated formwork enables special interior and facade shapes

COMPOSITE COLUMNS

The Composite Columns are made of a hollow steel section with a rebar cage placed inside. The columns are filled with concrete on site. Available in square, rectangular, and circular formats in standard profiles.

Multistory columns

- Easy handling of high vertical loads
- Used with single span beams

Single-story columns

- Used with continuous beams for longer spans

ADDITIONAL COMPONENTS

- Other steel structures such as trusses, braces, and various types of beam and column can be included in the frame delivery
- Connection solutions such as anchor bolts and corbels
- Slab hangers/trimmer beams for slab openings
- Safety solutions

Benefits of the DELTABEAM® Frame

- Compatible with all slab and facade types
- One supplier for the entire composite frame saves time and effort
- Long spans enabling flexible open space
- Additional room height and floor space
- Easy to form architectural shapes
- Light components are easy to transport and quick to install
- Lower heating and cooling costs
- Easy and space-saving HVAC installations
- Integrated fireproofing up to R180
- Superior local service

The DELTABEAM® Frame allows for BREEAM and LEED certifications.

For more information on DELTABEAM® Frame, visit https://www.peikko.com/deltabeamframe

Contents

1. Solution properties

The DELTABEAM® Frame is a composite frame solution consisting of:

- DELTABEAM® slim-floor composite beams
- composite columns
- joints between the structural members
- other supplementary steel structures

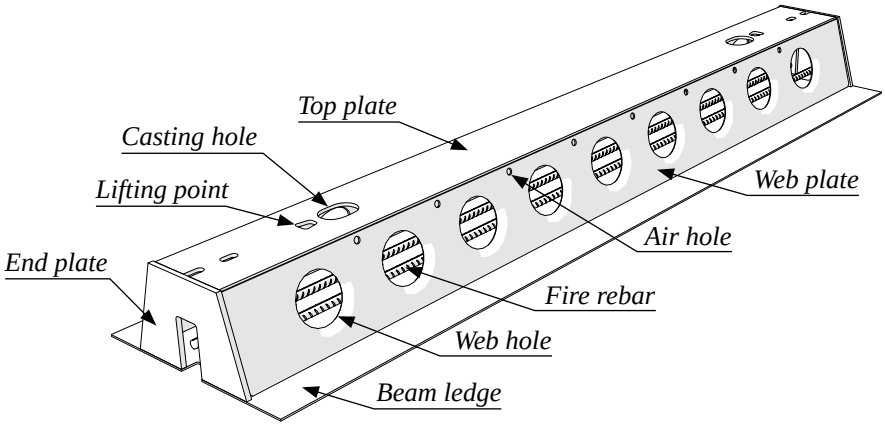
The principle of the DELTABEAM® Frame is to utilize the advantages of steel and concrete, and couple them to work together thus forming a highly efficient composite structure. The steel members of DELTABEAM® Frame are light to handle and are acting as a mold during concrete casting.

The structural system of the DELTABEAM® Frame is based on nominally pinned joints, while the sway stiffness of the frame is arranged by a bracing system such as shear walls or diagonal braces . The frame can be formed by multistory columns and single-span beams or by single-story columns and continuous beams. Structural members and joints can be designed to meet the highest robustness requirements. The DELTABEAM® Frame's standardized joint selection and other Peikko connection items allow the frame to be assembled safely and quickly without on-site welding. All components of the DELTABEAM® Frame can be designed with integrated fireproofing up to fire resistance class R180.

1.1 Components

DELTABEAM® allows for a slim floor structure where the beam is integrated into the floor. DELTABEAM® is manufactured from cut steel plates and is equipped with accessories such as fire rebars, connection details or fixings for safety systems according to the requirements. DELTABEAM® is delivered to the site ready for installation and, in the erection phase, the steel section of the DELTABEAM® acts as a steel beam and adjacent slabs can be placed on the ledges. After the floor units have been assembled, the DELTABEAM® is cast with concrete and acts as a formwork. The infill concrete and DELTABEAM® form a composite structure when the concrete has reached the required strength. For more information, refer to DELTABEAM® Slim Floor Structures - Technical Manual.

Figure 1. Typical DELTABEAM® features.



The COMPOSITE COLUMNS of the DELTABEAM® Frame are hollow steel sections filled with reinforced concrete. The rebar cage is fixed inside a circular, square, or rectangular hollow section and joint components such as base plates and consoles are welded at the factory. Columns are delivered to the site ready to be assembled and filled with concrete.

Figure 2. Typical composite column features.

