TMB ELEMENT

07/2020

PRE-STRESSED HOLLOW-CORE SLABS

TAM

OÜ TMB Element manufactures pre-stressed hollow-core slabs with the product name TAM slab in conformity with the standards of EN 1168 and EN 13369.

The slabs are manufactured with four different depths and optional length according to load-bearing capacity graphs. Besides, special-purpose TAM slabs are manufactured: cantilever slabs, thermally insulated slabs and differently cut slabs.

There are oval or round cores inside the slabs for reducing weight. The cross-section of the slabs to the vertical axis is symmetrical and constant at the full length of the product.

MATERIALS

The following materials are used at the production of TAM slabs:

- normal-weight concrete with the strength class of at least C50/60 with the production and characteristics conforming to standard EN 206-1 “Concrete. Specification, performance, production and conformity”;

- strand as pre-stressed reinforcement with characteristics conforming to standard prEN 10138-3 “Pre-stressing steels. Part 3: Strand”.

PRODUCTION

TAM slabs are produced of normal-weight concrete by press moulding with the equipment of extrusion technology on heated pre-stressing casting beds. Concrete is compacted by vibration and shear compaction technology. The cubic pre-stressing strength of the concrete $f_{cm,p}$ is at least 30 MPa.

Strand is used in the tension zone of the slabs as pre-stressed longitudinal reinforcement. The initial pre-stress of the strand does not exceed 1100 MPa. TAM slabs are reinforced only in the longitudinal direction, there is no transverse reinforcement. The width of the concrete strip at casting is 1196 mm, which is 4 mm smaller than the nominal width (1200 mm) of the slab in order to enable building tolerances. When the concrete strength necessary for transferring the tension of the pre-stressing reinforcement to concrete has been achieved, the concrete strip is cut into slabs with the necessary length by a diamond saw.

The main types of TAM slabs are manufactured in the factory also with bottom-insulation with polystyrene foam as thermal insulation. Also, cantilever slabs and slabs cut narrower or bevelled slabs are manufactured.
Water-draining openings with the diameter of 16 mm are made inside of the bottom flange at the both ends of the slabs at the distance of 500 mm, through which the water that may accumulate into the cores during construction is drained. Plastic plugs are placed in the factory into the cores at slab ends to prevent the pouring of mixture into the cores during grouting the slabs.

The bottom surface of TAM slabs is formed against a steel casting bed. The upper surface is formed by a casting machine. The upper surface can be roughened in order to improve adhesion between the slab and the structural topping.

QUALITY

The quality of TAM slabs is secured by factory production control and type tests of the slabs. The factory production control includes regular control of all the used devices, materials, slabs and the production process itself.

The conformity of slabs to standards is confirmed by type tests.

SOUND INSULATION, HEAT RETENTION AND FIRE RESISTANCE

The sound insulation, heat retention and fire resistance of TAM slabs has been measured in conformity with the standard EN 1168 “Precast concrete products. Hollow core slabs”. The guide „Betonirakenteiden äänitekniikka“ issued by Suomen Betonitieto Oy has been used for measuring the sound insulation of the hollow-core slabs.
The fire resistance classes have been determined according to data tables of the standard EN 1168 “Precast concrete products. Hollow core slabs”, annex G. The results are presented in Table 1.

Table 1.

Sound insulation, heat retention and fire resistance classes of TAM slabs

Slab type	Airborne sound insulation index R_w (dB)	Reduced impact noise index $L'_{n,w}$ (dB)	Heat retention R_t (m^2K/W)	Fire resistance class
TAM 22	50	76	0,16	REI90
TAM 27	52	75	0,18	REI90
TAM 27E	52	75	0,18	REI120
TAM 32R	54	74	0,20	REI120
TAM 40	55	72	0,22	REI120

PRODUCTION TOLERANCES

Production tolerances in Table 2 correspond to the product standard EN 1168 and standard EVS 1992-1-1.
The tolerances of the dimensions of cross-sections and the location of pre-stressed reinforcements are allowed in case of load factors specified in standard EVS 1992-1-1. The negative tolerance limit of pre-stressed reinforcement has been presented on the basis of durability requirements in a dry environment (exposure class XC1).

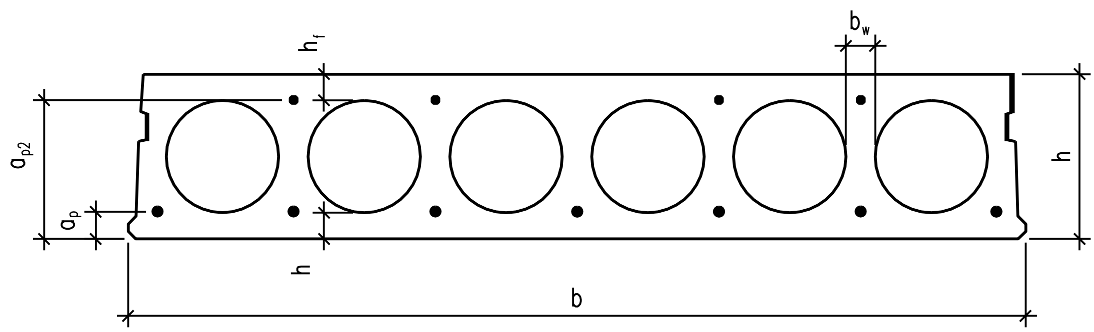
Table 2.

Production tolerances of TAM slabs. The notations are given in **figure 1**

Dimensions	Tolerance (mm)
Length	+/- 25
Width (b) - full-width slab - slabs that have been cut narrower	 +/- 5 +/- 25
Depth (h) - TAM 22 - TAM 27, TAM 27E, TAM 32, TAM 32R	 +14/-12 ±15
Openings - made into fresh concrete - made into hardened concrete	 +50; -0 ±15
Web thickness - single web (b_w) - total per slab (•b_w)	 -10 -20
Flange thickness (above and below the cores h_f) - TAM 22, TAM 27, TAM 27E, TAM 32, TAM 32R	 +15/-10
Vertical position of pre-stressed strand at tensile side (a_p, a_{p2}) - single strand - TAM 22 - TAM 27, TAM 27E, TAM 32, TAM 32R - average per slab	 ±12 ±15 ±7
Concrete cover of the pre-stressed reinforcement, including core edge (c)	- 10
Transverse curvature	±L/1000
Location of the tarid detail longitudinally and transversely	+/-25
The size of the opening or cavity, made in fresh concrete	+50/-10
The location of the of the opening or cavity, made in fresh concrete	±25
The waviness of the top surface	±10

Figure 1.

Symbols in the table of tolerances



TYPEINDICATIONS

The product name of pre-stressed hollow-core slabs manufactured in OÜ TMB Element is TAM slab.
The slab marking consists of a letter-number combination.

An example of slab marking: **TAM27-101**, where
TAM27 - slab type indication;
K - cantilever slab;
E – special type symbol;
R – special type symbol.
101 – marking of the customer

Table 3.

Type indications of the main and special types of TAM slabs

Slab height (mm)	Main type	Console slab	Cavity shape
220	TAM 22	TAM 22K	round
265	TAM 27	TAM 27K	round
265	TAM 27E	TAM 27EK	oval
320	TAM 32R	TAM 32K	oval
320	TAM 40	TAM 32RK	oval

DEAD WEIGHTS AND AREAS OF CROSS-SECTION

Table 4.

Dead weights and areas of cross-sections of TAM slabs

Slab type	Dead weight of a m^2 of the slab (kN)	Dead weight of one meter of length (kN)	Area of the cross-section of the concrete (m^2)	(%) of cores in the cross-section of the slab
TAM 22	3.1	3.7	0.15	41
TAM 27	3.6	4.4	0.17	44
TAM 27E	3.6	4.3	0.17	44
TAM 32R	4.0	4.8	0.19	48
TAM 40	4.0	5.6	0.23	51

CROSS-SECTIONS

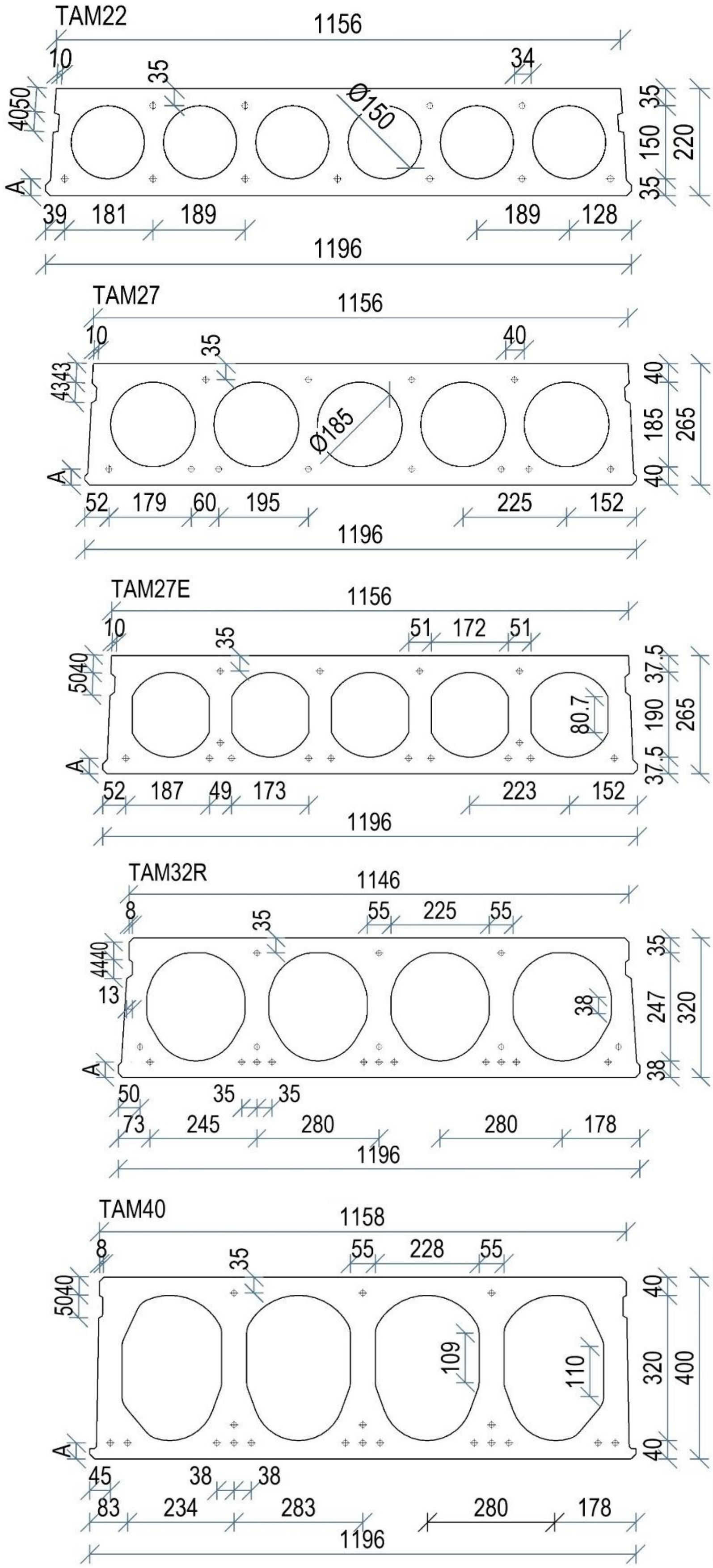
Nominal measurements of the cross-sections of TAM slabs and the position of pre-stressing reinforcement have been presented in Figure 2. The maximum possible reinforcement has been indicated in the cross-sections.

