A-BEAM S®

Design manual

Version 11/2021

CE

A-BEAM S®

A-BEAM® is a concrete-filled steel beam developed by Anstar Oy for placement inside a floor system. Thanks to a powerful composite effect, long span lengths and modifiable space solutions can be achieved affordably. In addition to hollow-core slabs, the beam can also be used for supporting thin-shell slabs, composite slabs and cast-in-place concrete slabs. The composite structures can be designed up to fire resistance class R120 without any additional protection on the site.

Saving space
Located inside the intermediate floor, the beam places no limitations on the use of space in the building.

Load-bearing capacity
The steel box beam and concrete produce a powerful composite effect, allowing for long span lengths.

Moisture control
The composite beam can be equipped with heating cables for quicker removal of moisture from inside the beam.

Connection technology
Anstar's experience as a professional in connections and fastenings ensures that the beam connections are quick to install and durable.

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Revision B. 26 November 2021

The A-BEAM S structure has been redesigned.
The standard range of standard beams has been expanded to composite column frames.
The beam's application range has been extended to thin-shell slab structures.
The strength of the beam's composite effect has been increased.
The beam's connection technology has been redesigned.
The beam has been determined with accident limit state design criteria.
The new version 5.0 of the ABeam software was published on 17 June 2021.

Revision A. 31 May 2018

Small corrections to text and figures. English version published.

Revision 0. 26 June 2017

Anstar Oy's new composite beam type is A-BEAM S.
Separate design and erection instructions have been prepared for the beam.
The beam's product approval is CE marking according to EN 1090-1.
The design software for the beam has been updated.
The new software version, ABeam 4.7, was published on 31 May 2018.

1 A-BEAM S

The Anstar S composite beam is designed as a load-bearing structure for intermediate floors and roofs. The beam is used with hollow-core slabs in structures where a flat beam frees the space beneath the slab for building services. The A-BEAM S has also been developed into a new application for continuous thin-shell slab floor structures. The continuous thin-shell slab achieves very slender structures with the A-BEAM S. The A-BEAM S is a sister product to the Anstar A-BEAM W.

In the A-BEAM S, the concrete dries and water evaporates from inside the beam in a favourable direction, i.e. through the grouting openings of the web, and there are also holes at the top edge of the beam to facilitate drying. The grouting inside the beam housing is performed on the site.

The beam's housing is made of steel plate, and its bending resistance is adjusted by means of reinforcement and the housing's plate thickness. The beam acts as a composite structure together with the hollow-core and thin-shell slabs and the slab's surface casting. The beam's composite-effect structures have been redesigned, improving their action with thin-shell slab structures in particular, which require significantly more composite effect. This gives the beam more bending resistance compared to the old housing type, allowing longer, more economical span lengths.

The beam is used as both a single-span and continuous-span structure and without separate fire protection up to fire resistance class R120. The beam has a new fire resistance design carried out in accordance with the latest European standards.

The beam's standard connection is the AEP hidden bracket to a reinforced concrete column and the AEL hidden bracket to a composite column. A connection library has also been prepared for the beam for typical connections to various frame structures.

Figure 1. A-BEAM S composite beam on a composite concrete/steel frame

2 A-BEAM S STRUCTURE

2.1 Composite beam manufacturing software

Anstar Oy's manufacturing programme for composite beams includes two beam types:

- **A-BEAM W** <u>The beam housing is filled with concrete at the workshop.</u> Well-suited to hollow-core slab floor structures, and particularly well-suited to continuous thin-shell slab floor structures. The beam's special application range is winter construction, with the concrete fill having good conditions to dry.
- **A-BEAM S** <u>The beam housing is grouted after erection on the site.</u> The beam is suitable for hollow-core slab floors and single-span thin-shell slab floor structures. The beam is also suitable for floors without surface casting.

These design instructions apply to the A-BEAM S to be grouted on the site.

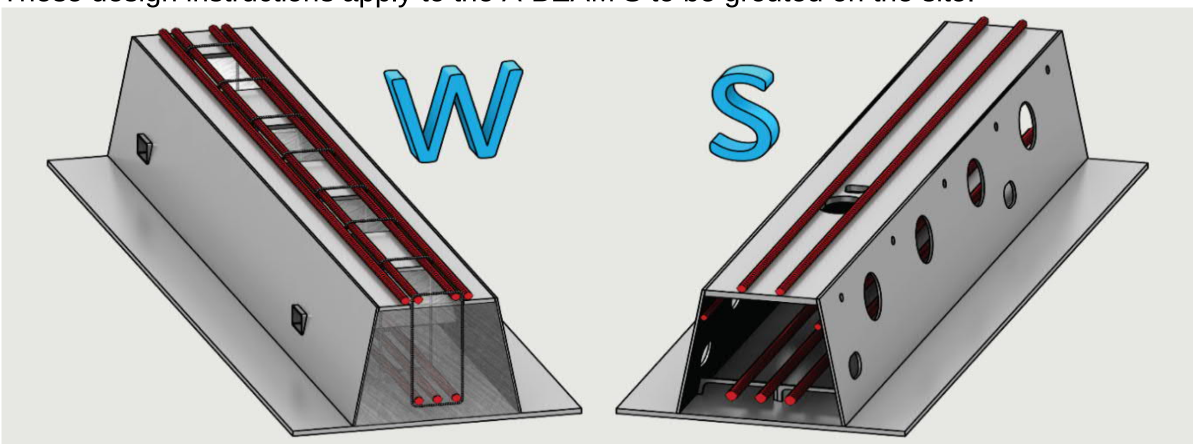


Figure 2. Structure of Anstar W and S composite beams

The A-BEAM S manufacturing programme has been adapted in accordance with the hollow-core slab height. The beam's width range has been adapted to the widths of standard concrete element columns and the most common composite tubular columns. Code 'A320S-400' stands for an A-BEAM S suitable for an OL320 hollow-core slab, with a web width of 400 mm on top of the lower flange. The beam is suitable for concrete columns B = 380 mm and composite columns B = 400 mm.

Table 1. A-BEAM S. Standard intermediate beams.

Intermediate beams	Hollow-core slab	Standard range according to column width							
A200S	200	A200S-200	A200S-250	A200S-300	By special order				
A220S	265	A220S-200	A220S-250	A220S-300	A220S-350				
A265S	265		A265S-250	A265S-300	A265S-350	A265S-400			
A320S	320		A320S-250	A320S-300	A320S-350	A320S-400	A320S-500		
A370S	370			A370S-300	A370S-350	A370S-400	A370S-500		
A400S	400				A400S-350	A400S-400	A400S-500	A400S-600	
A500S	500				A500S-350	A500S-400	A500S-500	A500S-600	A500S-700
A600S	500	Not applicable with this range					A600S-500	A600S-600	A600S-700

Table 2. A-BEAM S. Standard edge beams.

Edge beams	Hollow-core slab	Standard range according to column width					
A200S	200	AR200S-180	AR200S-230	AR200S-280	By special order		
A220S	265	AR220S-180	AR220S-230	AR220S-280	AR220S-330		
A265S	265		AR265S-230	AR265S-280	AR265S-330		
A320S	320		AR320S-230	AR320S-280	AR320S-330	AR320S-380	
A370S	370			AR370S-280	AR370S-330	AR370S-380	
A400S	400			AR400S-280	AR400S-330	AR400S-380	AR400S-430
A500S	500	Not applicable with this range			AR500S-330	AR500S-380	AR500S-430

2.2 Applications for A-BEAM Ss

2.2.1 A-BEAM S in the building's frame system

The A-BEAM S is used as a load-bearing intermediate floor and roof beam in concrete element and composite column frames where the load-bearing floor structure consists of a hollow-core slab or a continuous thin-shell slab cast-in-place. The web widths of the beam are selected according to the standard element column widths (B280–B580), allowing the floor slab to pass concrete/composite columns without narrowed slabs. For composite columns, there are intermediate size beams 250, 350 and 450, allowing beams with the width of standard tubular columns in composite column frames.

The A-BEAM S can also be used for mixed frame connections due to the connection solutions developed for different frame materials and load-bearing structures. The beam is connected to a reinforced concrete or composite column or a concrete wall using either AEP or AEL hidden brackets, or on load-bearing structures using normal connection methods. The beam can be used as a multi-span Gerber beam hanger going over supports, with the beam coupler connection located in the field. Another composite beam can also be connected to the side of an A-BEAM S.

Therefore, the W and A-BEAM Ss can be used in the same frame system to benefit from each beam's best properties with different floor structures.

2.2.2 A-BEAM S in a hollow-core slab floor

The beam is used to create a floor structure with no structures hindering building services under the floor. The beam acts as a composite structure with hollow-core slabs and surface casting, enabling longer span lengths and more slender structures.

1. **Floor surface structures**
   The beam's optimal application range is achieved with a surface slab that is at least 40 mm thick and reinforced over the beam. Composite effect structures are on the web of the beam and, in the redesigned beam, also on top of the beam, so concrete and transverse reinforcement significantly increase the effectiveness of the beam.

   The minimum thickness of the concrete topping acting as a composite structure is 40 mm, and it can be implemented in the roof with a reinforced concrete bay located in the insulation space. The reinforced concrete topping significantly increases the bending resistance of the structure and also protects the top surface of the beam against corrosion and fire. In other cases, the upper flange and its reinforcements must be protected separately.

   The beam can also be used without a surface slab, but then the composite effect of the concrete outside the beam cannot be fully utilised.

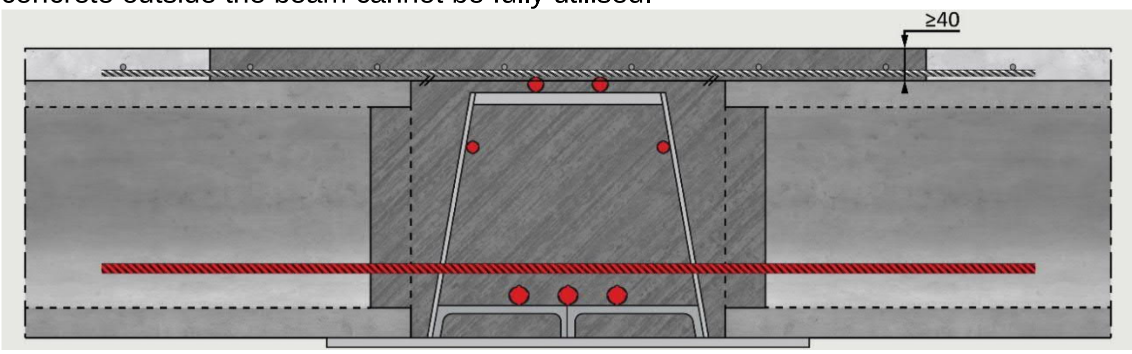


Figure 3. Intermediate floor structure, reinforced surface slab

2. Floor edge beams

The beam can be erected against the exterior wall element at the edge of the floor, and an edge bay can be cast up to the surface of the exterior wall. The beam can be raised using flange elevation parts. These can be used to increase the resistance of the beam and reduce deflection in floors with the necessary space. The beam can also be used to implement slight level differences in the top surface of the slab as necessitated by various surface materials, for example.

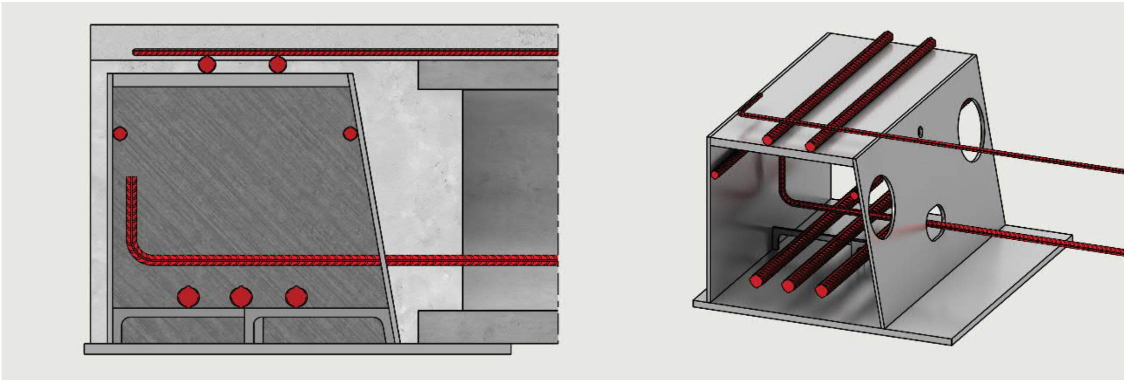


Figure 4. Edge beam structure in a hollow-core slab floor

3. Floor opening support

The S edge beam can be used to create large floor openings as the beam can be supported on load-bearing vertical structures. In this case, however, the beam's vertical web must be fire-protected.

Developed for smaller floor openings, an AOK support can be used to support the opening's edge slab up to 4.8 m opening widths. Therefore, the W beam and AOK support can be used to create the entire floor structure. AOK support's vertical web does not need fire protection, and it can be left as a finished surface structure.

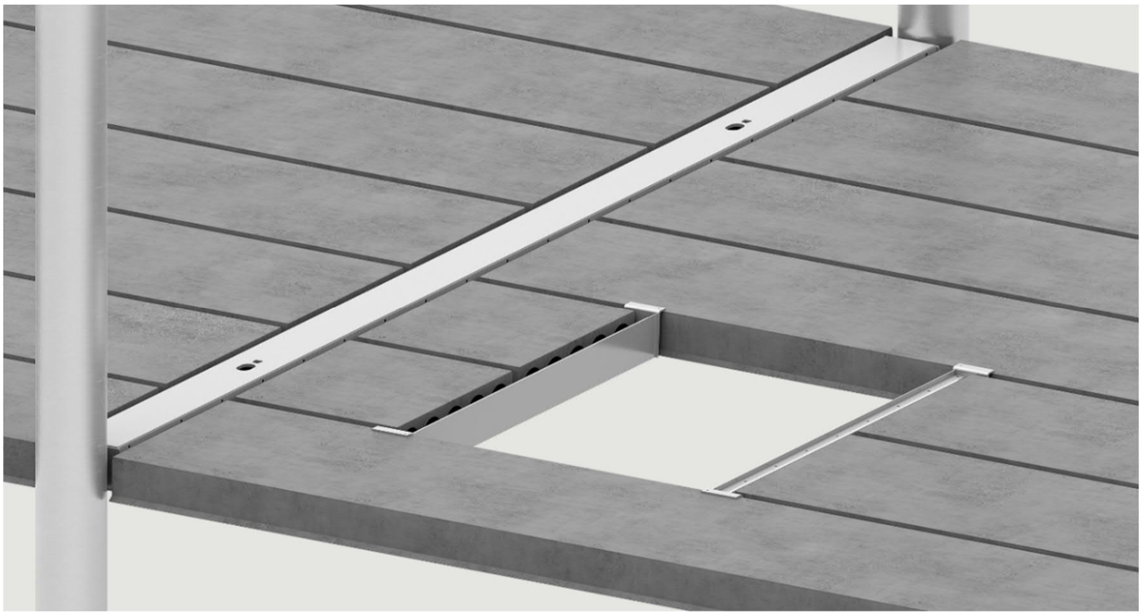


Figure 5. Floor opening support using AOK support

2.2.3 A-BEAM S in a thin-shell slab floor

The optimal and most effective application range of the A-BEAM S is a structure where the thin-shell slab is made into a continuous floor slab. Through continuity, the slab thickness can be reduced, and the composite effect of the concrete slab fully utilised in the A-BEAM S.

1. **Structures of a thin-shell slab floor**
   The thin-shell slab is placed on an elevation part in the A-BEAM S, as the height of the beam is usually not sufficient for a slender concrete slab. However, using this method, the overall height of the floor can be optimised with the A-BEAM S to the minimum, forming a slender and optimal structure.