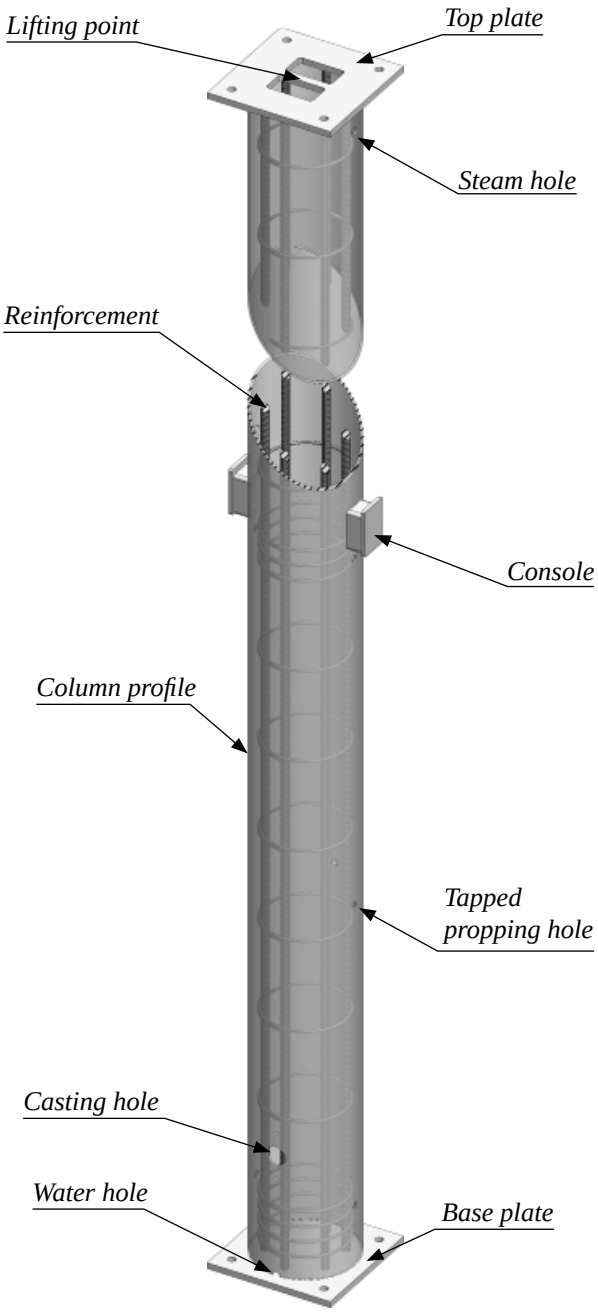
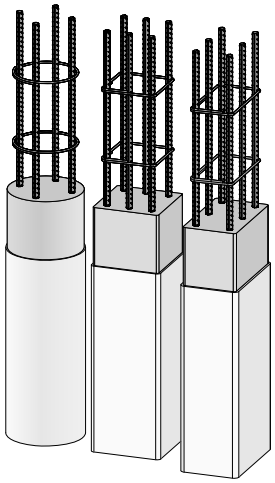


Figure 3. Selection of column cross-section shapes: circular, square, and rectangular composite columns.



The JOINTS of the DELTABEAM® Frame consist of a standardized selection of:

- column-to-foundation joints
- column-to-column joints
- beam-to-column joints
- beam-to-beam joints
- other joints such as bracing and fa cade joints

The range of joints is the result of continuous development work towards a safer and faster installation process.



ADDITIONAL COMPONENTS

- ANCHOR BOLTS: Peikko HPM® and PPM® Anchor Bolts
- SLAB HANGERS: Peikko PETRA® Slab Hanger
- OTHER CONNECTIONS between the frame and other structures
- OTHER STEEL STRUCTURES such as braces and trusses
- SAFETY SOLUTIONS such as fixing joints for safety fences or railings





2. Structural behavior

The structural behavior of the composite frame and load transfer mechanisms of composite frame members varies from one construction stage to another. The erection stage is considered to begin with the assembly of a steel member and last until the infill concrete has reached its required strength and the final bracing system is activated. In the final stage, the composite cross-sections of beams and columns are fully operational, the joints are finalized, and the temporary supports are removed. With multistory frames it is normal that during the construction, the lower floors reach the final state while the erection of upper floors is still on-going. For more specific information concerning DELTABEAM®, refer to DELTABEAM® Slim Floor Structures, Technical Manual .

2.1 Erection stage

Prior to concreting, the columns and beams of the DELTABEAM® Frame behave as pure steel members and are designed to carry the loads acting during the erection stage. Resistance of a pure steel member is considerably lower than the composite member in final stage.