TAM

Cross-sections

Figure 2.

Cross-sections of TAM slabs



Fire resistance class	Height of the strand, A (mm)
REI 60	35
REI 90	45
REI 120	55

BEARING CAPACITY AND CAMBER GRAPHS

The graphs of the bearing capacity of TAM slabs (figures 3…20) have been calculated in accordance with the standards:

- EN 1990 "Eurocode. Basis of structural design";

- EN 1991-1-1 "Eurocode 1: Actions on structures.
  Part 1-1: General actions. Densities, self-weight, imposed loads for buildings";

- EN 1991-1-2 "Eurocode 1: Actions on structures.
  Part 1-2: General actions. Actions on structures exposed to fire";

- EVS 1992-1-3 "Design of concrete structures.
  Part 1-3: Common rules for design of forced concrete structures".

The bearing capacity graphs of TAM 22, TAM 27, TAM 27E, TAM 32, TAM 32R and TAM40 can be used in case of residential, office, commercial, traffic and public gathering spaces and the graphs are valid on the following conditions:

- the standard value of bearing capacity does not include dead weight;
- exposure class XC1 (dry environment);
- slabs are supported by rigid structures;
- the support length of the slab at designing $65mm;
- ultimate deflection of the slab: span/250;
- ultimate deflection of the cantilever: length/125;
- the percentage of permanent and changeable load in the standard value is 30% and 70% respectively;
- the camber graphs apply to one-month-old unloaded slabs;
- the strength class of the concrete is C55/60;
- the pre-stressed reinforcement is a Ø12.5 mm strand consisting of seven wires, strength class 1860/1635, relaxation class 2;
- the initial pre-stressing values of strands are given next to the graphs.

The graphs are valid for the following imposed load classes (EVS-EN 1991-1-1):

- Figures 3, 6, 9, 12, 15, 18:
  classes **A (residential space), B (office space), G (traffic space,** 30 kN < weight of the vehicle # 160 kN), combination factors R_0=0.7; cR_1=0.5; R_2=0.3;

- Figures 4, 7, 10, 13, 16, 19:
  classes **C (public gathering space), D (commercial space), F (traffic space,** weight of the vehicle # 30 kN), combination factors R_0=0.7; cR_1=0.7; R_2=0.6;

- Figures 5, 8, 11, 14, 17, 20:
  class **E (storage spaces),** combination factors R_0=0.7; cR_1=0.7; R_2= 0.6;

- **in case of roofing (snow pressure)** use approximately figures 3, 6, 9, 12, 15, 18;

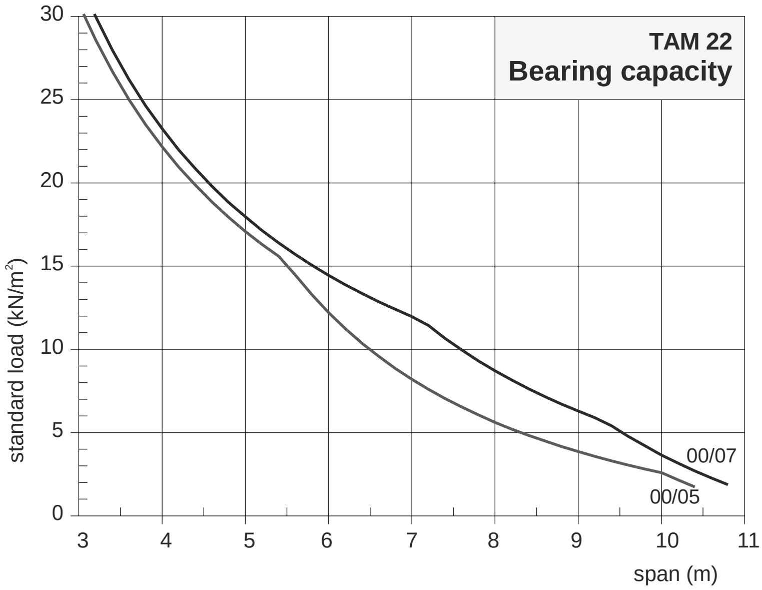
- **for other pressure classes** refer to slab manufacturer's checking calculations.

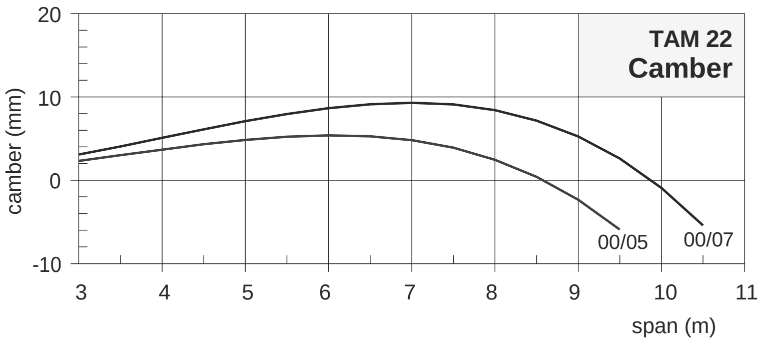
The numerators and the denominators in the graphs show the number of strands in the upper and lower flange of the slab respectively.

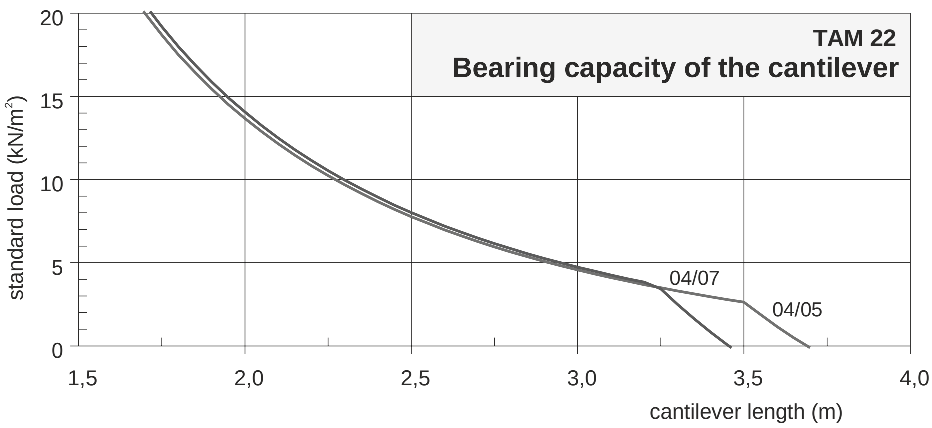
TAM 22

Bearing capacity and camber graphs

Figure 3. Bearing capacity and camber graphs of the slab TAM 22
- lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **A, B, G**: combination factors R_0=0.7; cR_1=0.5; R_2=0.3