   The beam's composite-effect structures are on the web of the beam and partly on top of the upper flange, and the thin-shell slab is placed with the top surface reinforcement of the screeding carried over the beam's reinforcements. The concrete slab and its transverse reinforcement greatly increase the beam's composite effect and thus its effectiveness.

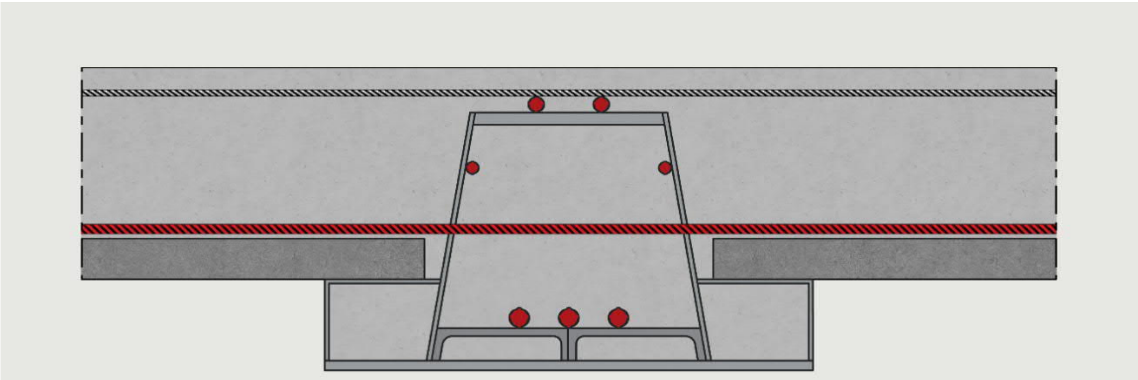
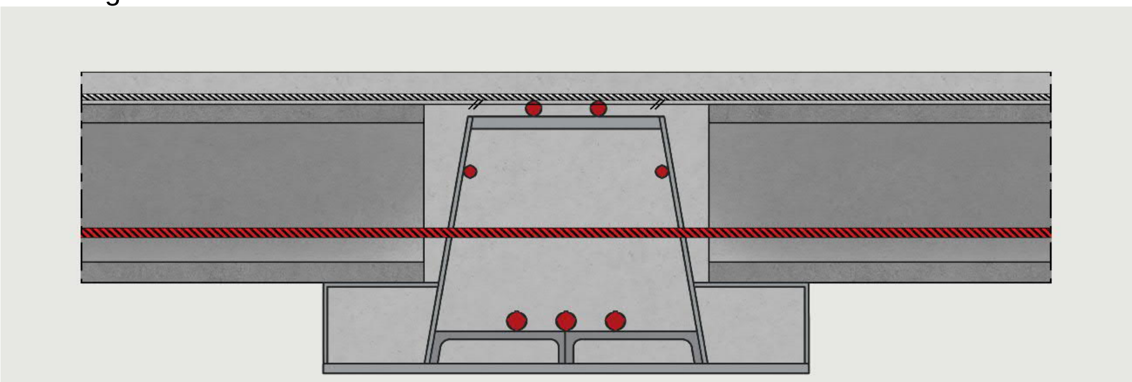


Figure 6. A-BEAM S in a thin-shell slab floor with reinforced screeding.

2.2.4 A-BEAM S with an elevation part in a hollow-core slab floor

The A-BEAM S can be used with long span length and high loads by elevating the beam with L steels welded onto the flange. Through continuity, the slab thickness can be reduced and the composite effect of the concrete slab fully utilised in the A-BEAM S.

1. **Slab floor construction in a hollow-core slab floor**
   The elevation parts can be on one or both sides of the beam and also of different heights, in which case the height of the slab on the different sides of the beam can also be changed.



2.3 A-BEAM S for centre line

An intermediate beam is used for a line with slabs on both sides of the beam. The web width is selected according to the column width and the beam height according to the hollow-core slab. The beam's connection bracket is located on the centre line of the profile (and column). Legend: See page 10.

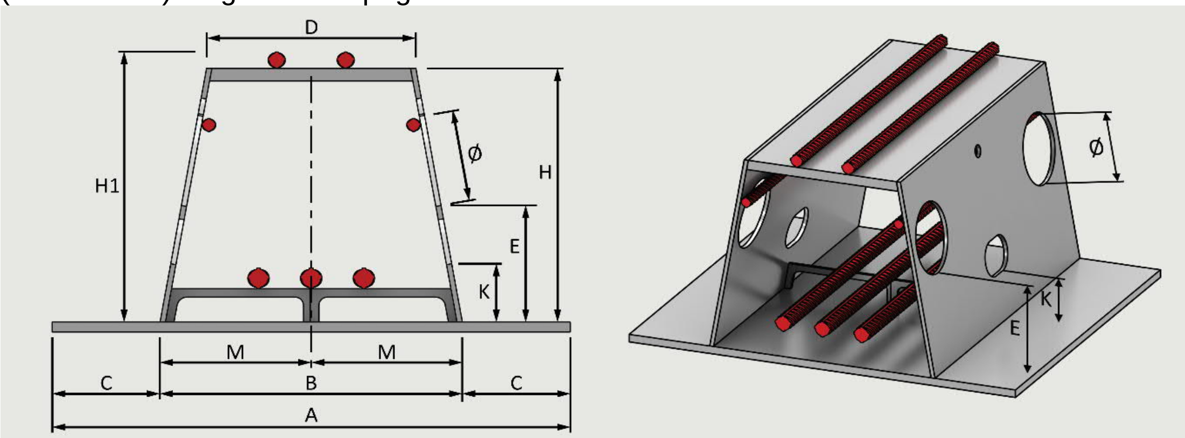


Figure 7. Intermediate beam structure.

Table 3. Intermediate beam dimensions

Beam code	A mm	B mm	C mm	D mm	H mm	H1 mm	E mm	Ø mm	K mm	M mm
A200S-200	396	200	98	130	200	212	45	110	–	100
A200S-250	446	250	98	180	200	212	45	110	–	125
A200S-300	496	300	98	230	200	212	45	110	–	150
A220S-200	396	200	98	123	220	232	55	110	–	100
A220S-250	446	250	98	173	220	232	55	110	–	125
A220S-300	496	300	98	223	220	232	55	110	–	150
A220S-350	546	350	98	273	220	232	55	110	–	175
A265S-250	446	250	98	160	255	271	95	110	60	125
A265S-300	496	300	98	210	255	271	95	110	60	150
A265S-350	546	350	98	260	255	271	95	110	60	175
A265S-400	650	400	125	310	255	271	95	110	60	200
A320S-250	446	250	98	144	305	325	140	110	65	125
A320S-300	496	300	98	194	305	325	140	110	65	150
A320S-350	546	350	98	244	305	325	140	110	65	175
A320S-400	650	400	125	294	305	325	140	110	65	200
A320S-500	750	500	125	394	305	325	140	110	65	250
A370S-300	550	300	125	177	355	375	155	140	70	150
A370S-350	600	350	125	227	355	375	155	140	70	175
A370S-400	650	400	125	277	355	375	155	140	70	200
A370S-500	750	500	125	377	355	375	155	140	70	250
A400S-350	600	350	125	218	380	405	155	160	70	175
A400S-400	650	400	125	268	380	405	155	160	70	200
A400S-500	750	500	125	368	380	405	155	160	70	250
A400S-600	850	600	125	468	380	405	155	160	70	300
A500S-350	600	350	125	185	475	500	230	180	70	175
A500S-400	650	400	125	235	475	500	230	180	70	200
A500S-500	750	500	125	335	475	500	230	180	70	250
A500S-600	850	600	125	435	475	500	230	180	70	300
A500S-700	950	700	125	535	475	500	230	180	70	350
A600S-500	750	500	125	300	575	600	300	200	140	250
A600S-600	850	600	125	400	575	600	300	200	140	300
A600S-700	950	700	125	500	575	600	300	200	140	350

2.4 A-BEAM S for edge line

An edge beam is used for a line where the slab is supported on one side of the beam only. The web width is selected according to the column width and the height according to the hollow-core slab. With long span lengths, the housing can be elevated using an elevation profile welded to the lower flange.

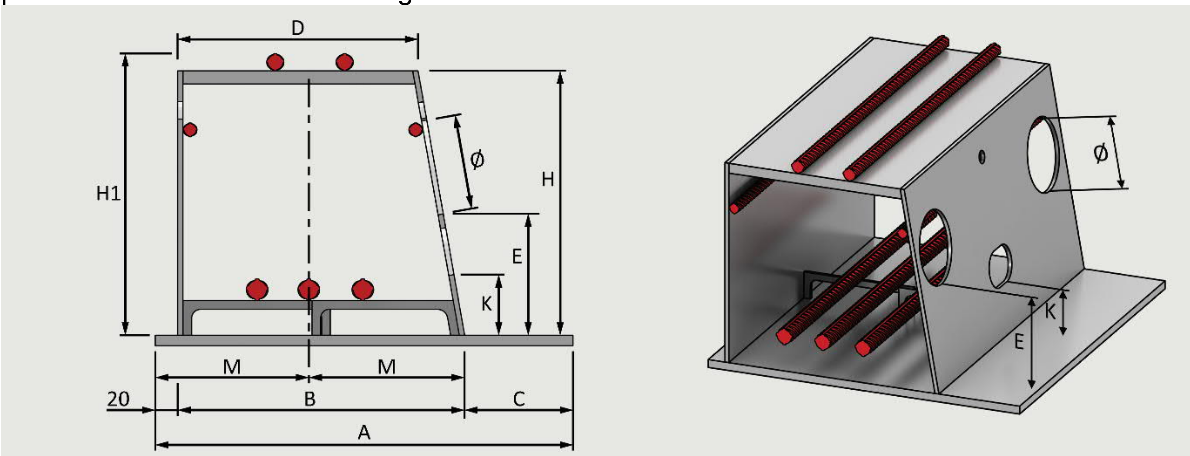


Figure 8. Edge beam structure.

Table 4. Edge beam dimensions

Beam code	A mm	B mm	C mm	D mm	H mm	H1 mm	E mm	Ø mm	K mm	M mm
AR200S-180	298	180	98	145	200	212	45	110	–	100
AR200S-230	348	230	98	195	200	212	45	110	–	125
AR200S-280	398	280	98	245	200	212	45	110	–	150
AR220S-180	298	180	98	142	220	232	55	110	–	100
AR220S-230	348	230	98	192	220	232	55	110	–	125
AR220S-280	398	280	98	242	220	232	55	110	–	150
AR220S-330	448	330	98	292	220	232	55	110	–	175
AR265S-230	348	230	98	185	255	271	95	110	60	125
AR265S-280	398	280	98	235	255	271	95	110	60	150
AR265S-330	448	330	98	285	255	271	95	110	60	175
AR320S-230	348	230	98	177	305	321	140	110	65	125
AR320S-280	398	280	98	227	305	321	140	110	65	150
AR320S-330	448	330	98	277	305	321	140	110	65	175
AR320S-380	498	380	98	327	305	321	140	110	65	200
AR370S-280	425	280	125	218	355	371	155	140	70	150
AR370S-330	475	330	125	268	355	371	155	140	70	175
AR370S-380	525	380	125	318	355	371	155	140	70	200
AR400S-280	425	280	125	214	380	400	155	160	70	150
AR400S-330	475	330	125	264	380	400	155	160	70	175
AR400S-380	525	380	125	314	380	400	155	160	70	200
AR400S-430	575	430	125	364	380	400	155	160	70	225
AR500S-330	475	330	125	247	475	495	230	180	70	175
AR500S-380	525	380	125	297	475	495	230	180	70	200
AR500S-430	575	430	125	347	475	495	230	180	70	225

Legend:

A = Lower flange width	H1 = Overall beam height
B = Web width at bottom	E = Grouting hole lower edge height
C = Flange projection width	Ø = Grouting hole diameter
D = Web width at top	K = Torsional steel hole height
H = Beam housing height	M = Beam/bracket positioning dimension in column

The torsional steel hole is 55*80, spacing 1200 mm in the hollow-core slab joints.

3 PRODUCT APPROVAL AND MANUFACTURING INFORMATION

ANSTAR Oy has entered into a quality control agreement with KIWA Inspecta Oy regarding the manufacture of steel parts for composite beams.

1. *Manufacturing markings*	The beams feature manufacturing markings: - CE marking according to SFS-EN 1090-1 for steel parts.[1] - ANSTAR Oy's code - Beam code and weight
2. *Materials*	The manufacturing materials used meet the following SFS-EN standards: - Web and flange plates SFS-EN 10025 S355J2+N - Reinforcement EN 10080 B500B - Concrete grouting inside the housing minimum C25/30 class 2
3. *Manufacturing method*	- Beams are manufactured according to SFS-EN 1090-2 in execution class EXC2 or EXC3. [2] - Welding class C or B SFS-EN ISO 5817. [9] - Rebar welding SFS-EN 17760-1. [16]
4. *Surface treatment*	- The lower flange, 50 mm of the web and the end plate are painted. - Painting: SFS-EN ISO 12944-5 A60 workshop priming – FeSa2.5. [12] - By special order, hot-dip galvanisation according to SFS-EN ISO 1461. [13] - Service life design more specifically in Section 5.6
5. *Product approval and quality control*	- Manufacture according to SFS-EN 1090-2 in execution class EXC2 or EXC3. - CE marking according to standard EN 1090-1. - CE marking certificate: 0416-CPR-7247-03.

4 A-BEAM S DESING CRITERIA

4.1 Design and manufacturing standards

1. Finnish European standards:

The beams are designed according to the following standards:

SFS-EN 1991-1+NA	Actions on structures. Part 1-1: General actions. [5]
SFS-EN 1992-1+NA	Design of concrete structures. Part 1-1: General rules and rules for buildings. [6]
SFS-EN 1993-1-1+NA	Design of steel structures. Part 1-1: General rules and rules for buildings. [7]
Concrete Code Card	No. 18EC (EN 1992-1-1) 31 July 2012. Designing a hollow-core slab floor system supported by beams. [20]

2. Other countries in the European Standards area

Basic Eurocode	EN-1992-1-1:2004/AC:2010
Sweden	SS-EN 1992-1:2005/AC:2010+A1/2014 + EKS 11
Germany	DIN-EN 1992-1 +NA/2013–04

3. Beam manufacture

SFS-EN 1090-1	Execution of steel structures. Part 1: Requirements for conformity assessment of structural components. [1]
SFS-EN 1090-2	Execution of steel structures. Part 2: Technical requirements for steel structures. Execution classes EXC2 and EXC3. [2]
SFS-EN 13670	Execution of concrete structures. Execution class 2 or 3. [17]
SFS-EN ISO 5817	Welding. Fusion-welded joints in steel, nickel, titanium and their alloys. Weld classes. [9]
SFS-EN 17760-1	Welding. Welding of reinforcing steel. Part 1: Load-bearing welded joints. [16]

4.2 A-BEAM S design instructions for the main structural designer

4.2.1 Applications for the beams

The beams are used as load-bearing structures for hollow-core slab floors in office, commercial, public, and industrial buildings as well as multi-storey car parks. Typical applications include the following frame systems:

1. Concrete element and mixed frame systems	- The columns are multi-storey reinforced concrete columns, and the floors are made of hollow-core or thin-shell slabs. - The beam is designed as a single-span structure and connected to a concrete column using an AEP bracket. - In roofs, a multi-span, continuous structure going past the column can be used, in which case the coupler connection is located in the field. - Similarly, a continuous or cantilever structure can be used in mezzanine floors when the column ends below the floor.
2. Composite frame systems	- The columns are multi-storey composite tubular columns, and the floors are made of hollow-core or thin-shell slabs. - The beam is designed as a single-span structure and connected to a composite column using an AEL bracket. - In roofs, a multi-span, continuous structure going past the column can be used, in which case the coupler connection is located in the field. - Similarly, a continuous or cantilever structure can be used in mezzanine floors when the column ends below the floor.
3. Floor structures	- There may be a structurally reinforced surface casting on top of the hollow-core slab, or the surface may be created using filler or without a surface structure. - The bending resistance of the structure can be significantly increased by desing a reinforced surface slab to produce a composite effect as part of the load-bearing structure of the beam.