During erection the steel members are filled with concrete; columns are pumped using the casting hole located at the bottom part of the column profile or with short columns the filling can be done from the top trough the casting hole at the top plate . DELTABEAM®s are filled simultaneously with casting of adjacent slabs.

DELTABEAM®s are loaded by the adjacent slabs through the beam ledges and the elastic deflection is compensated by the set precamber. With single-span beams and multistory columns a console connection is used between the members. During the erection stage the console transfers the vertical action from the end plate of the beam to the steel column profile. The console joint can be designed to resist the axial torsion of the beam thus removing the need of propping the beams. With continuous beams and single-story columns the beam is set on top of the column and the vertical action is transferred through the top plate of the column.

The column profile is connected to the floors below or to the foundation by a base plate and anchor bolts. Before the column is connected to the bracing system the column must be propped. Propping can be avoided by also designing the base joint to resist bending moments generated by horizontal forces during erection.

2.2 Final stage

DELTABEAM® and the infill concrete form a composite structure when the concrete has hardened. The composite action between the cross-section parts is enabled by the shear connection formed by the dowel action of web holes.

The composite columns are mainly axially loaded and bending moments result from eccentric loading and initial imperfections. Cross-sectional resistances are composed of the column steel profile, the concrete section and the reinforcing steel. In general cases, the column profile constitutes approximately 40% of the plastic resistance to compressive normal force, while the concrete section forms approximately 35% and the reinforcement 25%. Since all cross-section members of the composite column share the same centroid there is no longitudinal shear flow between the members at the mid-span of columns and shear connections are not required. Instead, at the section where vertical actions are introduced to the column surface, the load is transferred to the entire composite section with a shear connection. The shear connection is selected according to the actions and geometrical conditions.

2.3 Accidental situations

Overall robustness

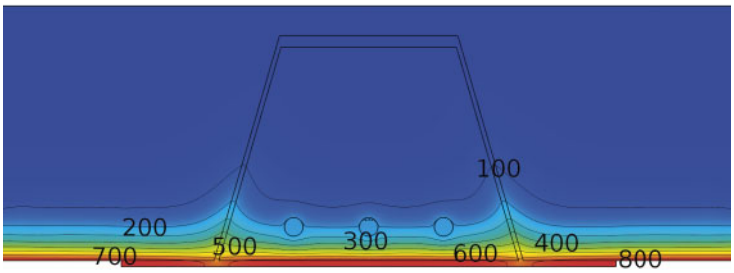
DELTABEAM® Frame can be designed to fulfill the robustness requirements of all consequences classes. The majority of the buildings where DELTABEAM® Frames are used are classified as 2a or 2b according to EN 1991-1-7:2006, where the most appropriate method to guarantee robust behavior is to use horizontal (2a) or horizontal and vertical (2b) tying between the structural members.

Fire situation

In the fire situation, the stress distribution over the cross-section of a structural member of a DELTABEAM® Frame changes due to the elevated temperatures and reduced material properties. All the structural members and joints of the DELTABEAM® Frame can have fire rating as high as R180, usually without additional fire protection.

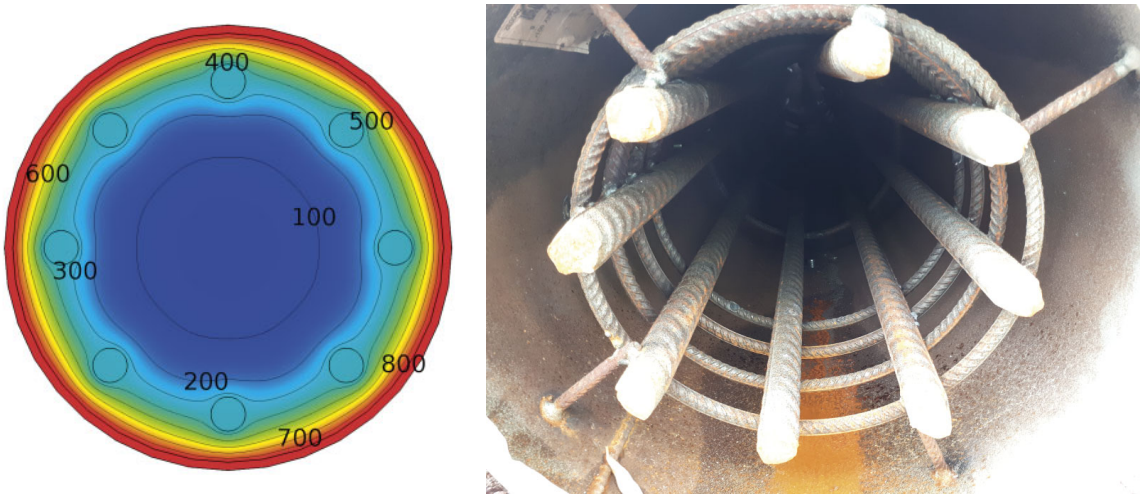
When required, the fire resistance of DELTABEAM® is enhanced with fire rebars installed inside the beam at the factory. When the bottom surface of the beam becomes exposed to the fire, the bottom flange is heated most rapidly but the upper part of the cross-section remains relatively cool. In the fire situation, the effective cross-section typically consists of beam webs and fire rebars in tension and a compressed top plate and concrete section .