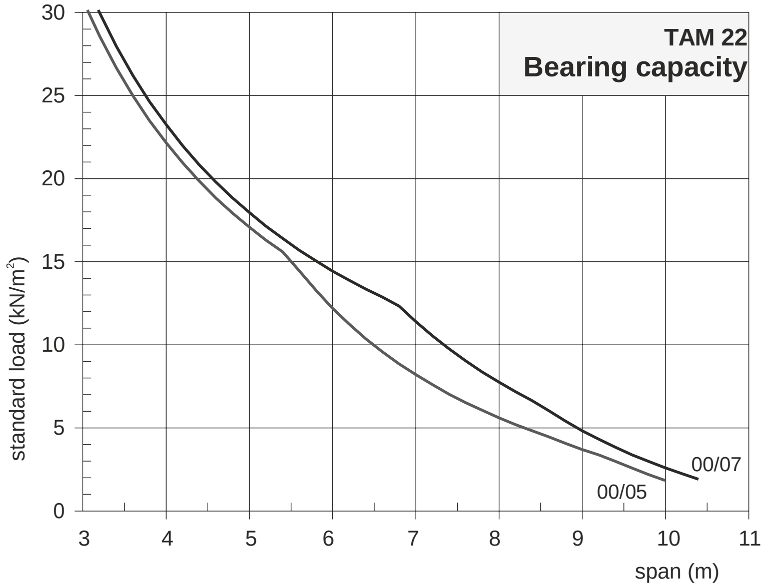


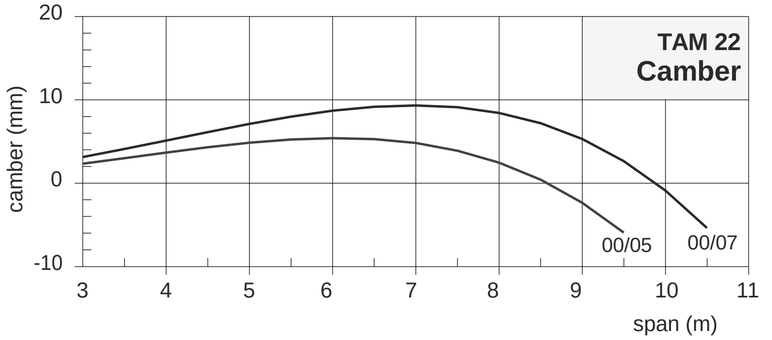


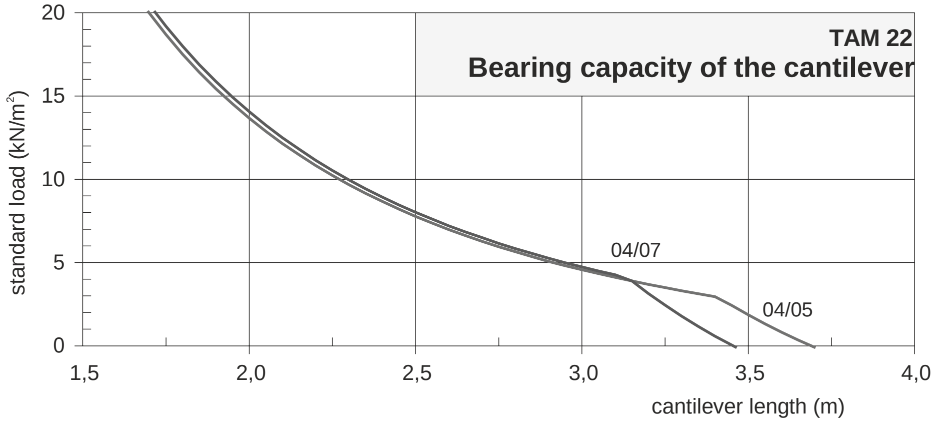
TAM 22

Bearing capacity and camber graphs

Figure 4. Bearing capacity and camber graphs of the slab TAM 22
- lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **C, D, F**: combination factors R_0=0.7; cR_1=0.7; R_2=0.6



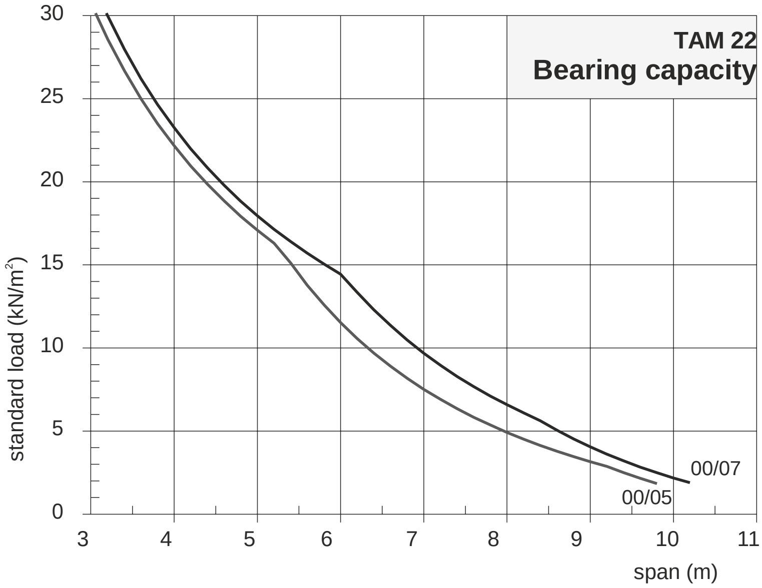


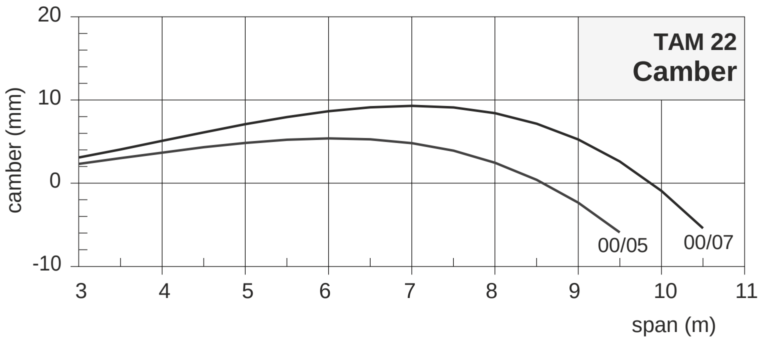


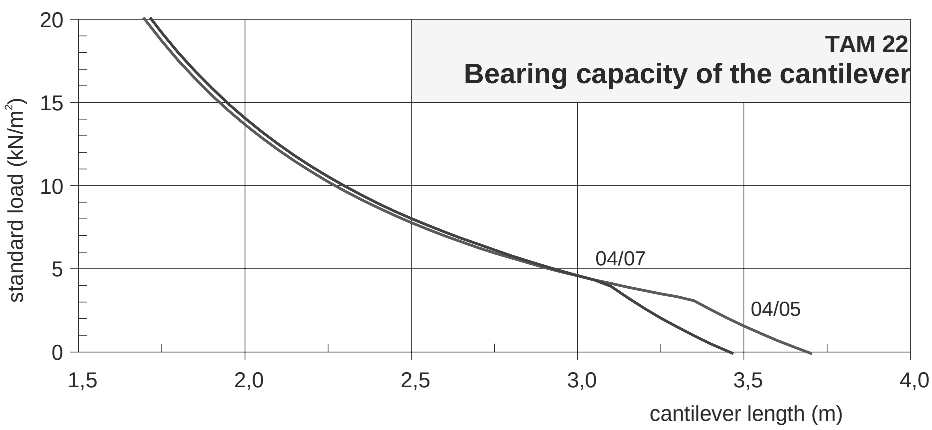
TAM 22

Bearing capacity and camber graphs

Figure 5. Bearing capacity and camber graphs of the slab TAM 27
- lower strands' initial pre-stress of **1000 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **E**: combination factors R_0=1.0; cR_1=0.9; R_2=0.8



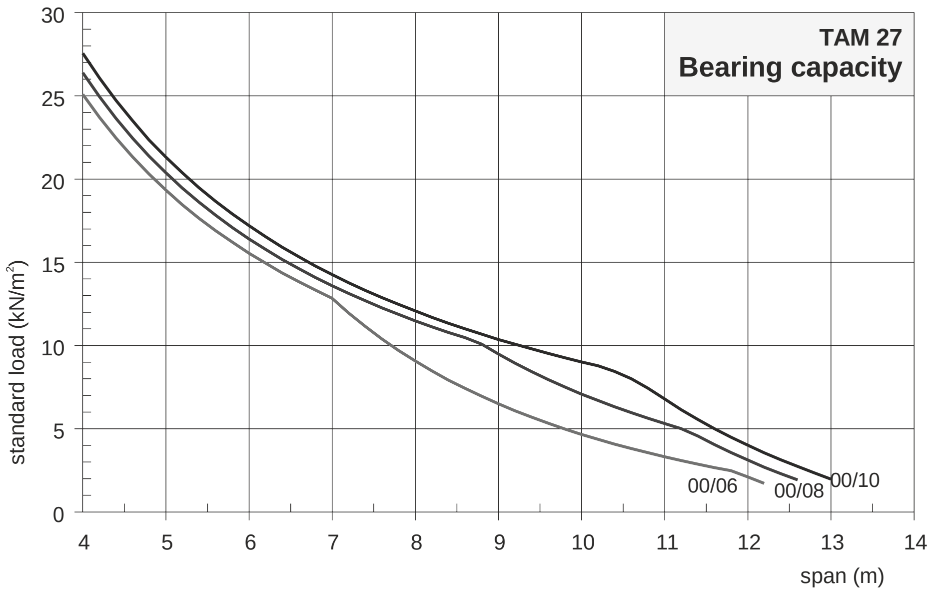


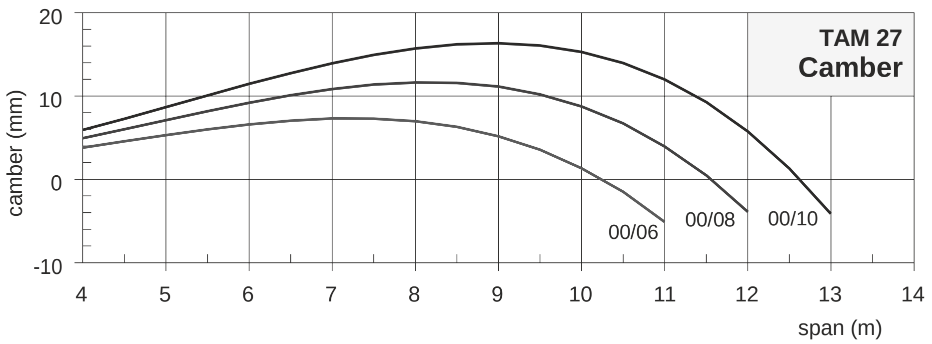


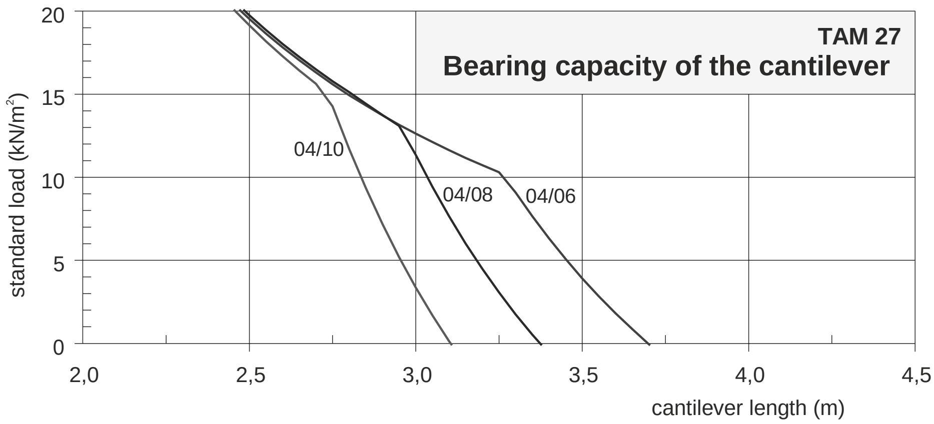
TAM 27

Bearing capacity and camber graphs

Figure 6. Bearing capacity and camber graphs of the slab TAM 27
- lower strands' initial pre-stress of **1000 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **A, B, G**: combination factors R_0=0.7; cR_1=0.5; R_2=0.3