4.2.2 Selecting the beam as the building's floor beam

The beam is selected as the load-bearing structure for the building's hollow-core slab floor for a design-and-build deal as follows:

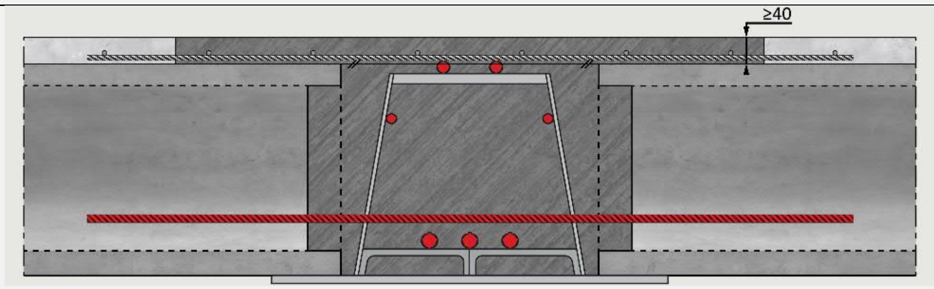
1. Hollow-core or thin-shell slab	- The hollow-core slab is designed according to the loads on the floor and the span length of the slab, taking into account that it is supported on a flexible lower flange. - The thin-shell slab is designed for the concrete load, and slab erection supports can be used to reduce the pouring load on the beam.
2. Beam cross-section	- The beam's cross-section dimensions are selected according to the hollow-core slab height and column width. - Preliminary design of the structure is carried out using the ABeam version 5 design software that can be downloaded from the Anstar website. - The software performs preliminary design of the cross-section according to the hollow-core or thin-shell slab selected. - The software also performs the preliminary design of the shear resistance of the slab's ribs according to Concrete Code Card 18EC
3. Hidden bracket suitable for the beam	- Connections to concrete columns are made using AEP-C hidden brackets and connections to concrete-filled composite tubular columns using AEL-C hidden brackets. - Design software selects the hidden bracket suitable for the purpose. - Connections transferring the beam end's reactive moment cannot be formed using AEP and AEL hidden brackets. - Structurally, it is not allowed to create a situation in which a hidden bracket connection transfers the beam end's reactive moment. - Vertical angle change must be allowed for the hidden bracket connection after joint grouting and surface casting such that the top surface of the bracket's tongue acts as the pivot point of the connection. - The space between the beam's end plate and the column must not be grouted full.

4.3 Structural function of the A-BEAM S

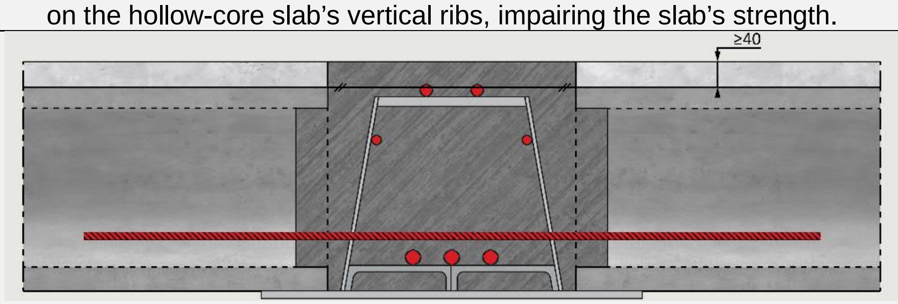
4.3.1 Functional cross-section

Together with the concrete of the housing, the joint grouting and the concrete of the surface slab and hollow-core slab's top rib, the beam creates a composite structure whose functional cross-section includes the following parts of the floor structures:

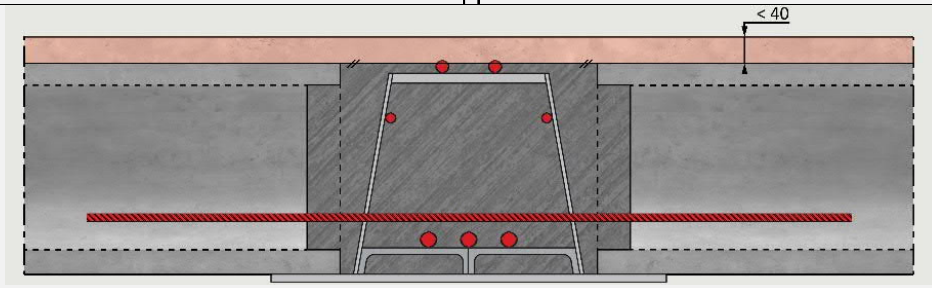
1. Surface slab ≥ 40 mm with sufficient transverse reinforcement. Recommended structure.

1. Slab structure	- A surface slab of structural concrete with structural transverse reinforcement ≥ T8K200 extending over the beam is poured onto the hollow-core slab.
2. Functional cross-section	- Concrete structures in the dark grey area are part of the functional composite structure cross-section. - The surface slab reinforcement spreads the splitting caused by slab deflection and slab end torsion to a wider area, preventing uncontrolled splitting of the surface slab. - The surface slab reinforcement also reduces the shear flow stresses in the hollow-core slab's vertical ribs, calculated according to NK 18. - Additional filling of the hollow core is not included in calculating the functional cross-section. - It is used to increase the shear flow resistance of the hollow-core slab's ribs.
3. Beam structure	 Figure 9. Functional cross-section of the A-BEAM S, reinforced surface slab.

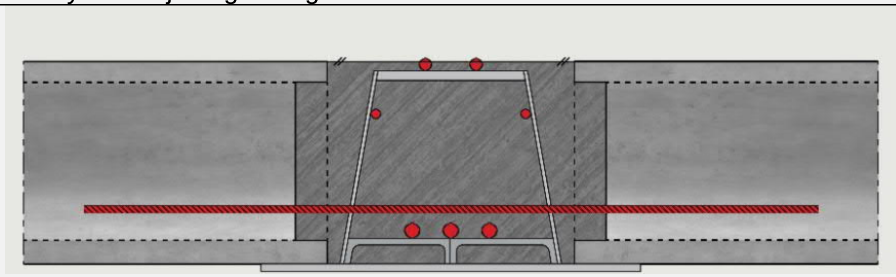
2. Surface slab ≥ 40 mm without transverse reinforcement. Non-recommended structure.

1. Slab structure	- A surface slab of structural concrete without structural transverse reinforcement extending over the beam is poured onto the hollow-core slab. - Anti-cracking mesh is not a required reinforcement.
2. Functional cross-section	- Concrete structures in the dark grey area are part of the functional composite structure cross-section. - Only concrete and joint grouting and surface casting on top of the beam are included in the functional cross-section. - The surface slab being without reinforcement, slab deflection and slab end torsion create cracks in the slab end and upper beam corner area. - The non-reinforced surface slab causes significant shear flow stresses on the hollow-core slab's vertical ribs, impairing the slab's strength.
3. Beam structure	 Figure 10. Functional cross-section of S the beam, non-reinforced surface slab.

3. Surface slab created using filler

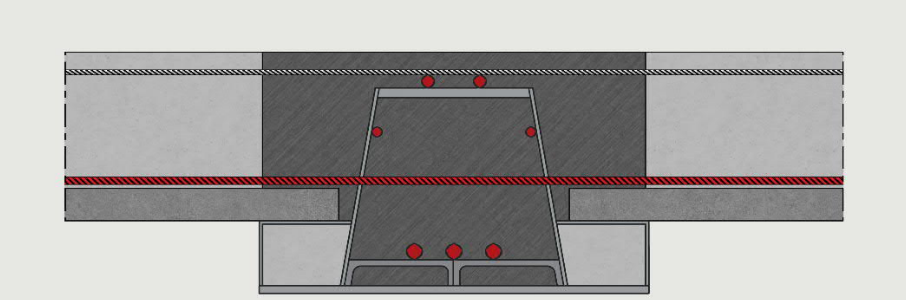
1. *Slab structure*	- A cement-based filler layer is poured over the hollow-core slab.
2. *Functional cross-section*	- The functional composite structure cross-section includes the concrete structures in the hatched area of the figure. - Only the concrete and joint grouting on top of the beam are included in the functional cross-section. The composite effect of the beam is very weak. - Cement-based fillers can also be used to provide the beam's top surface rebars with sufficient fire and corrosion protection. - The beam being without surface slab, slab deflection and slab end torsion create cracks in the slab end and upper beam corner area.
3. *Beam structure*	 Figure 11. Functional cross-section of the A-BEAM S with a filler layer

4. Hollow-core slab floor without surface structure

1. *Slab structure*	- No structural concrete is poured directly on top of the hollow slab, or there may be thermal or water insulation layers there. The upper slab is not included in the functional cross-section.
2. *Functional cross-section*	- The functional cross-section of the structure consists of the concrete of the joint in an area the width of the ends of the hollow-core slabs. - The composite effect of the beam is very weak. - In this case, it must be taken into account that the load deflection of the hollow-core slab causes splitting in the grouting in the area between the end of the slab and the web. - Sufficient fire and corrosion protection for the beam's top surface rebars must be ensured by other structures. - By special order, the beam can be made with a low 20-mm elevation part to give the upper surface a sufficient layer of protective concrete layer with joint grouting.
3. *Beam structure*	 Figure 12. Functional cross-section of the A-BEAM S without a top concrete

5. Continuous thin-shell slab floor

1. *Slab structure*	- The load-bearing slab consists of the thin-shell slab and concrete topping cast on top of it. The A-BEAM S must always have elevation parts. - The slab's top surface rebars must extend over the beam, and the bottom surface rebars can be anchored on the elevation part's support. If necessary, additional steel can be passed through the beam in the torsional steel tube.
2. *Functional cross-section*	- The functional composite structure cross-section includes the concrete structures in the hatched area of the figure. - Top surface reinforcement prevents splitting in the upper beam surface due to slab deflection and slab end torsion. - The thin-shell slab acts as a continuous slab, providing the beam with a significant composite effect.

3. Beam structure	 Figure 13. Functional cross-section of A-BEAM S, reinforced continuous slab.

4.3.2 Beam loads and resistances

The resistance values of the structure are calculated taking into account the development of the load history from the beam's erection to the final stage. It is also taken into account that structures are connected to the load-bearing cross-section at different times. The nominal loads and load combination are specified according to the principles below. The consequence class and reliability class are the same as for the building frame, and the manufacture execution classes are determined accordingly.

1. Consequence and reliability classes as well as manufacture execution classes

Consequence class/ reliability class	Steel structure's execution class SFS-EN 1090-2:2018	Concrete structure's execution class SFS-EN 13670	Note:
CC1/RC1	EXC2	Execution class 2	
CC2/RC2	EXC2	Execution class 2	Standard delivery
CC3/RC3	EXC3	Execution class 3	

2. Loads and design criteria

1. Live load during erection	- The design load during the erection stage is the dead load of the hollow-core slab with joint grouting and the live load of 0.5 kN/m2. - Other live loads during erection are possible, and information on these must be specified in the design-and-build deal drawings. - The moment of design during the erection stage: 1. Joints have been grouted but the grouting has not hardened yet. 2. Surface casting has been performed but it has not hardened yet.
2. Erection supports for the beams	The beam can either be erected without erection support or be supported for the hollow-core slab loads during erection. Erection support is provided according to the following principles: ***1. No erection supports*** The beam and its connections and load-bearing vertical structures withstand loads during erection as well as the torsional moment from the hollow-core slabs and the additional torsion caused by the play of the brackets. ***2. Erection supports at the end of the beam*** The erection support eliminates torsion to the connection during erection and prevents additional torsion caused by the play of the brackets. A typical case. ***3. Erection supports on the beam span*** Deflection and torsion of the beam during erection are limited by means of erection supports placed at the third-points to reduce the torsion transferred to the end connections. - Erection support is presented in more detail in Section 3.3 of the erection manual. - Anstar also provides project-specific instructions for beam-specific erection support on the site.
3. Erection	- Erection supports for the thin-shell slab should be used due to the

supports for the slab	slab's load-bearing capacity and the pouring load on the beam. - The thickness of the thin-shell slab and the need for erection supports are specified in the reference plans.
4. Ultimate limit state (ULS)	- The beam acts as a composite structure in ultimate limit state (ULS) conditions. - The design takes into account that the various structures (including the surface slab) and loads are connected to the functional cross-section at different times. - The design is performed using software.
5. Design for fire situations, suspension, torsional steel	- Beams can be designed up to fire resistance classes R15–R120 without fire protection of the lower flange. - In a fire situation, the hollow-core slab is suspended on the beam using pieces of torsional steel. - The torsional steel going through the beam ties the torsion caused by the eccentric load of the hollow-core slab to the beam.
6. Accident limit state (ALS)	- If necessary, a design analysis for accident situations can be performed according to SFS-EN 1992-1-1, Section 2.4.2.4, by using the partial safety factors in the accident limit state indicated in Table 2.1N of the standard to determine the resistance of the structure in exceptional situations. [6].
7. Dynamic loads	- Loads including dynamic effects are taken into account according to SFS-EN 1990-1, Section 4.1.5, by multiplying the static specific loads by the corresponding dynamic enlargement factors or factors determined by other means. - The dynamic load must not constitute a fatigue action.
8. Earthquake design	- Earthquake design is taken into account in the load combination according to SFS-EN 1991-1[5]. Therefore, the partial safety factor level of the load is selected in accordance with the European standard. - Earthquake design can be made using the so-called lateral force method without separate analyses. - The main structural planner determines the percentage of lateral force of the permanent and variable loads.
9. Fatigue actions	- The A-BEAM S has not been designed for fatigue actions. - Fatigue design is performed separately on a case-specific basis according to the principles in SFS-EN 1990-1, Section 4.1.4. [4] - The A-BEAM S's composite-effect structures create a resilient connection partly based on the rebar bond. - However, part of the composite effect comes from the concrete studs in the grouting openings of the web, whose fatigue resistance must be determined separately.
10. Using the beams at low temperatures	- The impact strength of the beam's standard materials is tested at –20 ^{o}C. - At operating temperatures lower than this, the material requirement must be increased in the reference plans.
11. Prevention of progressive frame collapse	- The main structural designer determines which system is used to prevent progressive frame collapse according to SFS-EN 1991-1-7, Section 3 and Annex A. - If beam lines are used as frame tying lines, this usually requires an additional part welded at the connections. - The columns or the space between or around them must have a space provision for an extra connection piece. - The main structural designer determines the tying force T_i. - The erection is the responsibility of the construction site.