Figure 4. Temperature [°C] distribution of a typical DELTABEAM® cross-section after 60 minutes of fire exposure.



When the composite columns of a DELTABEAM® Frame are exposed to fire, the steel column profile loses most of its strength and cross-sectional resistance is mainly formed by the concrete core and the reinforcement. The figure below shows the temperature distribution of a circular composite column with reinforcement after 60 minutes of fire exposure. Now the plastic resistance to compression in fire is roughly half of the resistance at room temperature. In this example, the concrete core forms more than half of the plastic resistance to compression in fire, the reinforcement contributes about 40% and the steel column profile only 2–3%.

Figure 5. Example of the temperature [°C] distribution of a circular composite column after 60 minutes of fire exposure.



DELTABEAM® Frame joints are usually designed with a load transfer zone embedded in the concrete so that temperature development is delayed.

3. Other properties

The steel components of the DELTABEAM® Frame are fabricated from hollow steel sections, steel plates and reinforcing bars that are welded together at the factory with other required components (e.g. rebars). The properties of the materials are shown in Table 1.

Table 1. Material grades and standards.

Material	Grade	Standard
Cold formed hollow sections	S355J2H S355NH	EN 10219-1 EN 10219-1
Hot finished hollow sections	S355J2H S355NH	EN 10210-1 EN 10210-1
Steel plates	S355J2+N	EN 10025-2
Ribbed bars	BSt500S B500B B500B K500B-T	DIN 488 SFS 1215 / SFS 1300 EN 10080 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 standard welding class is C according to EN ISO 5817 and EN 1090-2.

Peikko Group's production units are externally controlled and periodically audited on the basis of production certifications and product approvals by various organizations, including Inspecta Certification, VTT Expert Services, Nordcert, SLV, TSUS and SPSC.

The manufacturing tolerances of the DELTABEAM® Frame correspond to EN 1090-2 Annex D.2, Tolerance Class 1. The steel components of the DELTABEAM® Frame are fabricated to fulfill the requirements according to execution class EXC2. When separately agreed with Peikko, fabrication can be executed according the requirements of execution class EXC3.

The steel components of the DELTABEAM ® Frame are CE-marked according to EN 1090-2 as steel structures with a CE-marking sticker.

The default corrosivity category of the DELTABEAM ® Frame is C1 when preparation grade P2, cleanliness grade Sa 2½, and one primer base layer are included in the surface treatment. Other surface treatments may be delivered upon agreement with the customer.