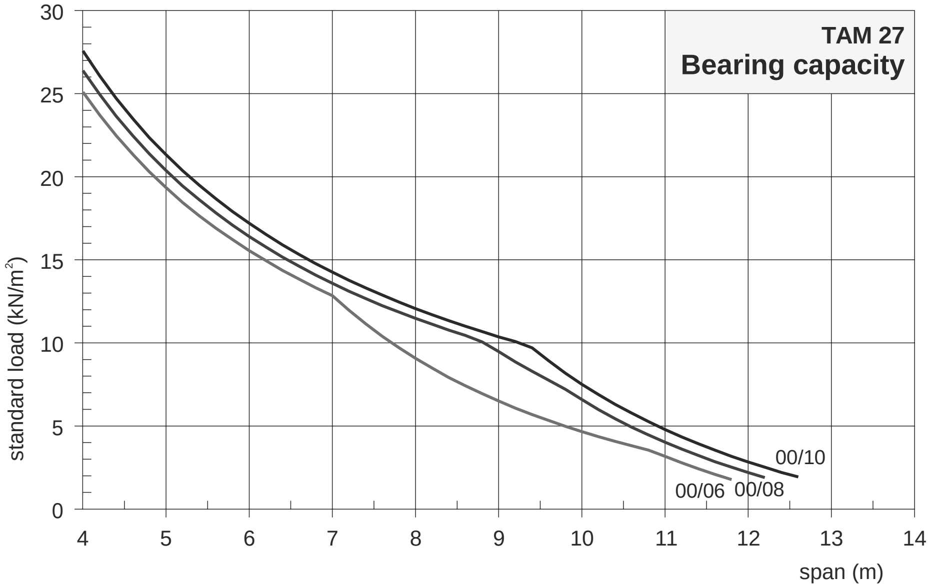


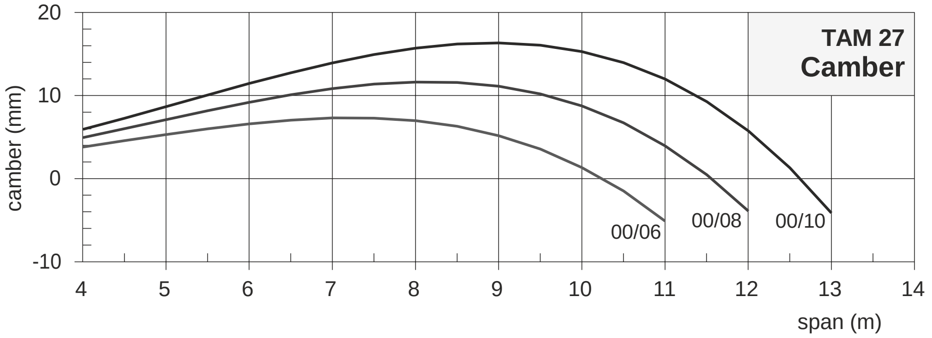


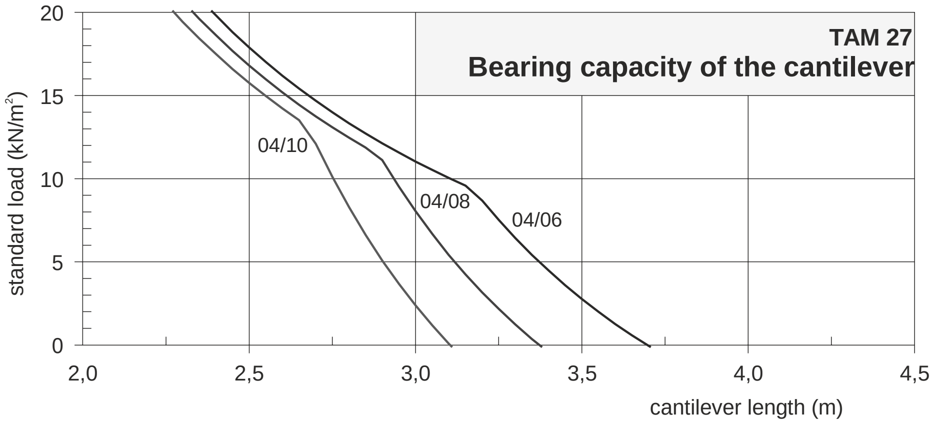
TAM 27

Bearing capacity and camber graphs

Figure 7. Bearing capacity and camber graphs of the slab TAM 27
- lower strands' initial pre-stress of **1000 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **C, D, F**: combination factors R_0=0.7; cR_1=0.7; R_2=0.6



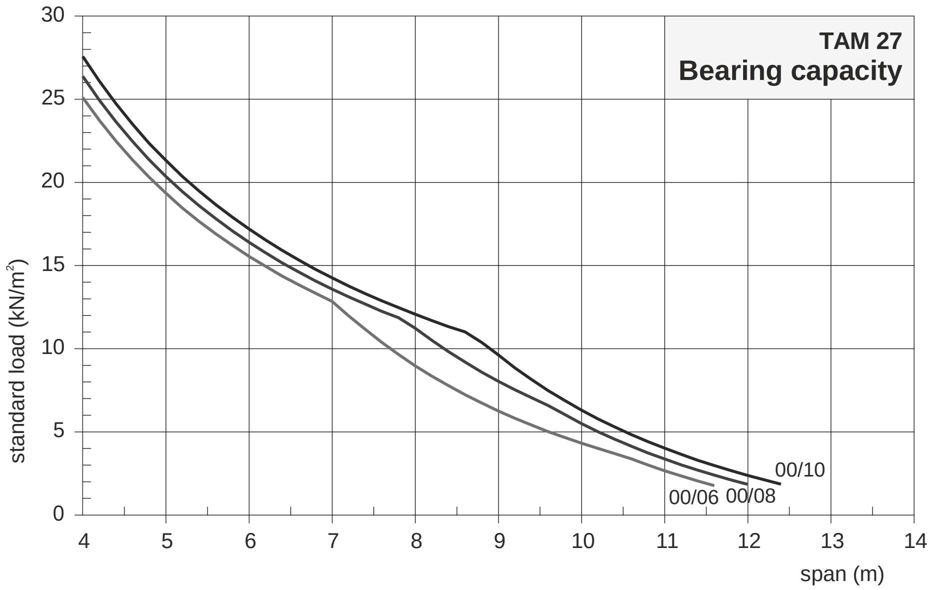


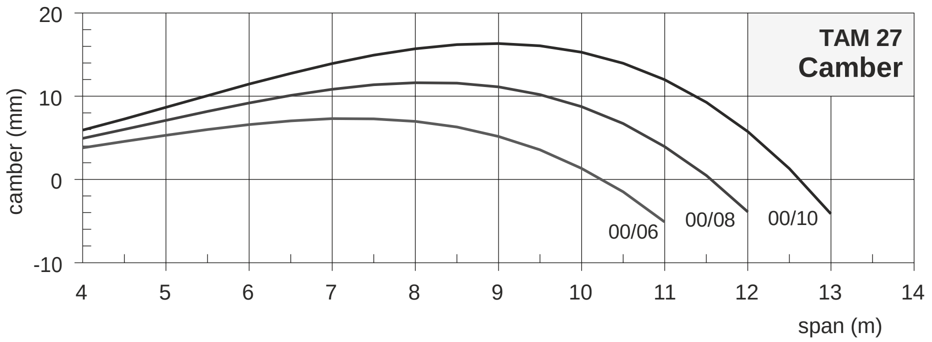


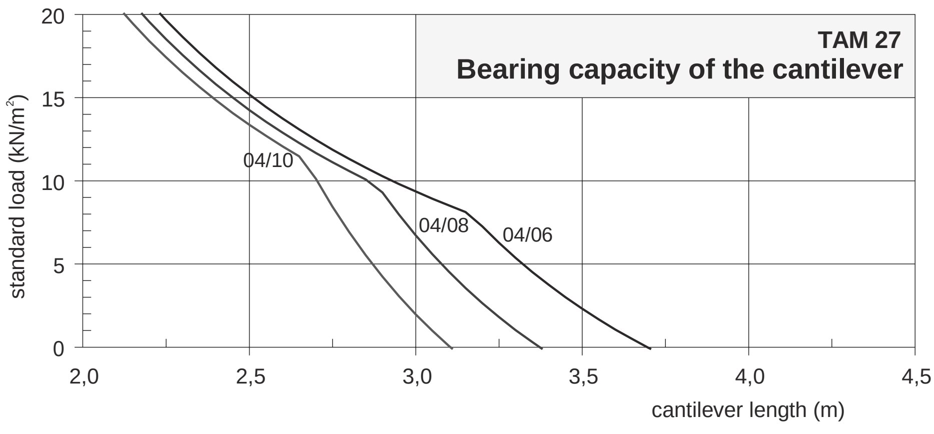
TAM 27

Bearing capacity and camber graphs

Figure 8. Bearing capacity and camber graphs of the slab TAM 27
- lower strands' initial pre-stress of **1000 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **E**: combination factors R_0=1.0; cR_1=0.9; R_2=0.8