4.3.3 Structural design of the beam and connections

1. Structural beam design details:

1. Circular reinforcement	- The hollow-core slab floor is stiffened into a functional plate structure using circular reinforcement. - The circular reinforcement is designed according to SFS-EN 1991-1-7. - It is designed by the main structural designer. - The reinforcement is located in the joint between the web and slab, above the torsional steel. - The reinforcement transfers the loads from the plate stiffening to the vertical stiffeners. AEP and AEL hidden bracket connections have been designed for horizontal load during erection, but they do not transfer the circular reinforcement forces. - The longitudinal resistance of the bracket connection is intended for exceptional erection stage loads when the circular reinforcement is not functioning yet. - In an ultimate limit state, the brackets must not be included in calculating the functional horizontal stiffening. - At the same time, the pieces of torsional steel act as part of the circular reinforcement, tying the hollow-core slabs to each other through the housing. The design is performed according to SFS-EN 1991-1-7.[5] - The torsional reinforcement calculated by the software does not include the catastrophe design required by the standard.
2. Joint action of the hollow-core slab	- The ABeam software designs the shear resistance of the hollow-core slab's ribs according to Concrete Code Card 18EC. - The joint action can also be checked using the Flexible software available from the Elementtisuunnittelu.fi website. - The final resistance analysis of the hollow-core slabs always belongs to the slab supplier. - If necessary, during the project implementation phase, Anstar can check the joint action of the hollow-core slab using the final material and cord data received from the slab supplier.
3. Filling of the hollow core	- The resistance of the profile does not normally require additional filling of the hollow cores other than for the minimum length of 50 mm required by Concrete Code Card 18EC. - Additional filling of the hollow cores is required in order to increase the shear flow resistance of the slab's ribs; the slab designer provides instructions for this. - With additional filling of the hollow cores, the shear flow resistance of the hollow-core slab's ribs can be significantly increased compared to standard filling, resulting in substantial savings in the slab's structure. - The additional filling can be designed with the ABeam software.
4. Surface slab reinforcement	- Reinforcing the surface slab significantly increases the beam's bending resistance and the slab's shear resistance. - The surface slab is dimensioned to produce a composite effect together with the rest of the structure when the slab thickness is at least 40 mm. - Transverse reinforcement is placed in the surface slab, also evening out the cracks in the surface slab and ensuring the composite effect.
5. Splitting of the surface slab	- Deflection of the hollow-core slab causes torsion at the slab's support, causing cracks in the joint grouting between the end of the hollow-core slab and the housing. - The effect of the cracks must be taken into account in selecting the surface structures. The cracks cannot be prevented, but they can be limited by using, for example, a reinforced surface slab or flexible floor surface materials, allowing for splitting of the surface slab at the end of the hollow-core slab.
6. Vertical	- The surface slab tends to move away from the top surface of the

separation of the surface slab	beam due to the lifting force caused by beam deflection. - To eliminate this phenomenon, the beam's top surface has horizontal bars bonding the surface slabs to the beam.
7. Removing moisture from inside the housing	- The housing is only grouted on the site after the slabs have been erected. - The moisture is removed through the grouting openings in the beam's web. - However, the final drying of the inner parts of the housing must be taken into account in scheduling the manufacture of the surface structures.
8. Structure's service life and durability design	- Service life and durability design is performed according to SFS-EN 1992-1-1, Section 4. - The surface treatment and protection requirements are specified in Section 5.7 of this manual. - Durability design must be performed separately for the upper and lower structures of the housing if they have different exposure classes.

2. Division of responsibilities and allocation of tasks in designing connections

Connections to load-bearing frame	Main structural designer's tasks and responsibilities	Anstar Oy's tasks and responsibilities
1. Bracket connection to concrete column	- Selects the connection type and preliminary bracket type and size. - Responsible for placement of the bracket's column component as well as the bracket's supplementary reinforcement in the concrete column. - Responsible for fire protection of the bracket.	- Calculates the bracket's final forces during the erection stage and final stage and confirms the resistance of the bracket selected. - Specifies the erection supports necessary. - Provides load data for the connection.
2. Bracket connection to composite column	- Selects the connection type and preliminary bracket size. - Responsible for placement of the bracket's column component in the composite column, supplementary reinforcement and welding the bracket to the column surface.	- Calculates the bracket's final forces during the erection stage and final stage and confirms the resistance of the bracket selected. - Specifies the erection supports necessary. - Provides load data for the connection.
3. Bolt connections on top of a column or wall	- Selects the connection type and preliminary bolt dimensions. - Performs final design of the connection using forces received from the beam design unit. - Responsible for bolt design in the concrete structure.	- Calculates the final forces on the connection during the erection stage and final stage. - Provides the main structural designer with data on the forces on the connection. - Designs the necessary provisions for the beam.
4. Welded connection to a mounting plate on top of a column or wall	- Selects the connection type and mounting plate dimensions. - Performs final design of the connection using forces received from the beam design unit.	- Calculates the final forces on the connection during the erection stage and final stage. - Provides the main structural designer with data on the forces.

	- Responsible for design of the mounting weld of the mounting plate and end plate in the concrete structure.	- Designs the necessary connection provisions for the beam.
5. Coupler connection in the field or secondary beam connection	- Preliminary placement of coupler connections. - Connections are taken into account in designing the rest of the floor structure.	- Designs and implements the connections on the beams.
6. Other special connections	- The division of responsibilities must always be agreed case-specifically in the detail design phase.	- If necessary, Anstar delivers data on the forces loading the connection. - Anstar manufactures the connection pieces needed for the beam.

5 A-BEAM S DESIGN

5.1 Design-and-build deal

Design phases:
Anstar Oy is responsible for designing and manufacturing the beams as part of a design-and-build deal. Our technical support will provide assistance with questions arising in various phases of the design process.
The design responsibilities in the design-and-build deal are as follows:

1. Allocation of design tasks in the bidding phase

Main structural designer	Anstar Oy
- Comparing frame options - Preliminary design of floor structures - Preliminary design of the beam - Preliminary design of the hidden bracket - Preliminary detail design - Preliminary connection design - Service life design - Query material for the design-and-build deal	- ABeam software - Anstar Oy's technical support - Technical assistance in design. - Hidden brackets - Connection type details - TS components - Bid calculation and preliminary inspection of the floor's joint action

2. Allocation of design tasks in the implementation phase

Main structural designer	Anstar Oy
- Updating structural plan drawings - Designing the circular reinforcement of the slab - Specifies the frame's tying system and forces - Updating detail drawings - Designing beam connections to concrete structures - Service life and durability design	- Beam design and strength calculation - Manufacturing drawings - Data for the hollow-core slab designer - Information about structural and connection detail updates - Providing concrete structure design with data on the forces on the connections

3. Preparation and construction

Main structural designer	Anstar Oy
- Having plans approved by building control - Supplementing the erection plan - Quality control plan	- Beam manufacture and delivery - Erection manual, A-BEAM S [23] - Additional instructions for erecting the beams - Instructions for providing the beams with erection supports

4. Initial data for design as part of the design-and-build deal

For implementation planning, the following information is needed from the main structural designer:	
1. Structural plan drawings	- Dimensioned structural plan drawings and preliminary beam codes - Design standard and reliability and consequence class - Execution class according to SFS-EN 1090-2 - Structure class of concrete structures according to SFS-EN 1992-1-1 - Floor loads, provisions, fire resistance class information and floor openings - Floor surface structure types and wall connection data to floor. - Column locations, materials and final dimensions - Preliminary connection detail data and connection types
2. Initial data for the beam	- Service life and durability data as well as surface treatment requirements - Any special manufacturing tolerances - Jaw removals: length, width and location - Other perforation: size and location - Equipment suspensions and other mounting provisions

5.2 ABeam 5 software for composite beams

The ABeam software for the beam's preliminary design can be downloaded from our website at www.anstar.fi. The software can be used for designing the beam for a design-and-build deal query. The user interface structure of the software is shown in Figure 14.

1. **Software user interface**
   In the main window, the software shows the beam's cross-section according to the initial data provided. The *Cross-section data* buttons are used to select the initial data windows below the figure.
   The following initial data is specified for the calculation:

General data of beam	- Select the general calculation data, location of the beam on the intermediate or edge line and erection support of the beam. - Select a hollow-core or thin-shell slab.
Beam cross-section	- Select the surface structure and materials of the slab. - Select the weight class and cross-section of the beam to be calculated from the standard profile library.
Floor system	- Select the hollow-core or thin-shell slab and materials to be used. - Select the erection support method for the beam flange.

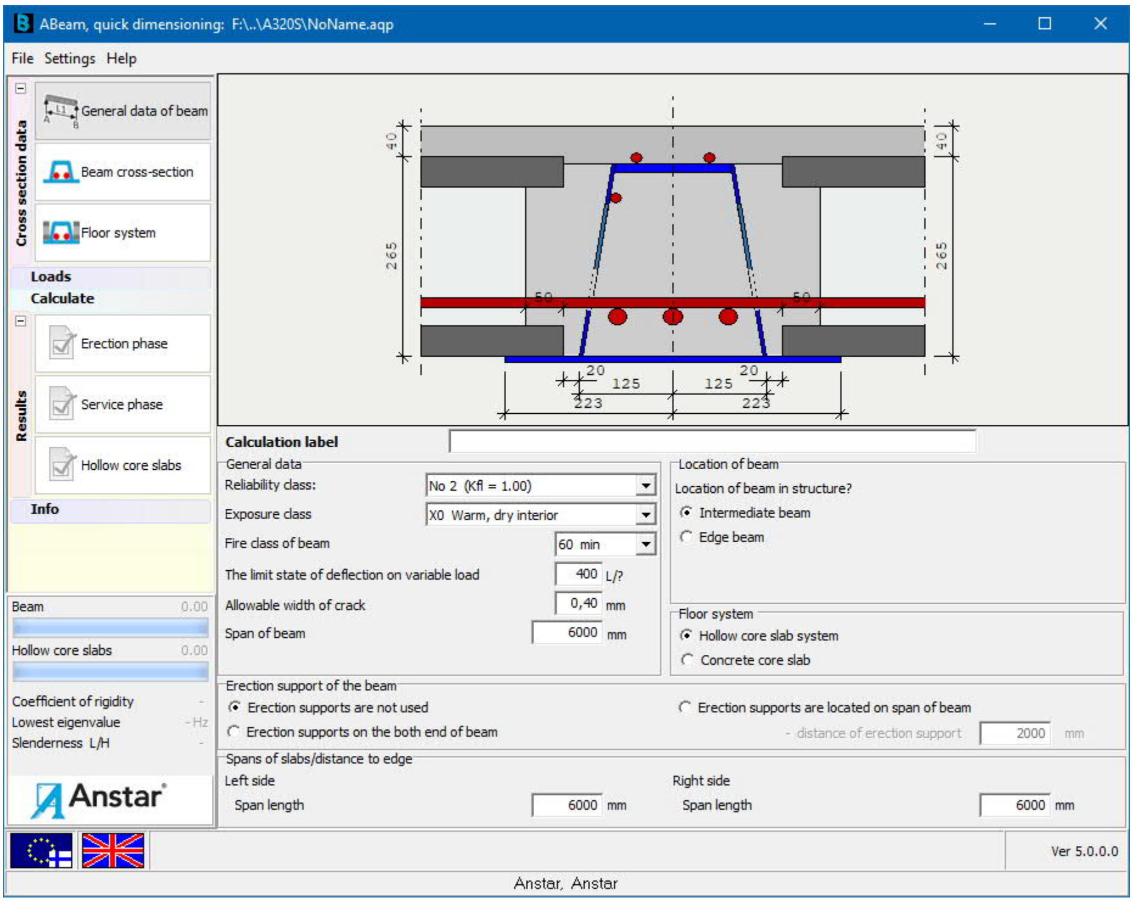
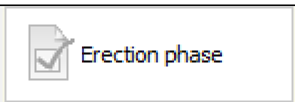
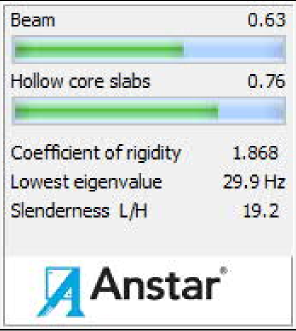


Figure 14. User interface of the ABeam software

The *Results* buttons are used to view the results of the calculation. A green check mark in the button means acceptable utilisation rates for all the quantities, and a red check mark means that the utilisation rate has been exceeded for some calculation value. The calculation results are presented in the following situations:

	- The window shows the power quantities during the erection stage and their utilisation rates when the joint grouting of the floor has been performed but has not hardened yet.
	- The window shows the power quantities in the ultimate limit state, deflection in the serviceability limit state, desing for fire situations and the utilisation rates of the quantities.
	- The software calculates the shear resistance of the ribs at the hollow-core slab's end according to Concrete Code Card 18EC.
	- The utilisation rates of the most important quantities for bending moment and shear resistance of the hollow-core slab's ribs are shown at the bottom of the window. - If these are green, all resistance values are OK. - The deflection must be checked separately.
Composite stiffness coefficient	- The coefficient describes how much of the surrounding concrete can be utilised for the beam's effect of composite action. Coefficient < 1.3, poor composite effect. Coefficient > 1.8, good composite effect.
Lowest natural frequency	- The lowest natural frequency describes the vibration sensitivity of the beam and hollow-core slab floor. - The lowest acceptable frequency is 3–5 Hz, but noticeable problems with vibration are avoided if the frequency is > 6 Hz, especially in office use. However, > 8 Hz is recommended.
Beam slenderness value L/H	- The beam slenderness value indicates the relation of the beam's span length to its structural height. - If the slenderness value is < 20, the beam is optimal. Beam deflection and fire design become determining factors at the slenderness value range 20–23. - If the value is > 23, reasonable beam structure design is no longer possible. Select the next profile size and use elevation parts.

2. Selecting the calculation standard

1. Project folder	- At the beginning of the calculation, create a project-specific folder in the File/Project folder menu. - When creating a project folder, you select the calculation standard used for said folder. - When you perform a new calculation later and select this project folder, the calculation standard copied to the folder will be used. - The calculation standard is shown as an icon in the bottom left corner. - The software remembers the folder and standard last used.
2. Changing the standard	- To change the standard, create another project folder to continue the calculation.

Calculation standards used by the software:

EN 1992-1-1:2004	Basic Eurocode
SFS-EN 1002-1-1:2005+NA	Finnish Eurocode + NA
SS-EN 1992-1:2005/AC:2010+A1/2014 + EKS 11	Swedish Eurocode + NA
DIN-EN 1992-1-1:2011-01+A1/2014	German Eurocode + NA

3. General data of beam

1. Location of beam	- Select either intermediate beam or edge beam. - The structure of the top window changes correspondingly.
2. Span of beam	- Specify the span length to be calculated.

	- This is usually the distance between the beam's end plates.
3. Spans of slabs/ distance to edge	- Specify the distance to the centre of the adjacent beam line or to the outer edge of the floor. - This determines the beam's load range.
4. Erection support	Specify the use and location of erection supports and the erection order of hollow-core slabs. There are three options available: 1. No erection supports 2. Erection supports are located under the jaw at the ends of the beam. The torsion to the bracket and the torsion of the connection are eliminated. 3. Erection supports are located on the beam of the span and the distance of the support is specified. This reduces deflection and torsion during erection.

4. Floor system

1. Type of slab	Hollow-core slab: For the hollow-core slab type, select one of the three options from different manufacturers. - BM-xx, select a Betonimestarit slab. - P-xx, select a Parma slab. - HD/F xx, select a Strängbetong slab. - The hollow-core slab material selections are used for calculating the composite effect of the structure as well as the shear resistance of the slab's ribs in accordance with Concrete Code Card 18EC. Thin-shell slab: - Thin-shell slabs can be selected from a height range of 50–200 mm. - If the slab structure is a simple solid slab, it can easily be calculated as follows: thin-shell slab + surface casting.
2. Erection of a hollow-core slab	- Hollow-core slabs can be erected either on the other side of the beam first or in turns. - This affects the need for erection support and the torsional moment to the support.
3. Erection of a thin-shell slab	To select erection of thin-shell slabs, proceed as follows: - Erect and cast the slabs simultaneously on both sides of the beam. - Erect and cast the slabs only on one side of the beam first.