4. Resistances

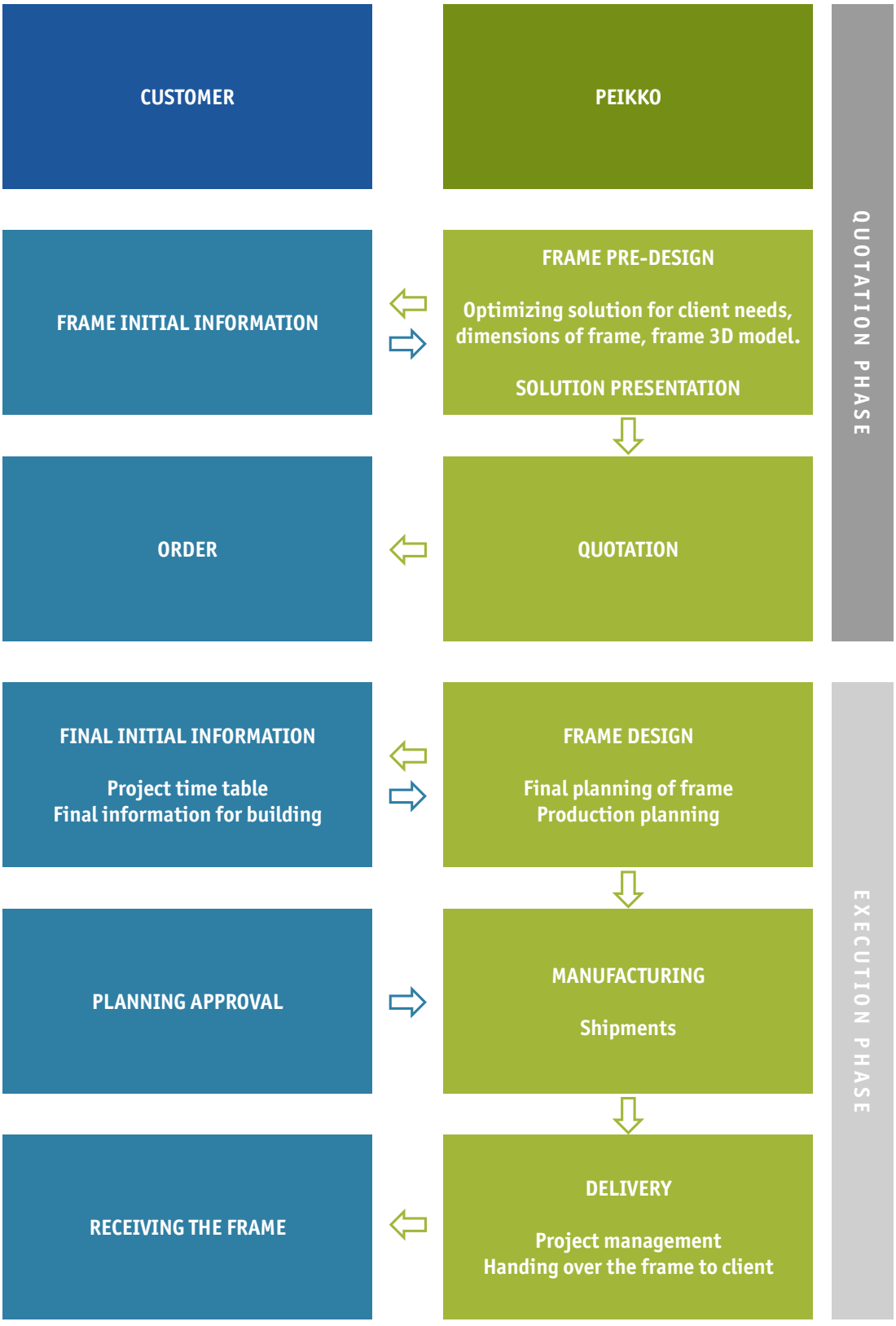
The steel members of the DELTABEAM® Frame are marked through harmonized standard EN 1090-1. The design is done according to the following Eurocodes and National Annexes:

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

Design phases and delivery processes

Peikko's website (www.peikko.com) contains information for designers. Figure 6 shows a typical delivery workflow between the customer and Peikko for a DELTABEAM® Frame. Material and initial information delivery dates are agreed with the project manager and engineer at the local Peikko unit.

Figure 6. The typical workflow.



INITIAL DESIGN DATA

1. An execution specification in accordance with EN 1090-2

Indicating at least the following:	*By default:*
❑ Consequence class	CC2
❑ Execution class	EXC2
❑ Preparation grade	P2-at the factory E60/1+FeSA 2½
❑ Corrosivity category	C2
❑ Tolerance category	2

2. Structural designs

In DWG and PDF format.

- ❑ List of drawings
- ❑ Plan drawings
- ❑ Sections
- ❑ Construction types
- ❑ Details
- ❑ Loads
- ❑ Fire resistance class

3. 3D model (not mandatory)

In IFC format.

For TEKLA/model sharing please contact you local Peikko office

These DELTABEAM® Frame installation instructions are intended to be used together with the project's erection method statement where the instructions may be complemented. If there are differences between the erection method statement and the instructions given below, the differences should be approved by structural engineer.