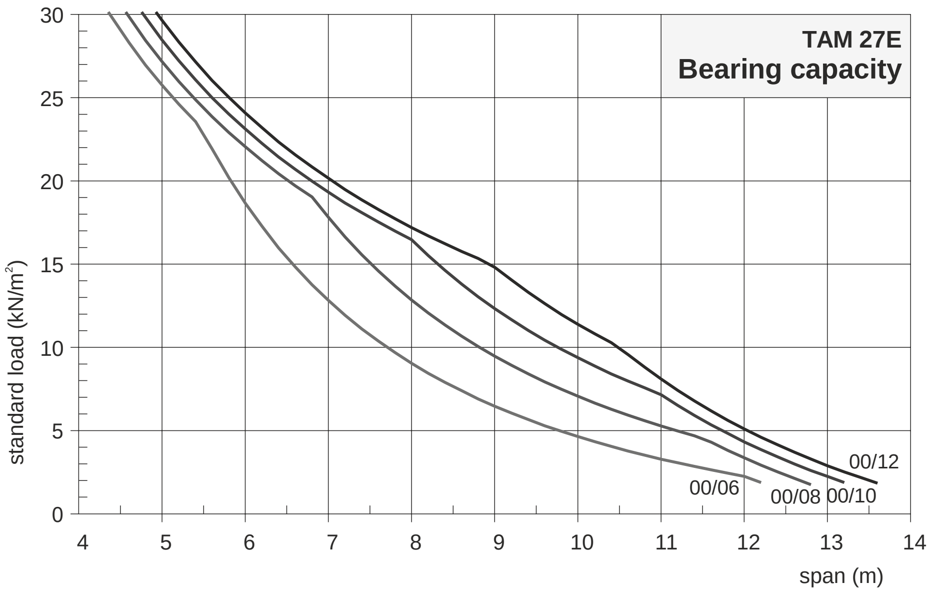


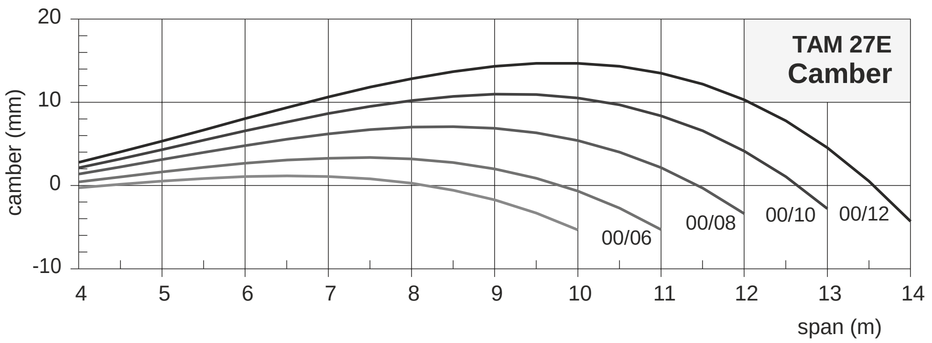


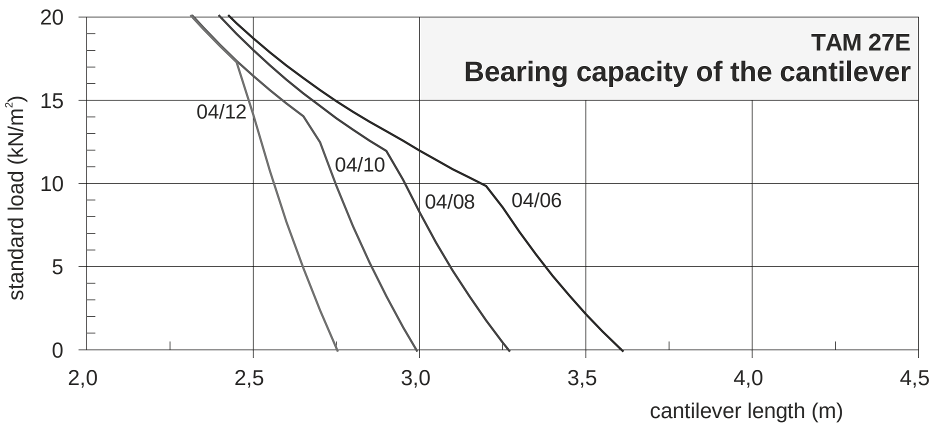
TAM 27E

Bearing capacity and camber graphs

Figure 9. Bearing capacity and camber graphs of the slab TAM 27E
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **A, B, G**: combination factors R_0=0.7; cR_1=0.5; R_2=0.3



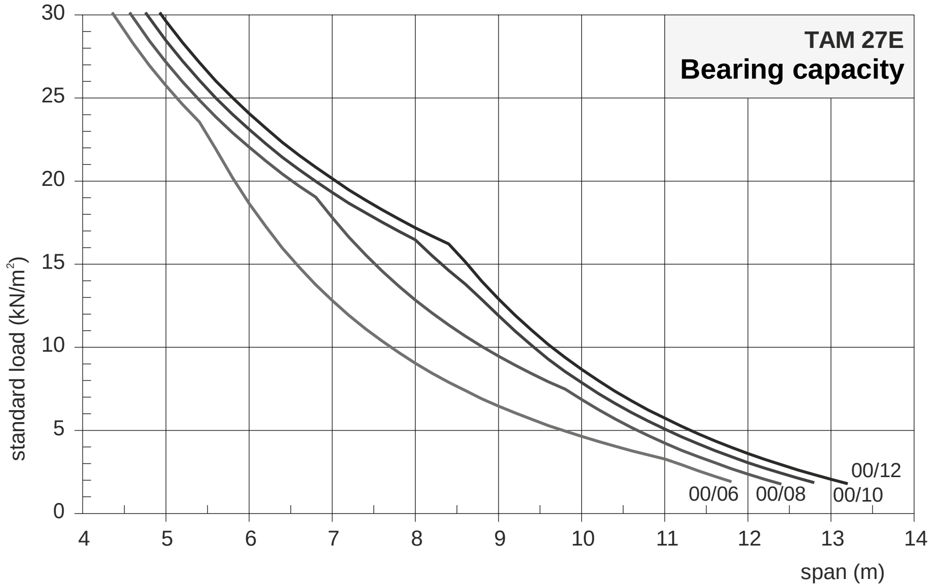


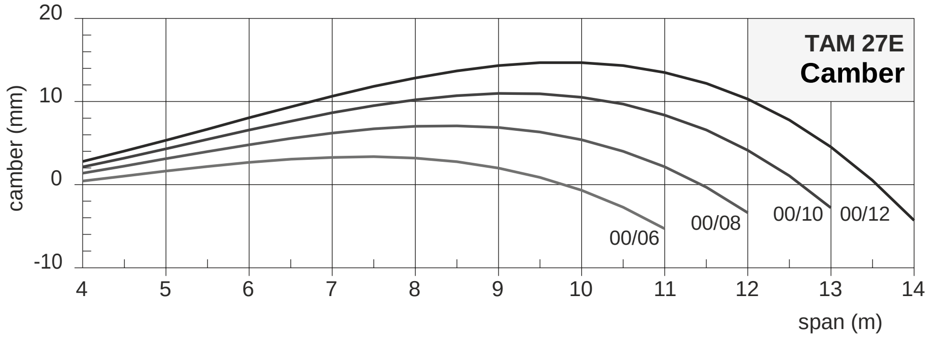


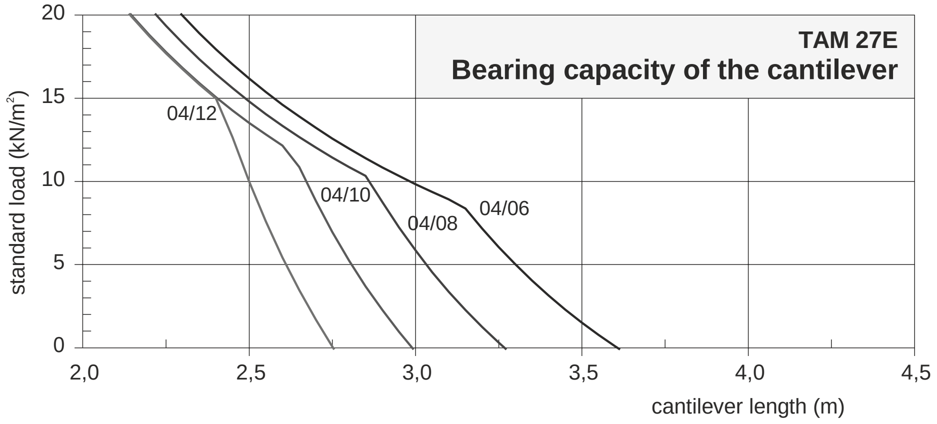
TAM 27E

Bearing capacity and camber graphs

Figure 10. Bearing capacity and camber graphs of the slab TAM 27E
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **C, D, F**: combination factors R_0=0.7; cR_1=0.7; R_2=0.6