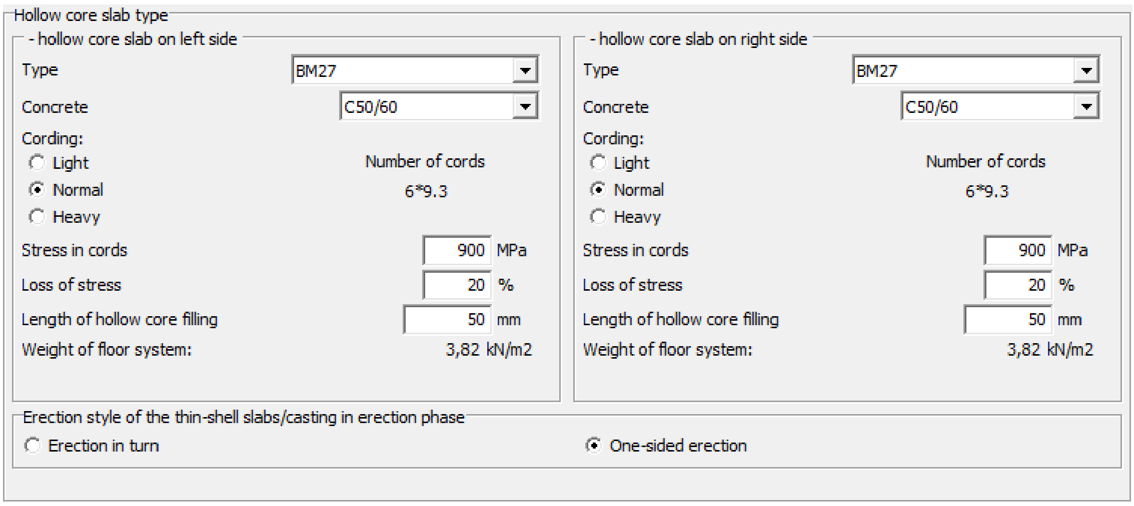


Figure 15. Information on the hollow-core slab

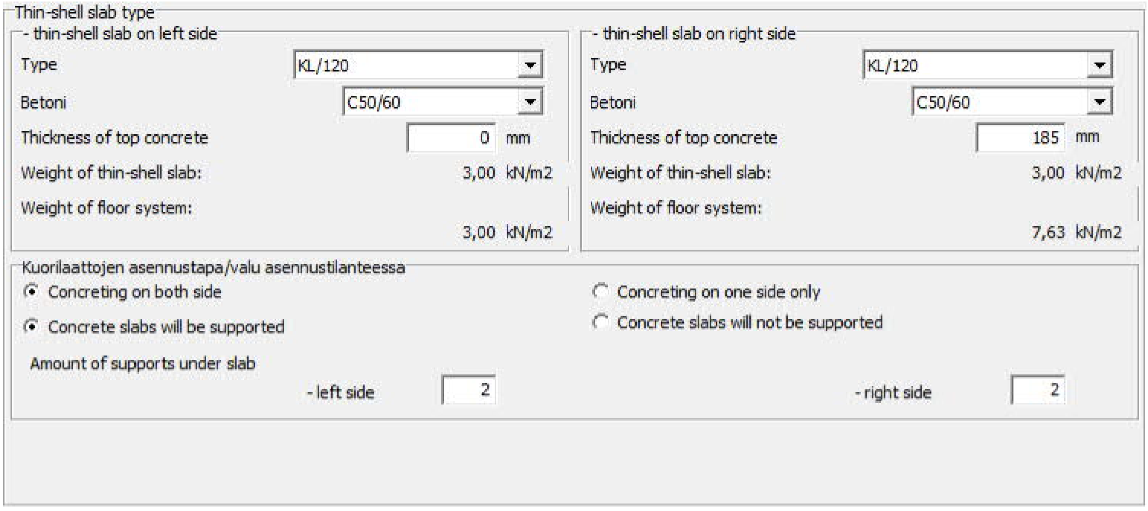


Figure 16. Information on the thin-shell slab

5. Beam cross-section

1. Type of top slab	- There are four surface structure options to choose from.
2. Structure of top slab	- Select the thickness and materials of the surface slab and specify whether the surface slab is taken into account in the calculation as a composite structure.
3. Transverse reinforcement	- Select the surface slab reinforcement that extends over the beam.
4. Height of the beam	- Normal: Select the beam for hollow-core slabs. - KL beam: Select the beam for a thin-shell slab structure.
5. Type of the beam	- There are three different weight classes to choose from. - The cross-sections – light L, normal N or heavy H – determine the bending resistance of the profile.
6. Choose cross-section of beam	- The cross-section is selected from the database according to the height and width. - The window shows the structure of the cross-section with the hollow-core slabs.
7. Elevation parts	- Elevation parts (L steel) can be used to adjust the beam height for hollow-core slabs of various heights. - Thin-shell slabs are almost always erected on an elevation part.
8. Joint concrete	- Select the strength of the joint and filling concrete (A-BEAM S).

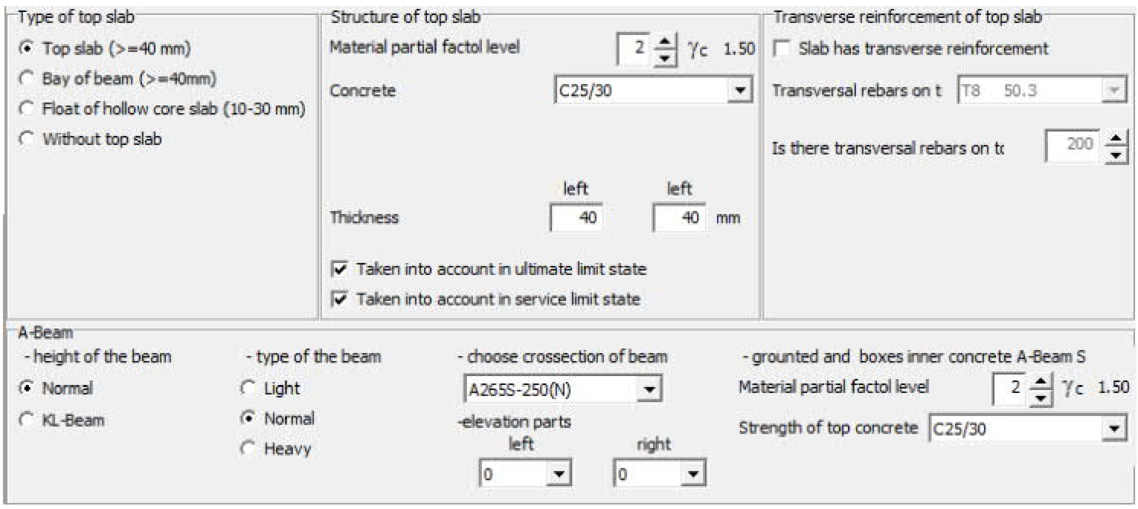


Figure 17. Surface slab and profile cross-section data

6. Loads

1. Dead load	- The software calculates the weight of the beam, slabs, joint grouting and screeding of the surface and thin-shell slabs. Do not give them. - Live loads are divided into permanent and variable loads, the latter of which is given a percentage (%) in a fire situation. - The loads are specific loads without a partial safety factor for loads.
2. Permanent load gk, gk	- Permanent load gk, gk effects the entire slab area, and it is given to the slab as a square load kN/m^2.
3. Trapezoidal load L1, qk1 – L2, qk2	- Trapezoidal load effects part of the slab area. The load must first be converted into a line load qk1, qk2 kN/m for the beam flange, and this information is then provided.

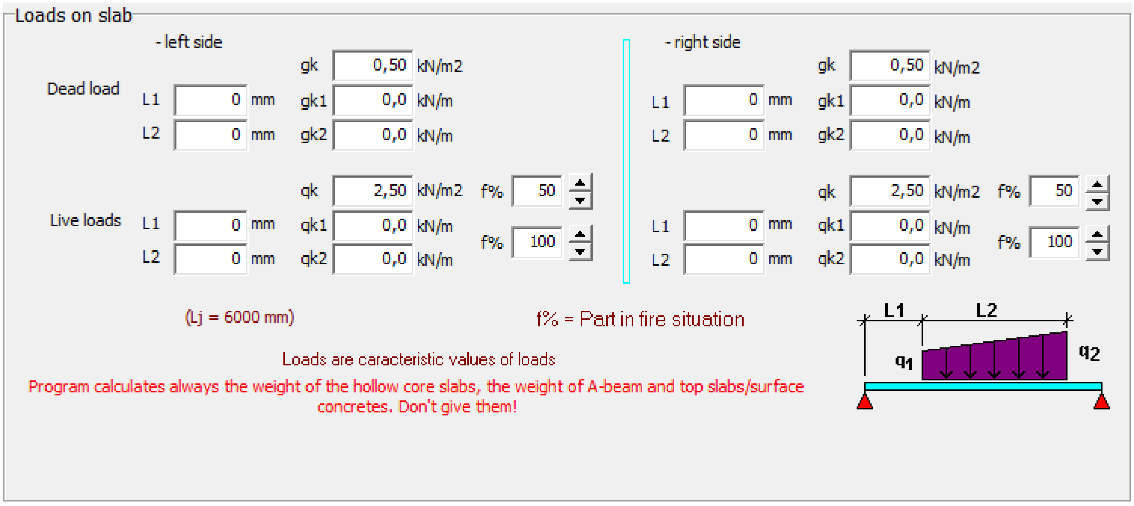


Figure 18. Loads on the slab

7. Calculating the beam

1. Erection stage	- The erection stage is calculated before hardening of the housing and joint grouting. - The forces in the bracket erection stage can be influenced by erection supports.
2. Ultimate limit state	- The ultimate limit state resistance is calculated for the beam, and the bracket utilisation rate for final loads. - The software selects the smallest AEP/AEL hidden bracket according to the loads specified and the dimensions of the beam. - In the beam design, Anstar checks the final resistance of the bracket.
3. Fire situation	- Fire situation resistance is calculated using the fire situation loads and time classification specified in the load data.
4. Shear resistance of the ribs at the hollow-core slab's end	- The software calculates the shear resistance of the ribs at the hollow-core slab's end in composite effect with the beam according to Concrete Code Card 18EC. - The resistance can be increased by filling of the hollow cores and reinforcement of the surface slab. - This preliminarily determines the suitability of the hollow-core slab for the case. - The software does not calculate the bending resistance of the hollow-core slab or determine the final cording.

5.3 Placement of the beam and slabs

5.3.1 Placement of the beam in relation to the columns

1. Dimensions of intermediate beams	<u>Intermediate A-BEAM S</u> - The A-BEAM S web width above the lower flange is an even figure (200, 250, 300, 350, 400, 500 and 600). - With standard concrete columns (180, 280, 380, 480 and 580), the web of the beam extends 10 mm over both sides of the column. - With standard composite columns (200, 250, 300, 350, 400 and 500), the web of the beam is level with the column's edge.
2. Placement of intermediate beams to the column	Placement of the A-BEAM S and bracket connection to the column: - The centre line of the A-BEAM S and bracket is always in the middle of the beam. - For a standard column, the bracket is always positioned on the column centre line, and the other connections are placed symmetrically in relation to the column centre line. - If the column width differs from the standard column, the bracket is in the middle of the column. Hollow-core slabs are either notched, or a formwork is made in the opening. - For a large column, the beam/bracket can be moved sideways from the column centre line, if necessary. The move must be indicated in the reference plans.
3. Dimensions of edge beams	<u>S edge beam</u> - The S edge beam web width above the lower flange is a standard even figure (230, 280, 330, 380 and 480). The standard edge projection width is 20 mm. - With standard concrete columns (230, 280, 380, 480 and 580), the web of the beam + the 20 mm edge projection extend 10 mm over both sides of the column. - With standard composite columns (250, 300, 350, 400 and 500), the web of the beam + the 20 mm edge projection are level with the column's edge.
4. Placement of edge beams to the column	Placement of the S edge beam and bracket connection to the column: - The centre line of the S edge beam and bracket is always in the middle of the distance (lower web width + 20 mm). - For a standard column, the bracket and any other connection are always placed on the column centre line - If the column width differs from the standard column, the bracket is in the middle of the column. Hollow-core slabs are notched or a formwork is made in the opening at the column. - For a large column, the bracket can be moved from the column centre line towards the wall structure, if necessary. - If necessary, the edge projection is extended to the wall structure or a sheet metal formwork is made, subject to separate order.

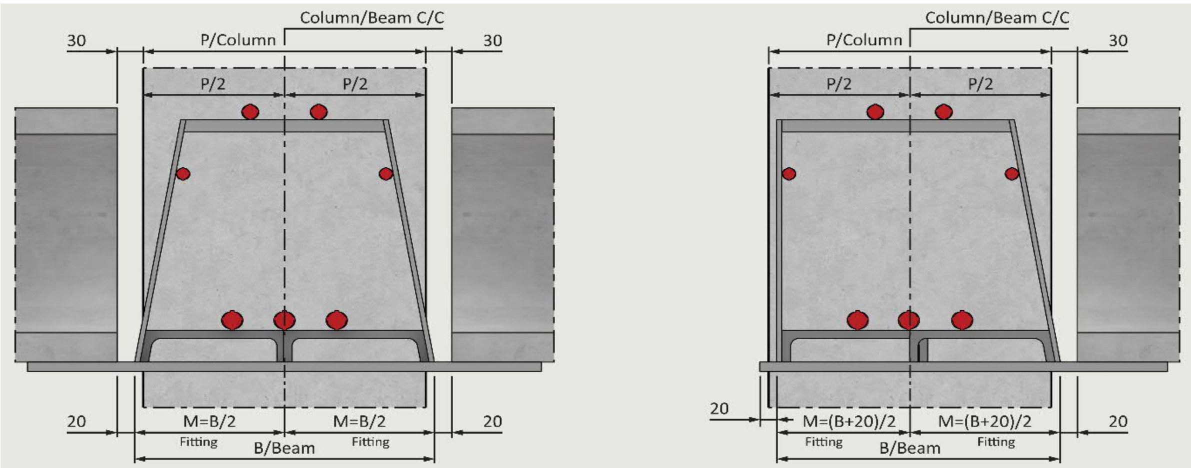


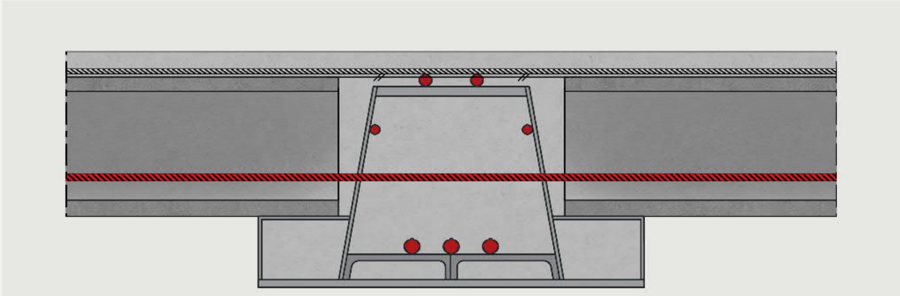
Figure 19. Placement principle of the A-BEAM S in relation to the column's module line.