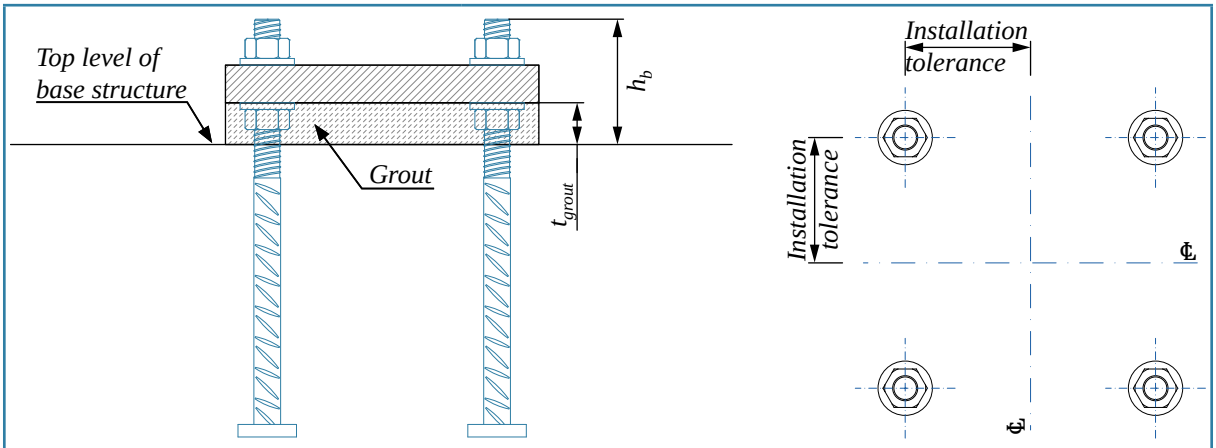
Before assembling the DELTABEAM® Frame

1. Control measurements for foundations: Anchor bolts

Should be done well in advance of the first deliveries

- ❑ See Peikko's Technical Manuals for HPM® Rebar Anchor Bolt or PPM® High-Strength Anchor Bolt for further information.
- ❑ Locate the anchor bolts where the composite columns are to be installed
- ❑ Inspect the bolts visually to ensure that they are not damaged
- ❑ Measure the locations of bolt groups and individual bolts
- ❑ Ensure that the locations of bolts are within the tolerances (for HPM® Anchor Bolts see Table 2 below, for PPM® High-Strength Anchor Bolts see the Technical Manual)
- ❑ Contact Peikko if the tolerances are exceeded

Table 2. HPM® Anchor Bolt installation tolerances and tightening torques.



Anchor Bolt	HPM 16	HPM 20	HPM 24	HPM 30	HPM 39
Thread diameter [mm]	16	20	24	30	39
Color code	Yellow	Blue	Gray	Green	Orange
Installation tolerance [mm]	±3	±3	±3	±3	±3
Bolt protrusion, h_b [mm]	105	115	130	150	180
Grout thickness, t_{grout} [mm]	See the correct elevation from project drawings				
Spanner size [mm]	24	30	36	46	60
Recommended torque value, min-max [Nm]	120-170	150-330	200-570	250-1150	350-2640

2. Deliveries and storage on site

The steel members of the DELTABEAM® Frame are delivered to the site in lots according to the project schedule. The deliveries should be planned so that assembly is possible as soon as the goods have arrived on site. The surface treatment of the steel members is not designed for long-term weather exposure.

- ❑ Reserve a storage area for the steel members which is large enough, flat and is within the reach of the planned crane positions
- ❑ Prepare lifting and moving equipment for unloading the items from the truck
  NOTE: *the DELTABEAM® steel members are not loaded onto the truck in the order of installation. The steel members are marked with identification codes in accordance with the drawings.*
- ❑ Lay the steel members on wooden logs and to protect the surface treatment
- ❑ If the steel members are to be stored in piles place wooden logs between them and ensure that the pile is stable (see Figure 7)
- ❑ For long-term storage, cover the steel members

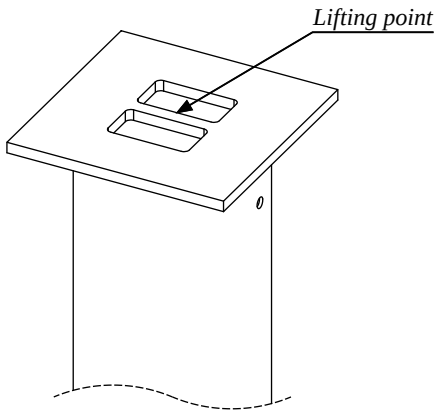
Figure 7. Storing of DELTABEAM® Frame steel members in piles.

Erecting columns

1. In the storage area

- ❑ Locate the next column in order according to the assembly plan
- ❑ Check the column identification label to ensure that the column is correct
- ❑ Ensure that the column is free of dirt, water, snow, and ice
- ❑ Check that the internal reinforcement is intact
- ❑ Lift the column using the hoist bracket located at the top of the column (see Figure 8)
  Attach the lifting hook directly to the lifting point.
  Do not use fabric slings between the hook and the lifting point
  The weight of the column is shown on the label attached on the column

Figure 8. Lifting point located at the top of the column.