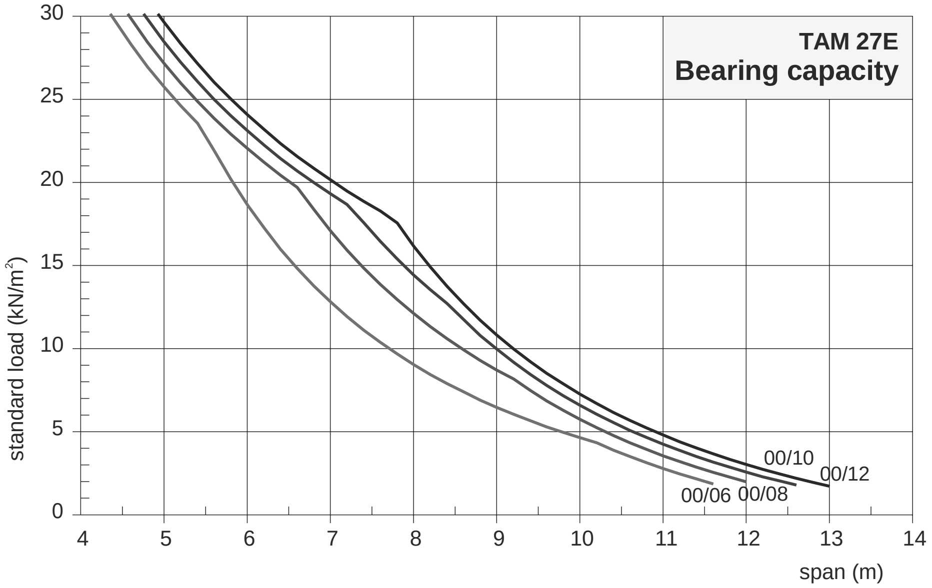


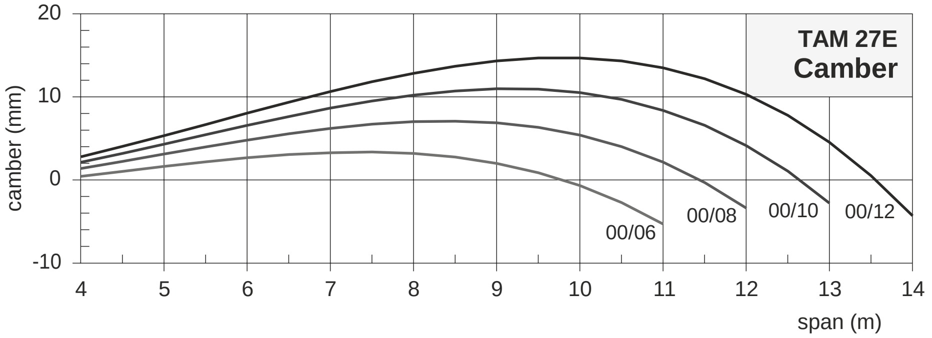


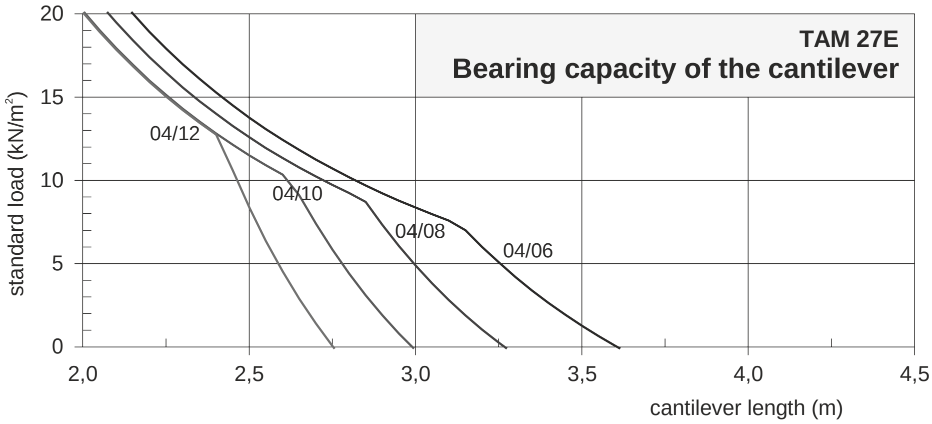
TAM 27E

Bearing capacity and camber graphs

Figure 11. Bearing capacity and camber graphs of the slab TAM 27E
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **E**: combination factors R_0=1.0; cR_1=0.9; R_2=0.8



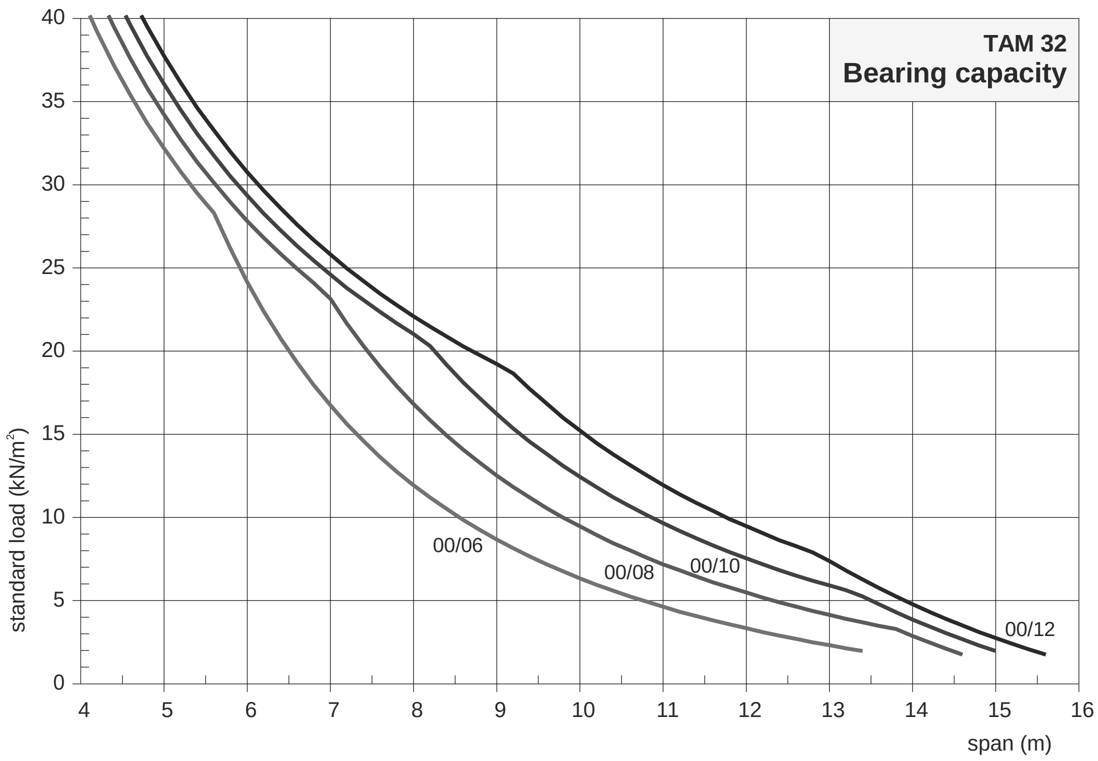


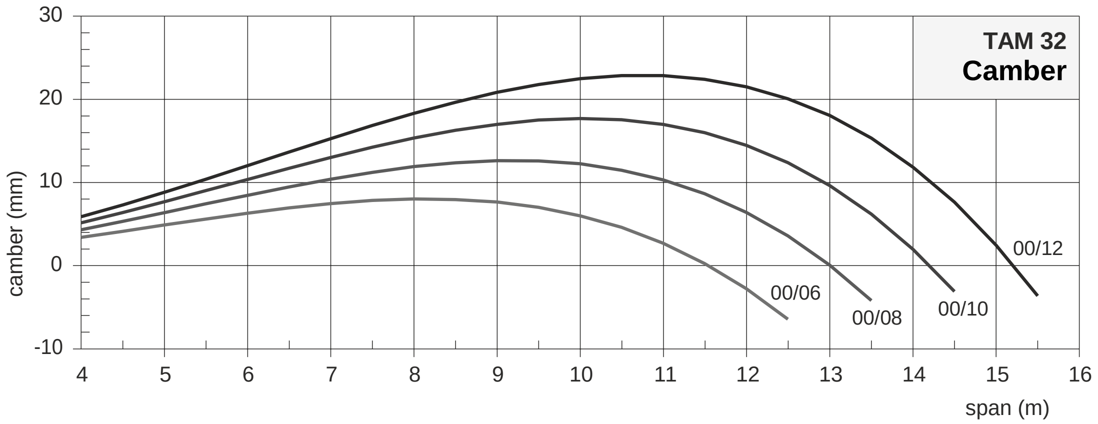


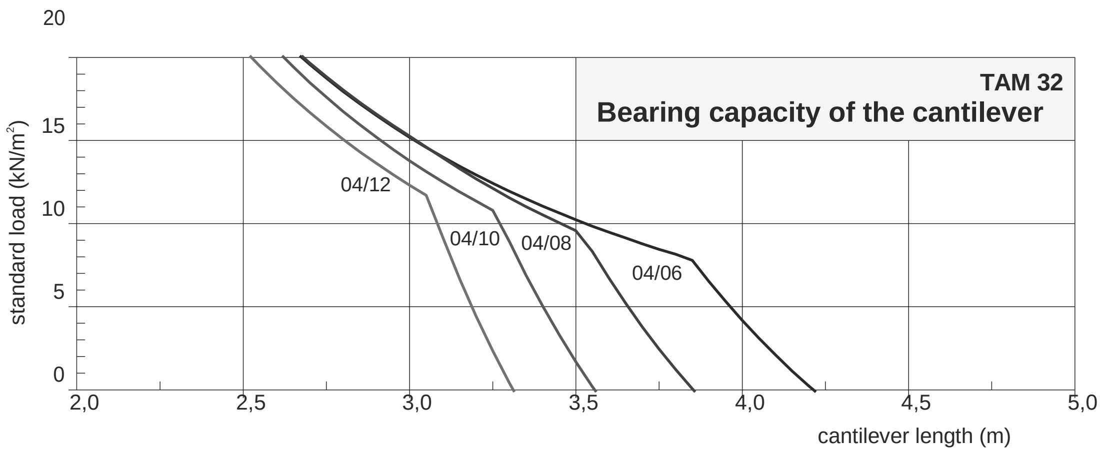
TAM 32

Bearing capacity and camber graphs

Figure 12. Bearing capacity and camber graphs of the slab TAM 32
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **A, B, G**: combination factors R_0=0.7; cR_1=0.5; R_2=0.3