5.3.2 Placement of a hollow-core/thin-shell slab to the beam

1. Placement of hollow-core slabs	- The theoretical clearance of the end of the hollow-core slab from the A-BEAM S web is 20 mm regardless of the width of the beam projection and the height of the slab. - For slabs OL200–OL370, the slab's theoretical support surface is 80 mm, and the minimum value allowed is 65 mm. - For slabs OL400–OL500, the slab's theoretical support surface is 105 mm, and the minimum value allowed is 85 mm.
2. Placement of thin-shell slabs	- The theoretical clearance of the end of the thin-shell slab from the A-BEAM S web is 20 mm regardless of the width of the beam projection and the height of the slab. - Follow the instructions provided by the manufacturer for the minimum widths of the thin-shell slab's end support surfaces.
3. Slabs with elevation parts	- In the case of slab with elevation parts, the placement of the hollow-core/thin-shell slab's head is also determined by the beam web's lower edge. - Therefore, the elevation part does not change the theoretical length of the hollow-core/thin-shell slab.
4. Concrete filling of the hollow cores	- In terms of strength engineering, the functioning of the A-BEAM S does not require concrete filling of the hollow cores for a length greater than the basic value indicated in the Concrete Code Card. - Additional filling of the hollow cores is required when the shear flow resistance of the slab's concrete ribs is not sufficient in the joint action analysis in accordance with Concrete Code Card 18EC. - For slabs OL400–OL500, Anstar recommends that the additional filling of the hollow core is always carried out, with the final need depending on the beam design. - The ultimate responsibility for desing the slab rests with its supplier, who performs the calculations using the final structural values of the hollow-core slab. - The ABeam software performs the hollow-core slab ribs' strength analysis for the shear flow with actual beam/slab dimensions.

5.3.3 Hollow-core slab beams with elevated parts

<table>
<tr><td>1. General</td><td colspan="3">- The structural height of the standard beams can be elevated by means of elevation parts for significant loads and span lengths.
- The ABeam software includes standard elevation parts for the most commonly used cases.
- The elevation parts can be used to enable the next standard beam height for the hollow-core slab.</td></tr>
<tr><td>2. Hollow-core slab beams with elevated parts.</td><td colspan="3">- An elevation part can be placed for both flanges or only for one flange. Therefore, the height of the slab on the different sides of the beam can be changed.
- The elevation part is always filled with concrete at the workshop.
- The following table shows the standard heights in the beam software for hollow-core slabs, which use the next larger beam size.</td></tr>
<tr><td rowspan="7">3. Standard A-BEAM S elevation parts with a hollow-core slab</td><td>A200S</td><td>–</td><td rowspan="7">- The height of the hollow-core slab can be adjusted by changing the height of the elevation part.
- The surface slab must be extended reinforced over the beam.
- Without reinforcement and/or the surface slab, uncontrolled splitting appears in the top corners of the beam, possibly interfering with the surface structure functions.</td></tr>
<tr><td>A265S</td><td>L65</td></tr>
<tr><td>A320S</td><td>L65</td></tr>
<tr><td>A370S</td><td>L50</td></tr>
<tr><td>A400S</td><td>L80</td></tr>
<tr><td>A500S</td><td>L100</td></tr>
<tr><td>A600S</td><td>L100</td></tr>
</table>

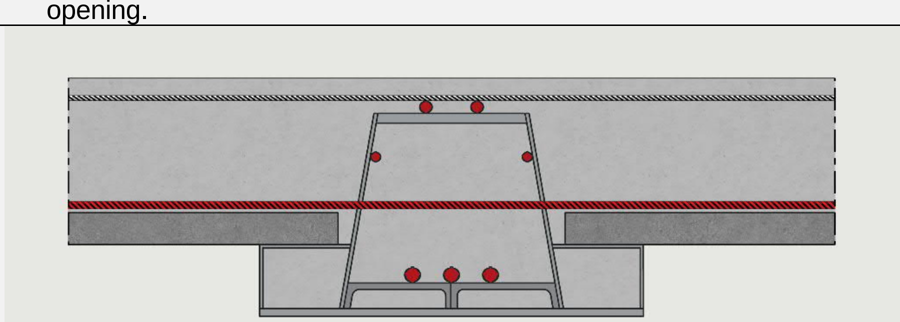
4. Typical structure of a slab with elevation parts	

5.3.4 Thin-shell slab beams with elevation parts

1. General	- A thin-shell slab is usually so slender in height that the A-BEAM S always requires elevation parts for the thin-shell slab structure. - For continuity, the top surface reinforcement of the thin-shell slab must be extended over the A-BEAM S. - The structural height of the beam can be elevated by means of elevation parts for significant loads and span lengths. - The ABeam software includes standard thin-shell slab elevation parts for the most commonly used slab cases.
2. Thin-shell slab beams with elevated parts	- The theoretical clearance of the end of the thin-shell slab from the A-BEAM S web is 20 mm regardless of the width of the beam projection and the height of the slab. - Follow the instructions provided by the manufacturer for the widths of the thin-shell slab's end support surfaces.

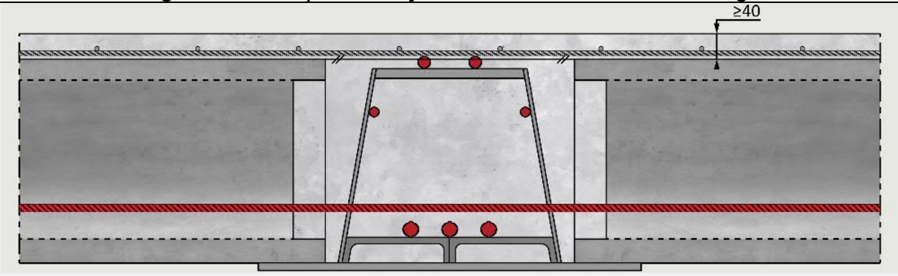
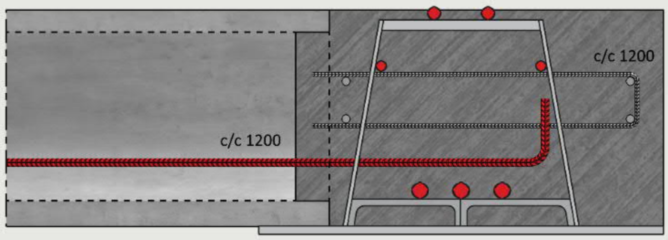
3. Standard A-BEAM S elevation parts and the overall thin-shell slab height

A-BEAM S	Slab	Elevation part	Minimum concrete layer on top of the upper flange, mm
A200S	180	L70	50
A220S	180	L90	50
A265S	200	L110	55
A320S	200	L160	55
A370S	250	L170	65
A400S	250	L200	70
A500S	250	L300	75

4. Changing the slab thickness and elevation part	- The thickness of the slab can be adjusted by changing the height of the elevation part. - The change must be made so that the overall height (elevation part + slab) remains unchanged. - On top of the beam, there must be a minimum layer of concrete with reinforced slab top surface as shown in the table above. - The slab's main reinforcement must always extend over the beam. - A single-span thin-shell slab structure is highly problematic, since the composite effect connection between the beam and the slab is weakened and slab torsion will cause uncontrolled splitting on the surface slab at the top corners of the beam and at the composite effect stud in the grouting opening.
5. Typical thin-shell slab structure with the A-BEAM S	

5.3.5 Supplementary reinforcement for the beam

1. General	- Additional steel in the A-BEAM S ensures the beam's effect of composite action with the surrounding concrete in ultimate limit state conditions.

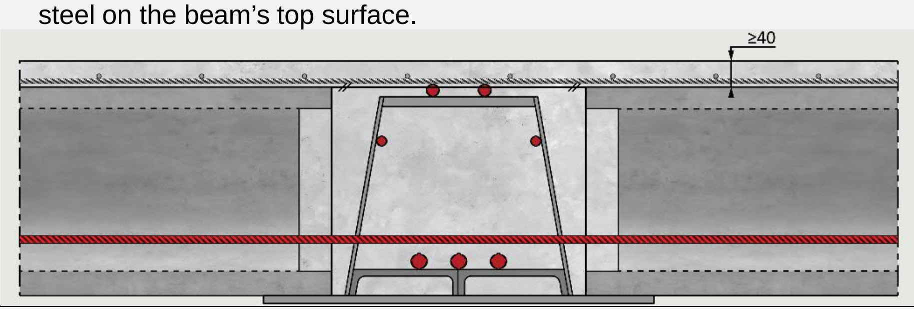
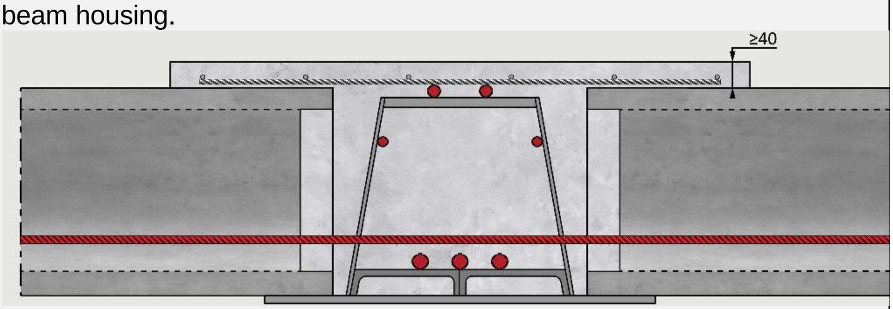
	- In a fire situation, additional steel ensures the action of the beam when the unprotected lower flange no longer acts as a load-bearing structure.
2. Torsional steel and beam suspension	- The torsional steel is used to tie the torsional moment caused by the hollow-core slab's eccentric placement to the beam. Red steel in Figure 20. - The torsional steel is taken through the beam's web hole in the hollow-core slab's joint. - In a fire situation, hollow-core slabs are also suspended from the beam by means of this torsional steel. - The pieces of torsional steel are designed by Anstar and are part of the site acquisitions.
3. Transverse reinforcement of the surface slab	- To achieve the full effect of the A-BEAM S's composite action, the surface slab must have a surface casting of structural concrete with transverse reinforcement. - Without the surface slab or the reinforcement, the A-BEAM S forms a composite structure only bonded with the concrete inside and the beam's joint grouting, and a significant part of its resistance is lost.
4. Circular steel for the hollow-core slab floor	- Pieces of circular steel are placed in the joint grouting between the hollow-core slab and the beam and are dimensioned to combine the hollow-core slab floor into a plate stiffening the building, transferring the horizontal loads to the vertical stiffening. - Steel design is the responsibility of the main structural designer.
5. Principle drawing for supplementary reinforcement	 Figure 20. Supplementary reinforcement for the A-BEAM S
6. Principle drawing for the edge bay's torsional reinforcement	

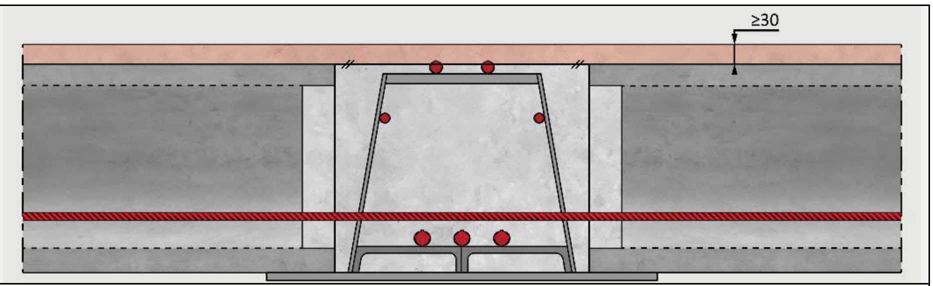
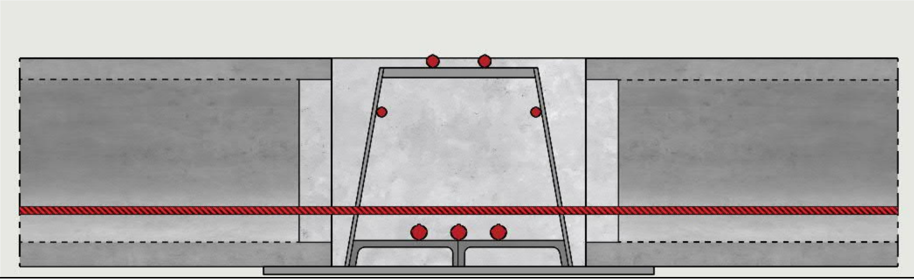
5.3.6 Grouting for the structure

1. General	- The housing of the A-BEAM S acts as a composite structure with the hollow-core slab when all grouting has hardened. - The joint action of the housing profile and slab as a composite structure is influenced by the following concrete grouting:
2. Concreting of the beam housing	- The joint between the A-BEAM S and the hollow-core slab is filled with concrete on the site once the additional steel has been installed. - Concreting is performed up to the level of the top surface of the hollow-core slab in one go without construction joints. - A structural concrete mix must be used, keeping the amount of free water small in a controlled manner in order to accelerate the drying process. - Freezing of concrete during hardening is prevented by equipping the beams with heating cables at the factory, if necessary. - The housing grouting acts as part of the load-bearing structure, and quality control of the concrete must be carried out according to the requirements for structural concrete.

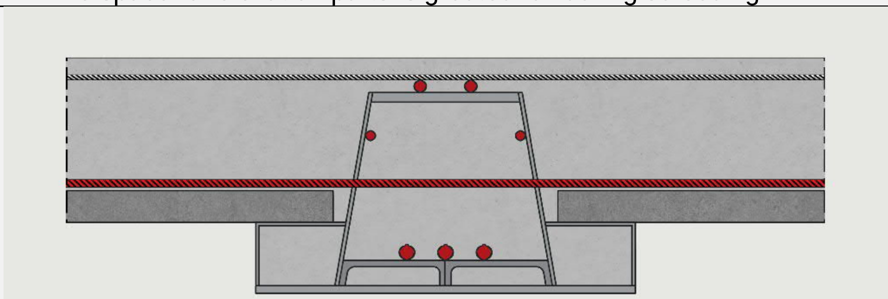
3. Joint grouting of the hollow-core slab	- After the beam casting, the longitudinal joints of hollow-core slabs are filled with concrete using a more workable grout.
4. Surface casting of the hollow-core slab	- The surface or filler casting of the hollow-core slab floor is performed after the joint grouting has hardened. - If surface casting is reinforced, quality control of the concrete must be carried out according to the requirements for structural concrete.

5.3.7 Surface casting of the hollow-core slab

1. General	Structurally, there are four different ways of performing the surface casting of the hollow-core slab floor, and this influences the structural function of the beam. The surface casting options are:
2. Reinforced surface casting ≥ 40 mm	- Reinforced surface concrete meeting the quality requirements for structural concrete is applied on top of the slab. - Such structures include intermediate floor slabs of office and public buildings, where the span lengths are long and surface casting is applied to the floor surface structures. - Reinforcement is placed in the surface casting to even out cracks caused by deflection of the hollow-core slab. - The surface slab reinforcement transfers the hollow-core slab's shear flow to the beam, thereby straining the ribs of the hollow-core slabs as little as possible. (BNK 18, additional instruction). - The surface slab provides fire and corrosion protection for the pieces of steel on the beam's top surface. 
3. Surface casting bay on top of the slab ≥ 40 mm	- A reinforced concrete topping bay can be used in the roofs of buildings to significantly increase the bending resistance of the structure. - The bay is located in the thermal insulation space of the structure, also protecting the upper flange of the beam against fire and corrosion. - The bay is made as a structural element during the concreting of the beam housing. 
4. Filler casting	- Such structures include intermediate floors of residential buildings and other structures only requiring a thin layer of filler on top of the slab. - Light floor surface structures are placed on top of the filler. - The filler must also protect the pieces of steel on the top surface of the beam against fire and corrosion.

	
5. No surface casting	- Such structures include roofs and parking deck floors, where water and thermal insulation layers are placed on top of the slab. - There must be a sufficient layer of protective concrete for corrosion and fire protection of the top surface rebar. - In this case, a 20-mm high elevation part can be used to provide an adequate concrete layer on top of the beam. 