2. At the assembly location

- ❑ Adjust the lower nuts and washers of the Peikko HPM® or PPM® Anchor Bolt to the correct level
- ❑ If the column needs to be propped, have the equipment ready
- ❑ Ensure the correct alignment of the column before laying it on the anchor bolts
- ❑ Lower the column onto the anchor bolts and install the upper washers and nuts
- ❑ Screw the upper washers and nuts onto the bolts and align the column to the vertical by adjusting the leveling nuts
- ❑ Tighten the nuts at least to the minimum given in the installation manual of Peikko's HPM® or PPM® Anchor Bolts. For HPM® Anchor Bolts see Table 1. For PPM® Anchor Bolts see the technical manual.
- ❑ If the column is to be propped, the diagonal props are fixed into the floor and to the threaded holes of the column profile (see Figure 9)
- ❑ Release the crane
- ❑ Grout the joint between the column's base plate foundation/floor using non-shrinking grout. See the installation manual for Peikko's HPM® or PPM® Anchor Bolts for further information

Figure 9. Propping a column.

Concreting columns

Columns can be filled with concrete by two different methods:

- Pumping from the bottom
- Filling from the top

The filling method affects the column design, so it is always decided during the design process.

1. Before concreting

- ❑ Ensure that the column is free of dirt, water, and ice
- ❑ Ensure that the column is installed in the correct vertical position
- ❑ Ensure that the steam holes are closed using plastic plug
- ❑ Ensure that there is a large enough opening at the top of the column to control the filling
- ❑ Ensure that the propping (if required) is intact
- ❑ Ensure that the concrete (grade, aggregate size, consistency) fulfills the planned requirements
- ❑ When pumping from the bottom, ensure that a suitable hose input joint (see Fig 10) is available and that it fits into the column and the concreting hose
- ❑ Have a shaft or form vibrator ready for compacting (if not using self-compacting concrete)

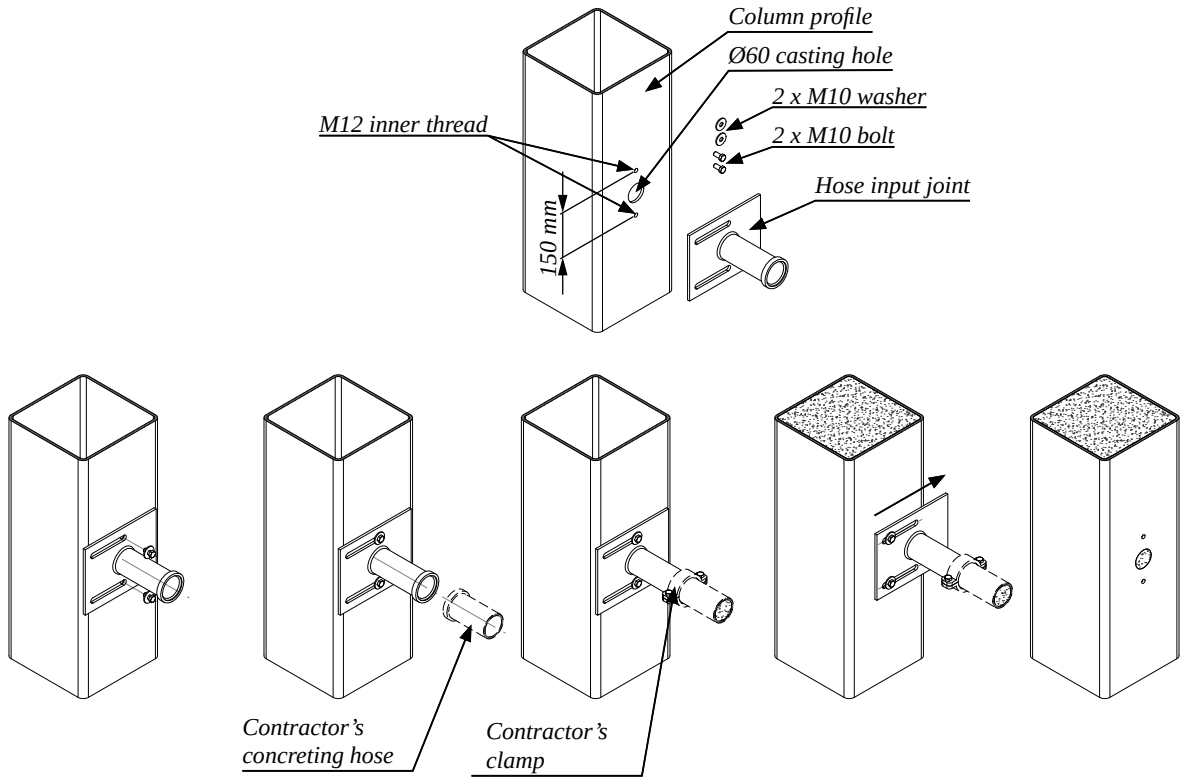
2. Receiving the concrete

- ❑ Self-compacting concrete: verify the consistency and temperature of each batch
- ❑ Regular concrete: check each batch visually
- ❑ Air-entrained concrete: measure the air content of the concrete in each batch