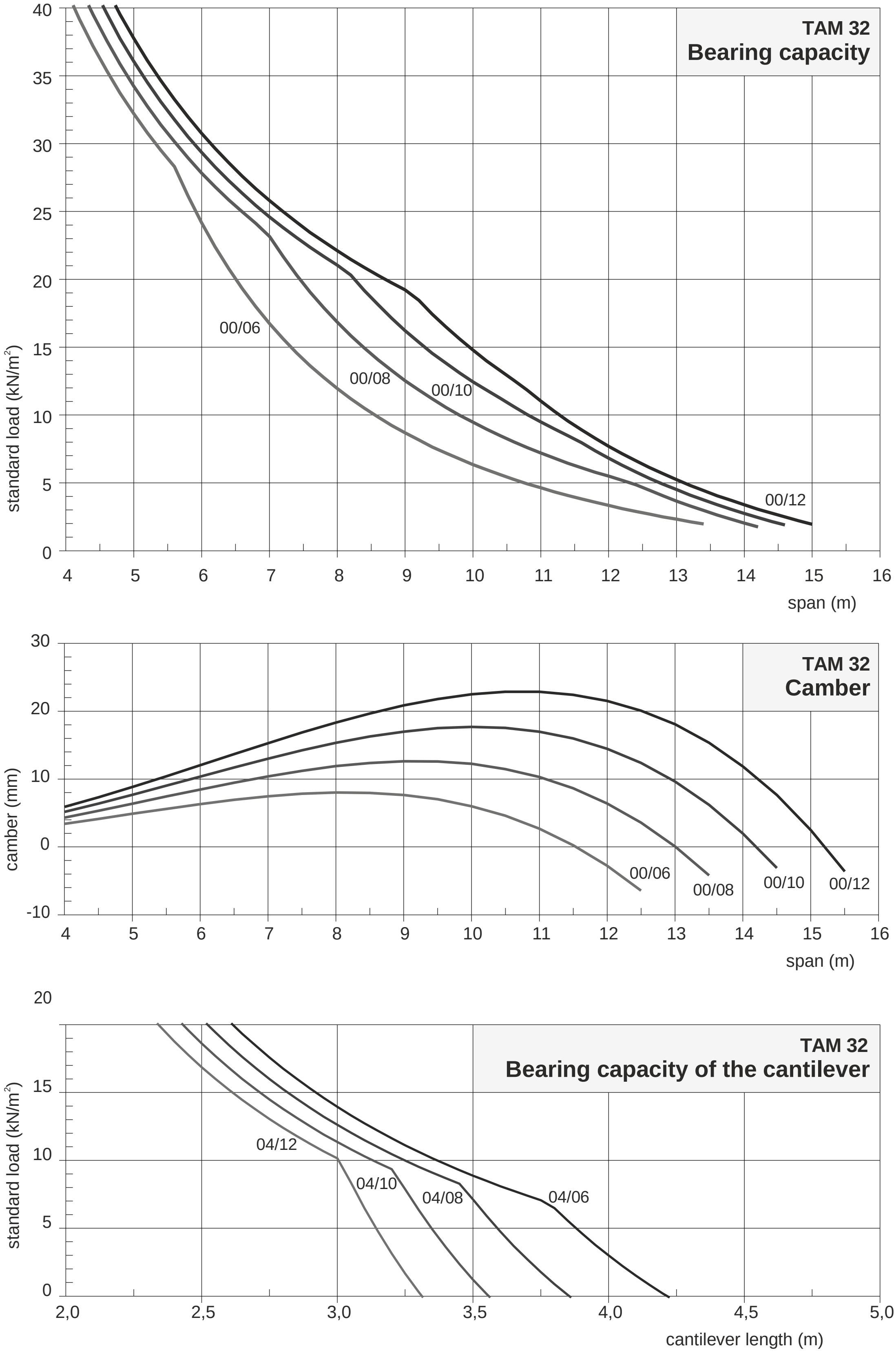






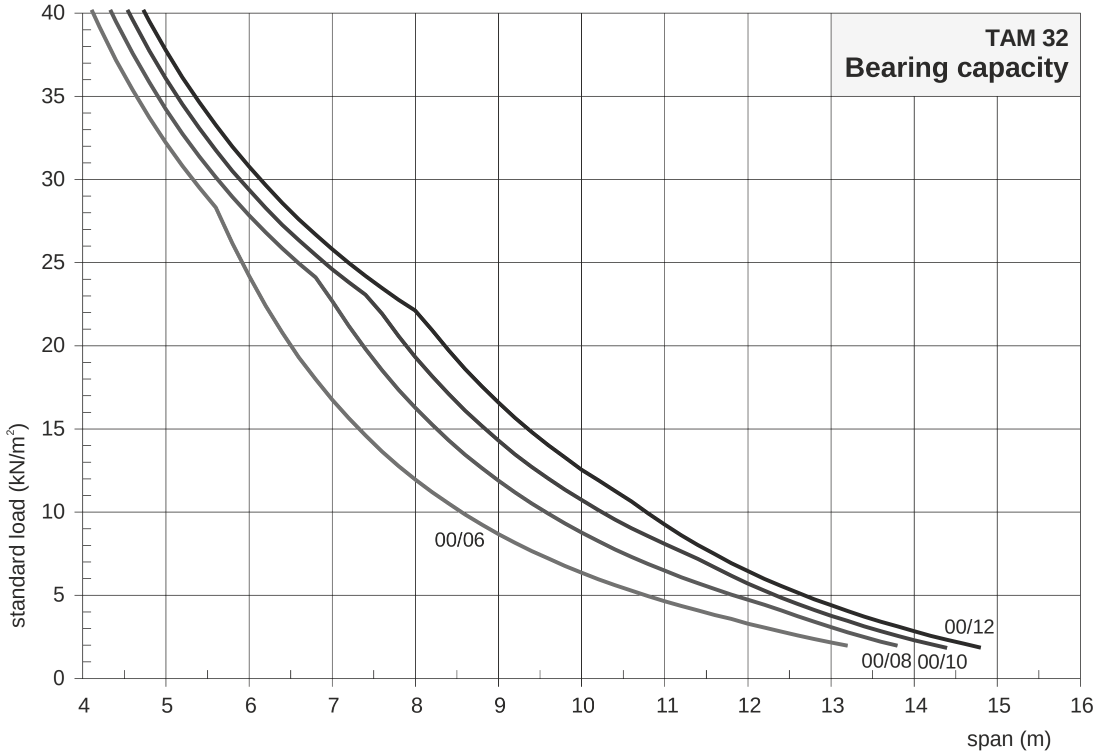
Bearing capacity and camber graphs

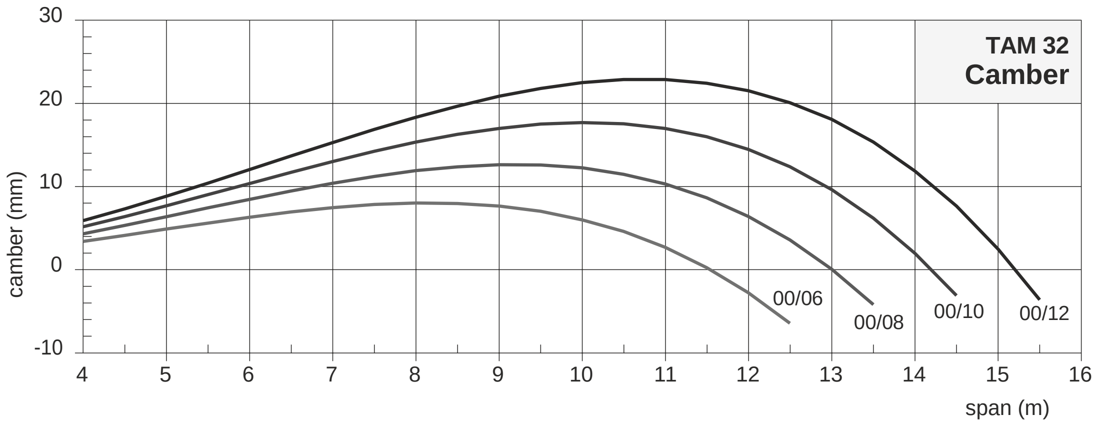
Figure 13. Bearing capacity and camber graphs of the slab TAM 32
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **C, D, F**: combination factors R_0=0.7; cR_1=0.7; R_2=0.6

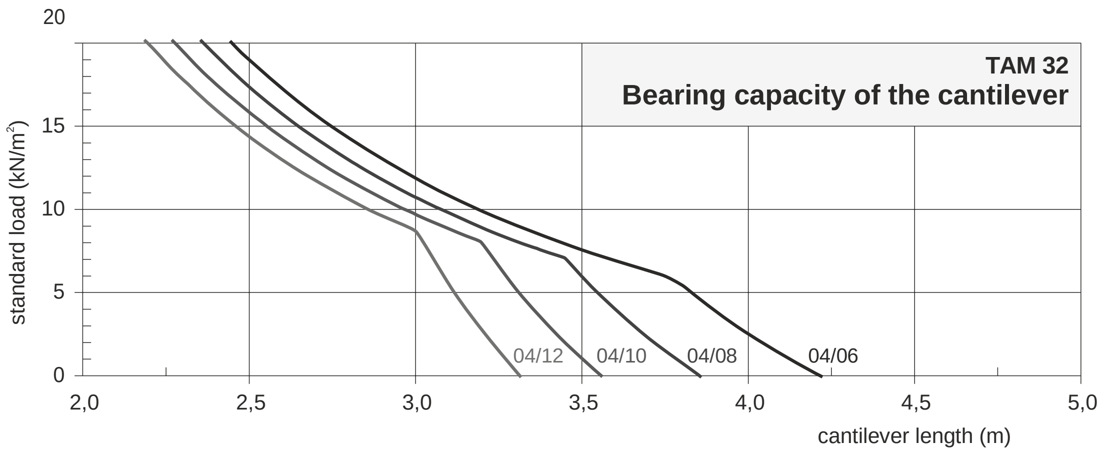


Bearing capacity and camber graphs

Figure 14. Bearing capacity and camber graphs of the slab TAM 32
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **E**: combination factors R_0=1.0; cR_1=0.9; R_2=0.8