5.3.8 Casting of a thin-shell slab

1. Erection support	- The thin-shell slab should always be shored for pouring loads using erection supports with 1–2 support lines. - Shoring reduces the stresses on the beam during erection.
2. Screeding of a thin-shell slab	- Casting can be done either on one side of the beam separately or on both sides. - The order of casting must be known during beam design. - The space for elevation parts is grouted full during screeding.
3. Structure of a thin-shell slab beam	

5.4 A-BEAM S connections

5.4.1 AEP-C hidden bracket connection to a concrete column

1. General	The A-BEAM S's standard hidden bracket for concrete columns and walls is AEP-C. - The resistance values and more detailed design instructions for the brackets are provided in the user manual for AEP-C hidden brackets. (The new user manual will be published at the end of 2021 and, until then, the old AEP bracket will be in use.)[22] - The bracket provides a torsional stiff joint for the A-BEAM S and a swivel joint for the bending moment to the column surface. - The AEP-C hidden bracket is designed for the R15–R120 fire resistance classes. - The AEP-C hidden bracket is designed for the A-BEAM S's ultimate limit and accident limit states.
2. Placement of	- The bracket is placed on the side of a concrete column such that the

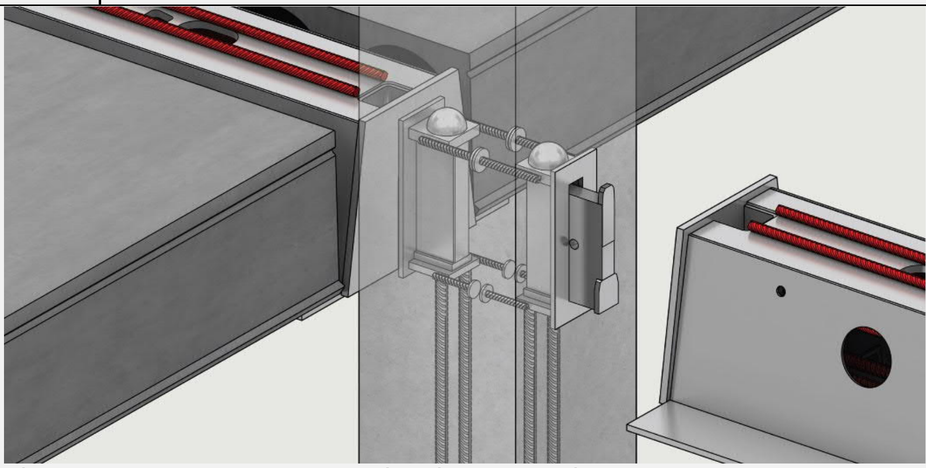
the bracket	connection is centred as described in Section 5.3.1. - The elevation of the AEP-C bracket's column component's bottom surface is determined by the bottom surface of the hollow-core slab (= top surface of the lower flange). For more information, refer to the user manual for the AEP-C hidden bracket. - The bracket has a one-piece and two-piece connection through the column. - The structure of the bracket's tongue part is suitable for both a concrete beam and the composite beam's AEL-C bracket, allowing for free selection of the beam and column material.
3. Design of the bracket	- Anstar designs the entire connection and provides instructions for the design of the connection's placement and supplementary reinforcement for the column and beam.
4. Delivery of the bracket	- Anstar Oy manufactures the AEP-C brackets and delivers its column and tongue components to the prefabrication factory that manufactures the column. - All the required bracket connection pieces are manufactured for the beam component.
5. Principle drawing of the connection	 Figure 21. A-BEAM S's AEP-C bracket connection to a concrete column

Table 5 includes the application range for the AEP-C hidden brackets by the A-BEAM S size class. The bracket is suitable for both the intermediate and edge beams and also for round composite and concrete columns.

Table 5. Compatibility of the AEP-C hidden bracket with the S beam by size class.

AEP-C bracets in S beam	A200S	A220S	A265S	A320S	A370S	A400S	A500S	A600S
AEP400C						Not applicable with this range		
AEP600C								
AEP800C								
AEP1100C								
AEP1500C	Not applicable with this range							

5.4.2 AEL-C hidden bracket connection to a concrete column

1. General	The A-BEAM S's standard hidden bracket for composite and steel columns is AEL-C. - The resistance values and more detailed design instructions for the brackets are provided in the user manual for AEL-C hidden brackets. (The user manual will be published at the end of 2021 and, until then, the old AEL bracket will be in use.)[22] - The bracket provides a torsional stiff joint for the A-BEAM S and a swivel joint for the bending moment to the column surface. - The AEL-C hidden bracket is designed for the R120 fire resistance class. - The AEL-C hidden bracket is designed for the ultimate limit and accident limit states.
2. Placement of the bracket	- The bracket is placed on the side of a steel column such that the connection is centred in the column as described in Section 5.3.1. - The elevation of the AEL-C bracket's column component's bottom surface

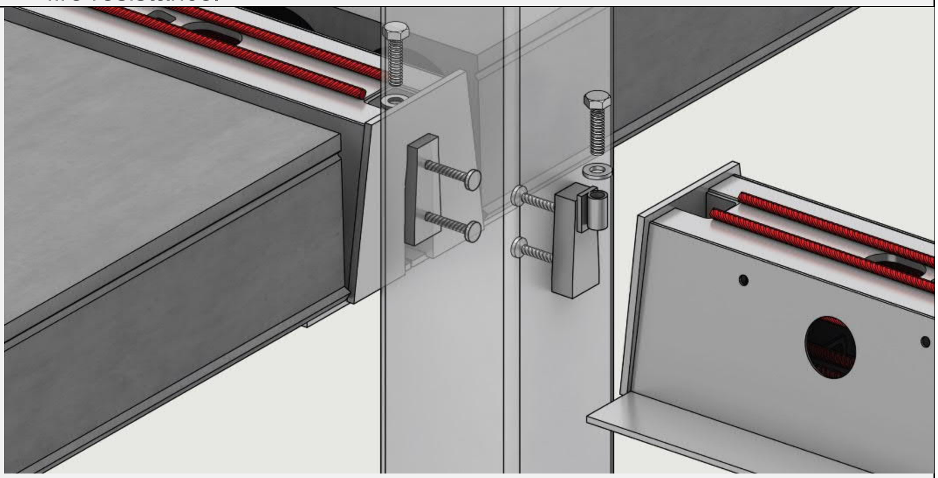
	is determined by the bottom surface of the hollow-core slab (= top surface of the lower flange). For more information, refer to the user manual for the AEL-C hidden bracket. - The bracket has a one-piece and two-piece connection through the column. - The structure of the bracket's tongue part is suitable for both a composite beam and a concrete beam's AEP-C bracket.
3. Design of the bracket	- Anstar designs the beam component of the bracket and provides instructions for designing the connection in the column.
4. Delivery of the bracket	- Anstar Oy manufactures the AEL bracket's column component and delivers it to the workshop that manufactures the composite column, where the bracket is welded to the surface of the composite column. - The bracket becomes a stud connection that goes inside the column for fire resistance.
5. Principle drawing of the connection	 Figure 22. A-BEAM S and AEL-C bracket connection to a composite column

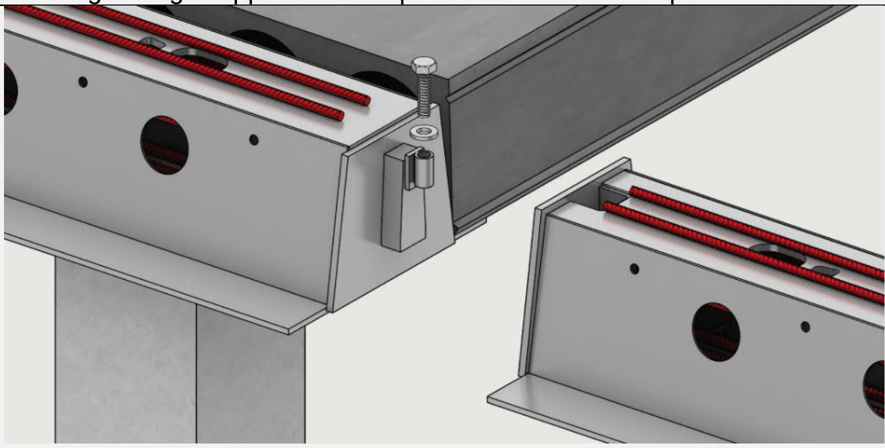
Table 6 includes the application range for the AEL-C hidden brackets by the A-BEAM S size class. The bracket is suitable for both intermediate and edge beams.

Table 6. Compatibility of the AEL-C hidden bracket with the A-BEAM S by size class.

AEL-C bracets in S beam	A200S	A220S	A265S	A320S	A370S	A400S	A500S	A600S
AEL400C						Not applicable with this range		
AEL600C								
AEL800C								
AEL1100C								
AEL1500C	Not applicable with this range							

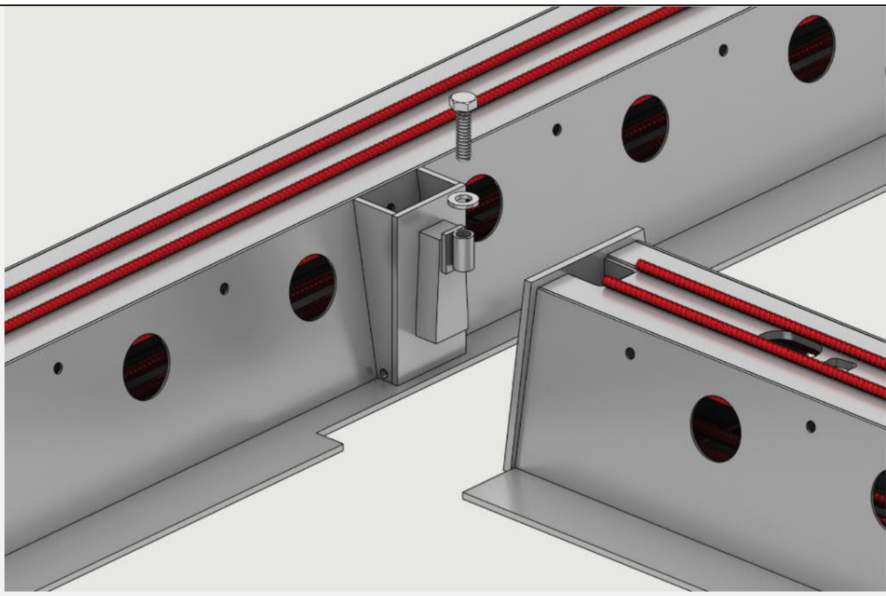
5.4.3 Beam coupler connection in the field

1. Beam coupler connection in the field	- The A-BEAM S is designed as a continuous structure going over the column in the roof, meaning that the coupler connection is located in the field near the origin of the bending moment. - The beam is designed as continuous. The connection transfers the beam's shear force, torsional moment, and longitudinal force. - The connection does not transfer the beam end's bending moment. - The beams can also be separate S and W beams and also with elevation parts.
2. Execution of the connection	- The connection is made as an end plate connection, which is a special application of the Anstar AEL hidden bracket. - The end plate comes only about 10 mm outside the web surface, with 15 mm clearance between the end plates. - The connection is torsional stiff during erection, so erection support is usually not necessary. - The connection is locked permanently in all directions with one connection screw.
3. Design and	- Anstar designs and delivers all the necessary connection pieces.

delivery	
4. Fire protection and grouting	- The connection area must be protected between the end plates under the beam's lower flange with flame-retardant material. - The end plate of the beam and the top surface mounting bolt must be fire-protected by grouting from the top of the beam. - No grouting is applied to the space between the end plates.
5. Structure of the connection	 Figure 23. A-BEAM S coupler connection in the field. Gerber connection.

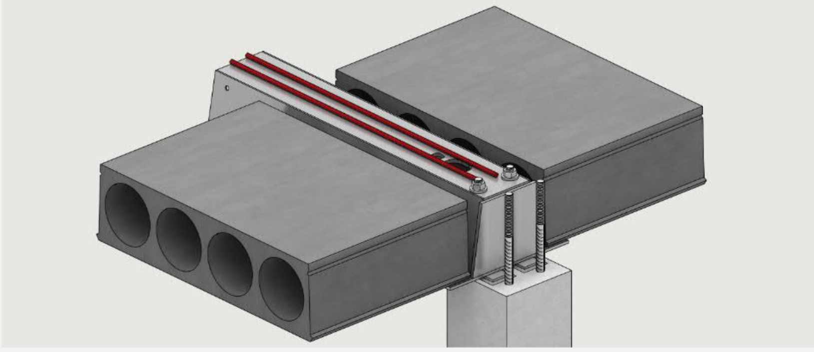
5.4.4 Connecting a beam to the side of another beam

1. End plate connection to the side of another beam	- When the load-bearing direction of a hollow-core slab changes in the adjacent slab field, a secondary A-BEAM S is connected to the side of another A-BEAM S. - The beam is designed as a single-span structure, and the connection transfers the beam's shear force, torsional moment and longitudinal force. The connection does not transfer the beam end's bending moment. - The beams can also be separate S and W beams and also with elevation parts.
2. Execution of the connection	- The connection is made as a special application with the Anstar AEL-C hidden bracket. - The connection components come only about 10 mm outside the adjoining beam's web surface, with 15 mm of connection clearance. - The connection is torsional stiff during erection, so erection support is usually not necessary. - The connection is locked permanently in all directions with one connection screw.
3. Design and delivery	- Anstar designs and delivers all the necessary connection pieces.
4. Fire protection and grouting	- The connection area must be protected between the end plates under the beam's lower flange with flame-retardant material. - The mounting bolt on the beam connection's upper surface must be fire-protected according to the user manual for the AEL-C bracket.

5. *Structure of the connection*	 Figure 24. Connecting a secondary A-BEAM S to the side of a primary beam

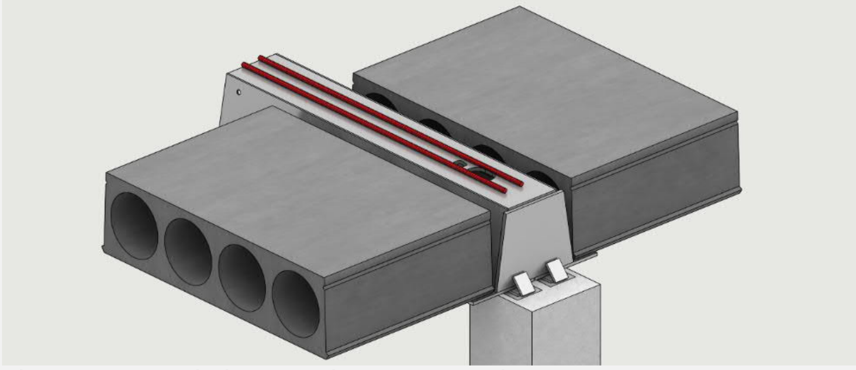
5.4.5 Bolt connection on top of a column or wall

1. *Bolt connection on top of a beam/wall*	- The A-BEAM S can be connected on top of a column or wall using two AHP rebar bolts. - The location of the connection's vertical support reaction and the beam height are adjusted by placing two steel fitting plates on top of the mounting plate on the column. - The vertical support reaction of the beam is transferred from the end plate through the fitting plates to the mounting plate and then to the column. - The tensile force due to the torsional moment from the connection is transferred through the bolts to the column. - In an accident limit state, the horizontal shear force of the connection is transferred through the bolts' edge compression to the column. Alternatively, the beam can be welded to the mounting plate through the fitting piece.
2. *Designing the connection, ultimate limit state*	- The connection transfers the beam's torsional moment and horizontal shear force, and the bolts are dimensioned as per the following forces: - Tensile forces to the bolts: N_d = $-V_d /2 \pm M_{vd} /p$, where V_d = Calculation value for the beam's vertical shear force (minimum). M_{vd} = Calculation value for the beam's torsional moment (maximum) p = Distance between bolt centres in the beam's transverse direction. - The horizontal shearing force is transferred through the bolts' edge compression unless circular reinforcement is used for this purpose. - The bolts can be dimensioned according to Anstar's AHP bolt user manual.
3. *Designing the connection, accident limit state*	- The main structural designer designs the connection for additional horizontal force in an accident limit state in CC3 structures, tying the beam to the load-bearing vertical structures.
4. *Fire protection and grouting*	- The connection area must be protected under the beam's lower flange with flame retardant material. - The end plate and bolts of the beam must be fire-protected by grouting.
5. *Design and delivery*	- The main structural designer designs all connection pieces in the column. If necessary, Anstar delivers the final design loads (Vd, Td) for the connection's erection and ultimate limit states.