3. Concreting – pumping from the bottom

- ❑ Align the pump hose, avoiding sharp bends and steep climbs
- ❑ Before concreting, pump any inadequate concrete into a concrete waste dump
- ❑ Attach the hose to the input joint (see Fig 10)
- ❑ Start filling the column (recommended filling rate is 1 m/min)
- ❑ If the filling is blocked and the concrete pressure starts to rise, do not try to open the blockage by increasing the pump pressure
- ❑ When the concrete level reaches the top of the column, continue pumping as long there is segregated concrete coming out
- ❑ Take extra care that the concrete at the top end of the column is properly compacted and in the last 1.5 m from the top of the column if necessary
- ❑ Close the hose input joint by sliding the joint (see Fig 10)
- ❑ Remove the concreting hose and connect it to the next column
- ❑ Wipe any external concrete splatters from the column
- ❑ When 30 minutes have elapsed from the end of the concreting, check the level of concrete at the top of the column
- ❑ If the concrete level has dropped, top up the column with additional concrete and vibrate the top section as long as there are air bubbles coming up
  NOTE: *With self-compacting concrete, vibrate according to the instructions provided by the concrete supplier. Optionally, the top end can be filled by grouting.*
- ❑ When the concrete has hardened enough (approximately 12 to 24 hours) remove the input joint

Figure 10. Operating the hose input joint.

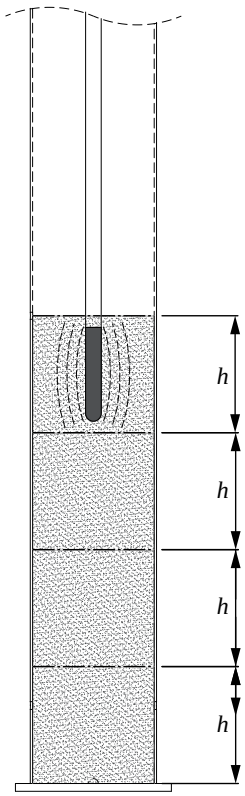


Concreting truck with pump.

4. Concreting – filling from the top

- ❑ Align the pump hose, avoiding sharp bends and steep climbs
- ❑ Before concreting, pump any inadequate concrete into a concrete waste dump
- ❑ Lower the vibrator to the bottom of the column
- ❑ Start filling the column (recommended filling rate is 1 m/min)
  To prevent segregation, minimize the drop height of the concrete. Never use a drop height of more than 1 m.
- ❑ Use the vibrator in vertical steps so that the maximum step size (h) is 30 cm (see Figure 11), simultaneously monitoring the filling and staying 10–20 seconds at each step. Do not move back and forth.
- ❑ Take extra care with vibrating for the last 1.5 m from the top of the column
- ❑ Wipe any external concrete splatters from the column
- ❑ When 30 minutes have elapsed from the end of the concreting, check the level of concrete at the top of the column
- ❑ If the concrete level has dropped, top up the column with additional concrete and vibrate the top section as long as there are air bubbles coming up
  NOTE: *With self-compacting concrete, vibrate according to the instructions provided by the concrete supplier. Optionally, the top end can be filled by grouting.*

Figure 11. Compacting the concrete in layers with a shaft vibrator.



5. Concreting at cold temperatures

When the air temperature is below +5 °C during casting or two days thereafter, a cold weather concreting plan must be prepared. Precautions should be taken when daily average temperatures remain below +10 °C. Rapid strength concrete is recommended. Higher strength concrete, cold weather concrete, or hot concrete may also be considered. Columns can be equipped with internal heating cables.

- ❑ Remove any snow and ice inside the column
- ❑ Ensure that the heating cables are intact
- ❑ Wrap the column in insulation material
- ❑ Monitor and record the temperature during the hardening process

Installing DELTABEAM® Composite Beams

Refer to the DELTABEAM® Slim Floor Structures, Technical Manual.

Technical Manual Revisions

Version: PEIKKO GROUP 11/2017. 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

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ISO 45001