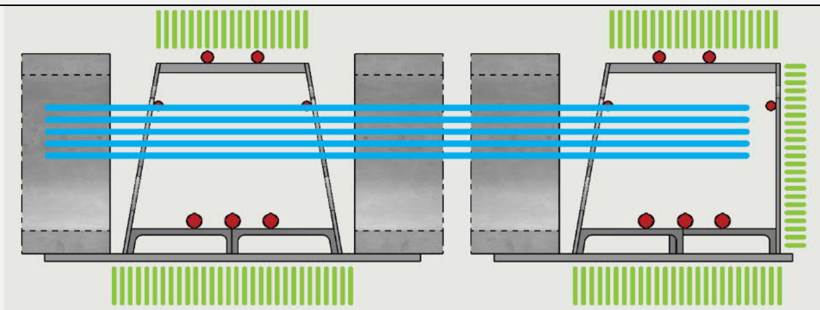
	- Anstar delivers only the connection pieces that are integral to the beam.
6. Structure of the connection	 Figure 25. Bolt connection on top of a column or wall with two bolts

5.4.6 Welded connection to a mounting plate on top of a column or wall

1. Mounting plate connection on top of a beam/wall	- The A-BEAM S can be connected on top of a column or wall by welding its end plate to a mounting plate on the column using mounting pieces. - If necessary, the height of the connection can be adjusted using fitting pieces made of steel plate, which must first be welded to the mounting plate. - The vertical support reaction of the beam is transferred from the end plate through the fitting pieces to the mounting plate and the column. -
2. Designing the connection, ultimate limit state	- The connection transfers the beam's torsional moment, and the weld is designed for the following forces. - Forces acting on the fitting piece and mounting plate welds: N_d = $-V_d /2 \pm M_{vd} /p$, where V_d = Calculation value for the beam's vertical shear force (minimum). M_{vd} = Calculation value for the beam's torsional moment (maximum) p = Distance between centres of welds. - The horizontal shearing force is transferred through the welds, unless circular reinforcement is used for this purpose. - The weld is dimensioned according to EN 1993-1-8. - The mounting plate must also be designed for a force of ±Nd
3. Designing the connection, accident limit state	- The main structural designer designs the connection for additional horizontal force in an accident limit state in CC3 structures, tying the beam to the load-bearing vertical structures.
4. Fire protection and grouting	- The connection area must be protected under the beam's lower flange with flame retardant material. - The end plate and connection plates of the beam must be fire-protected by grouting or a wall structure.
5. Design and delivery	- The main structural designer designs all connection pieces in the column. If necessary, Anstar delivers the final design loads (Vd, Td) for the connection's erection and ultimate limit states. - Anstar delivers only the connection pieces that are integral to the beam.

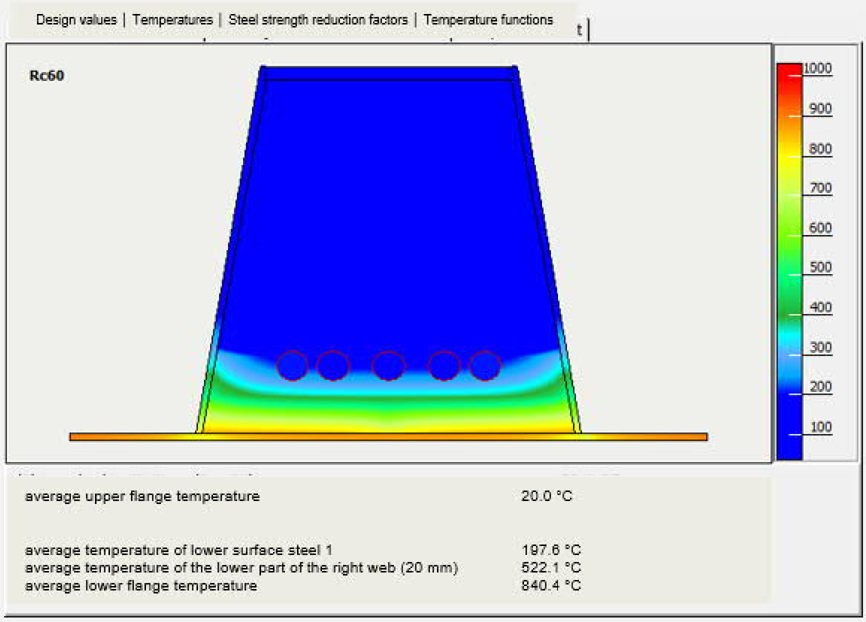
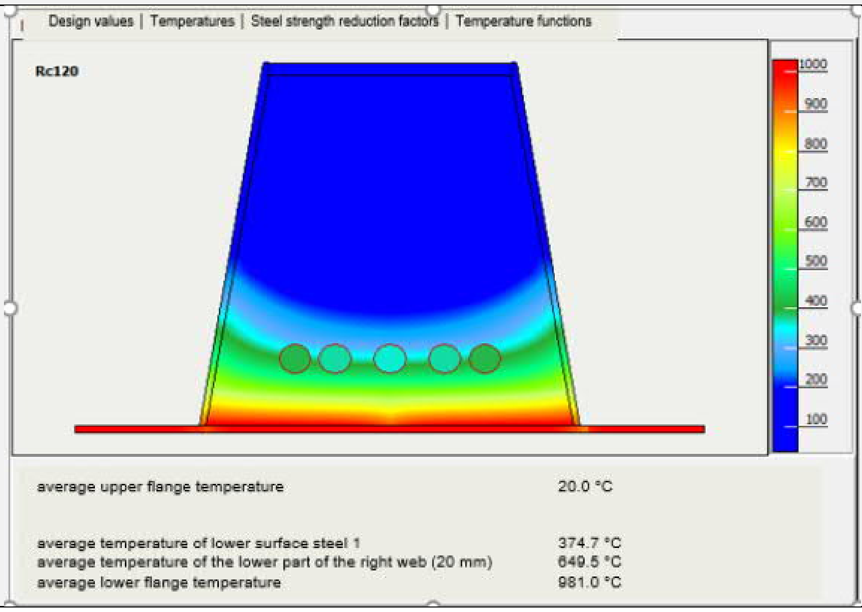
6. *Structure of the connection*	 Figure 26. Welded connection to a mounting plate on top of a column or wall

5.4.7 Additional fixings to the beam for building services

1. *Additional fixings on the site*	- Additional fixings can be made to the A-BEAM S on the site for erections required by building services. - However, heavy equipment suspensions are implemented through beam design to provide the beam with safe fixing points. - Figure 27 shows the allowable fixing areas.
2. *Lower flange*	- Equipment suspensions can be welded on the lower flange, in the area between the webs.
3. *Upper flange*	- Weld fixings of equipment supports can be made on the upper flange. - However, the fixings must always be planned in advance, and the connection pieces are included in the beam delivery.
4. *Webs*	- On an edge beam, fixings can be made for temporary handrails if necessary.
5. *Beam lead-through*	- A limited number of small pipes and other installations required by building services can be fed through the housing both in the horizontal and vertical directions. - However, information about this must always be delivered to detail design. The necessary perforation or piping must be added to the beam.
6. *Lead-through areas in the A-BEAM S*	 Figure 27. Allowable lead-through and fixing areas of the A-BEAM S

5.5 A-BEAM S fire design

1. *Fire resistance classes and fire protection*	- The A-BEAM S is designed for fire resistance classes R15, R30, R60, R90 or R120 for a situation where the fire is below the slab. The upper surface is at normal temperature. - The lower flange of the beam is thus without fire protection. Beam elevation parts can also be left without fire protection because they are filled with concrete. - The vertical web of an edge beam must be protected either structurally/by external wall or by sufficient fire-proofing/concrete to the required class. - The upper flange structures of the beam must have a sufficient concrete layer or some other form of structural fire protection on the surface of the upper flange steel.
2. *Fire design*	- Fire design is performed for each beam according to the principles of European standards

	SFS-EN 1992-1-2 and SFS-EN 1993-1-2. - Fire design is based on the temperature of the elements calculated using the FEM method and their resistance to fire. - The joint material of the expansion joint must be of non-combustible and heat-insulating material.
3. Torsional steel	- In a fire situation, the torsional steel transfers the hollow-core slab's loads to the housing profile when the lower flange's load-bearing capacity becomes insufficient.
4. Beam connections	- The beam connections must be protected to the fire class of the beam. - Fire protection methods for the beam and its standard connections are presented in Section 6 of the erection manual [23] and the user manuals for the hidden brackets.
5. Indicative A-BEAM S temperature distribution after 60 minutes of fire	
6. Indicative A-BEAM S temperature distribution after 120 minutes of fire	

5.6 Service life design of the structure

1. Service life design	- A-BEAM S's service life and durability design for concrete structures is performed according to the instructions in SFS-EN 1992-1-1, Section 4. - The requirements of SFS-EN ISO 12944 are applied to steel structures [12]. - The analysis must be performed separately for the top and bottom of

	the beam, particularly if they have different exposure classes.
2. Durability of concrete and rebar	- The concrete and pieces of rebar inside the housing have sufficient protection in each exposure class. - The nominal value for the concrete cover outside the housing is specified according to the exposure class for the structural and rebar parts of the housing's upper surface.
3. Durability of steel parts	- Surface treatment of the steel parts left outside the concrete is carried out according to SFS-EN 12944-2 [12] by applying the instructions to the exposure classes of SFS-EN 1992-1-1. - The atmospheric corrosivity category according to SFS-EN 12944-2 and its requirements are only taken into account in the surface treatment of the visible lower flange and the web against the exterior wall. - The standard delivery includes workshop priming for the lower flange and the web at a height of 50 mm. - The other protection requirements are specified in the reference plans.
4. Nominal values for concrete cover	- Table 7 shows the nominal value C_{nom} for the concrete cover of the reinforcement or steel parts by exposure class according to SFS-EN 1992-1-1, Table 4.1, minimum value $C_{min,cur}$. - The nominal value for the concrete cover of the steel parts is $C_{nom} = C_{min,cur} + \Delta_{cdev}$ (= 10 mm). - Table 7 also shows the recommended minimum surface treatments and protection methods in various exposure classes.

Table 7. Nominal value C_{nom} and minimum surface treatment methods for the concrete cover.

Exposure class SFS-EN 1992-1-1	50-year service life C_{nom} mm	100-year service life C_{nom} mm	Surface treatment options and protection methods recommended for the beam.	
			Lower flange surface treatment	Upper flange surface treatment
X0	20	20	Workshop priming. Finish painting only for visible parts as necessary. Specified in the structural plans.	No surface treatment. Minimum concrete cover requirement for top surface rebar.
XC1	20	30	Workshop priming. Necessary finish painting specified in the structural plans.	No surface treatment. Minimum concrete cover requirement for top surface steel parts.
XC3	35	45	Workshop priming. Necessary finish painting specified in the structural plans.	Minimum concrete cover requirement for top surface steel parts. Structural concrete topping and waterproofing prevents water from getting inside the beam.
XD1–XD3	50	60	The beams are hot-dip galvanised according to the standard [13]. Torsional reinforcement and circular steel are hot-dip galvanised.	Beams are hot-dip galvanised. Structural concrete topping and waterproofing prevents water from getting inside the beam.
XS1–XS3 XA1–XA3 XF1–XF4	–	–	The beams may only be used on the basis of site-specific special analyses. The beam's surface treatment, protection methods and concrete cover's nominal value are specified according to the site requirements.	

6 DESIGN-AND-BUILD DEAL DELIVERY DOCUMENTS

The standard delivery includes the following beam manufacturing documents and design data for updating the structural plans:

Table 8. Documents included in the beam delivery

Documents and other design data delivered to the main structural designer	Contents and purpose of the documents
1. Manufacturing drawings	For building control
2. Beam strength calculations	For building control
3. Beam table	Data for updating structural plan drawings
4. Forces on bracket connections	Final bracket and force data for designing adjoining concrete structures.
5. Forces on other connections	Final connection and force data for designing connections to the beam and concrete structures.
6. Product approval information	The following information can be found on our website - CE marking certificate - Quality control certificates

REFERENCES

[1] *SFS-EN 1090-1 Execution of steel structures and aluminium structures. Part 1: Requirements for conformity assessment of structural components.*
[2] *SFS-EN 1090-2, Execution of steel structures and aluminium structures. Part 2: Technical requirements for steel structures.*
[3] *SFS-EN ISO 3834. Quality requirements for fusion welding of metallic materials. Part 1: Criteria for the selection of the appropriate level of quality requirements.*
[4] *SFS-EN 1990, Eurocode. Basis of structural design.*
[5] *SFS-EN 1991-1, Eurocode 1. Actions on structures, parts 1–7.*
[6] *SFS-EN 1992-1-1, Eurocode 2. Design of concrete structures. Part 1-1: General rules.*
[7] *SFS-EN 1992-1-2, Eurocode 2. Design of concrete structures. Part 1-2: General rules. Structural fire design.*
[8] *SFS-EN 1993-1, Eurocode 3. Design of steel structures. Part 1-10: General rules.*
[9] *SFS-EN 1992-4:2018, Design of concrete structures. Part 4. Design of fastenings for use in concrete.*
[10] *not applicable*
[11] *SFS-EN ISO 5817, Welding. Fusion-welded joints in steel, nickel, titanium and their alloys. Weld classes.*
[12] *SFS-EN ISO 12944, Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Part 1 and parts 2–7.*
[13] *SFS-EN ISO 1461. Hot dip galvanized coatings on fabricated iron and steel articles.*
[14] *SFS-EN 10025, Hot rolled products of structural steels. Part 1: General technical delivery conditions.*
[15] *SFS-EN ISO 1684 Fasteners. Hot dip galvanized coating.*
[16] *SFS-EN 17760-1 Welding. Welding of reinforcing steel. Part 1: Load-bearing welded joints.*
[17] *SFS-EN 13670 Execution of concrete structures.*
[18] *SFS-EN 13225 Precast concrete products. Linear structural elements.*
[19] *SFS-EN 13369 Common rules for precast concrete products.*
[20] *Concrete Code Card (Betoninormikortti) No. 18EC (EN 1992-1-1) 31 July 2012 Hollow-core slab floor system supported by beams.*
[21] *Anstar Oy. AEP Bracket User Manual.*
[22] *Anstar Oy. AEL Bracket User Manual.*
[23] *Anstar Oy. A-BEAM S Erection manual.*
[24] *Not appilcable*
[25] *Anstar Oy. AHP Rebar Anchor Bolts*

LIST OF TABLES

PICTURES

A-BEAM® is a concrete-filled steel beam developed by Anstar Oy for placement inside a floor system. Thanks to a powerful composite effect, long span lengths and modifiable space solutions can be achieved affordably. In addition to hollow-core slabs, the beam can also be used for supporting thin-shell slabs, composite slabs and cast-in-place concrete slabs. The composite structures can be designed up to fire resistance class R120 without any additional protection on the site.

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