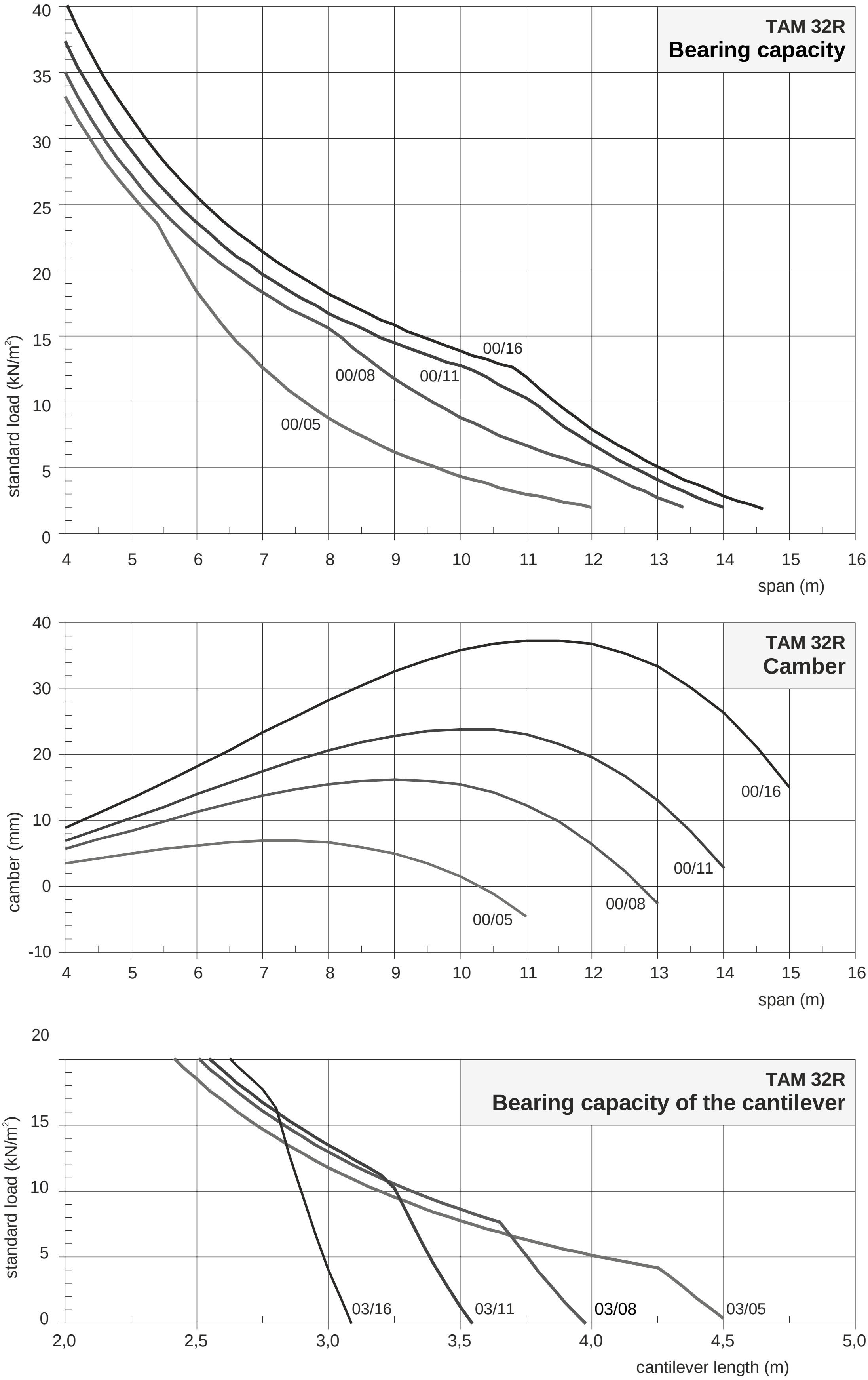






Bearing capacity and camber graphs

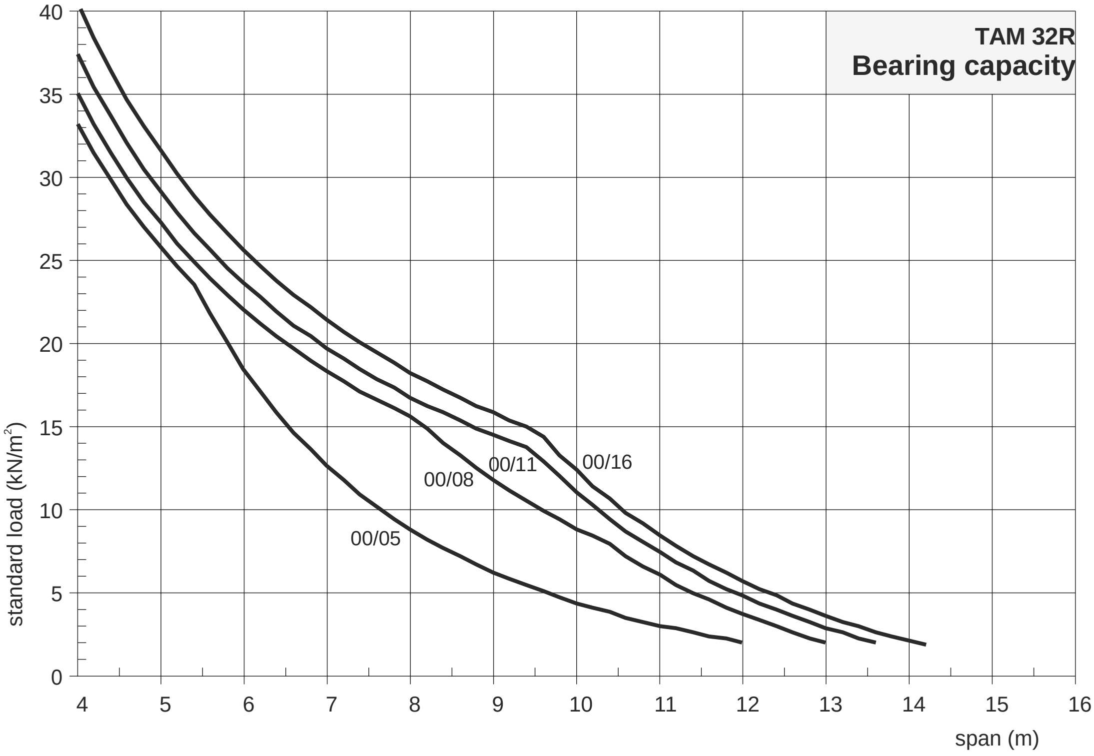
Figure 15. Bearing capacity and camber graphs of the slab TAM 32R
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **A, B, G**: combination factors R_0=0.7; cR_1=0.5; R_2=0.3

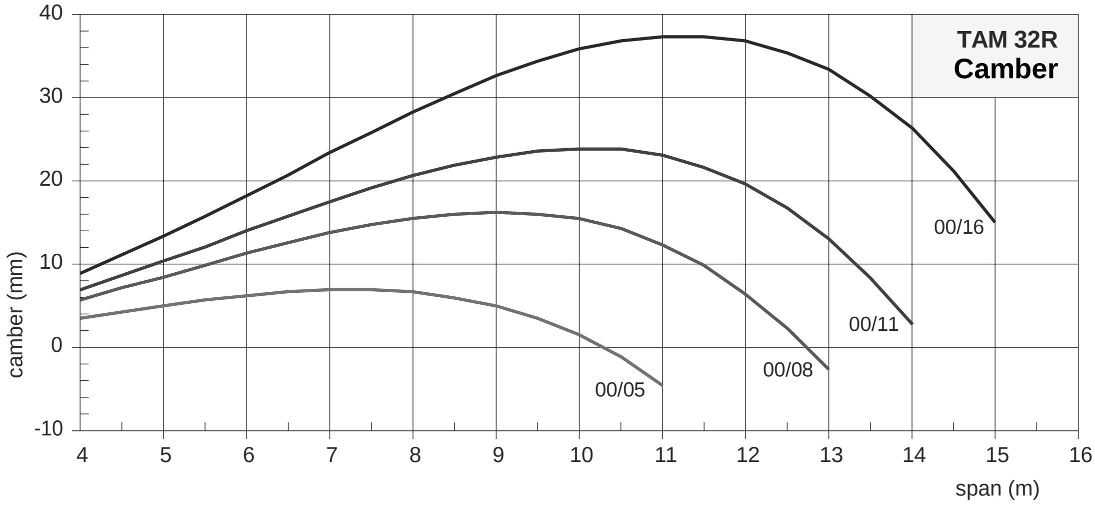


TAM 32

Bearing capacity and camber graphs

Figure 16. Bearing capacity and camber graphs of the slab TAM 32R
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load classes **C, D, F:** combination factors R_0=0.7; cR_1=0.7; R_2=0.6





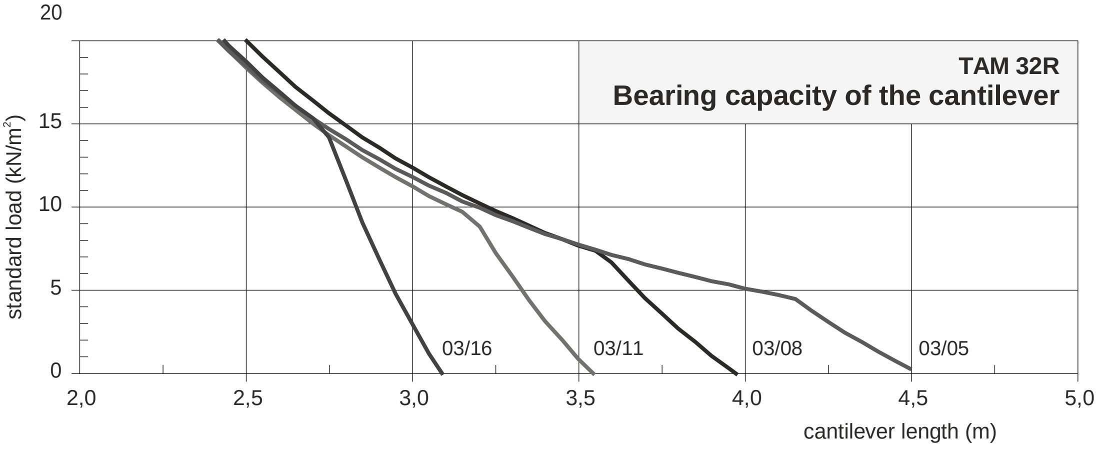
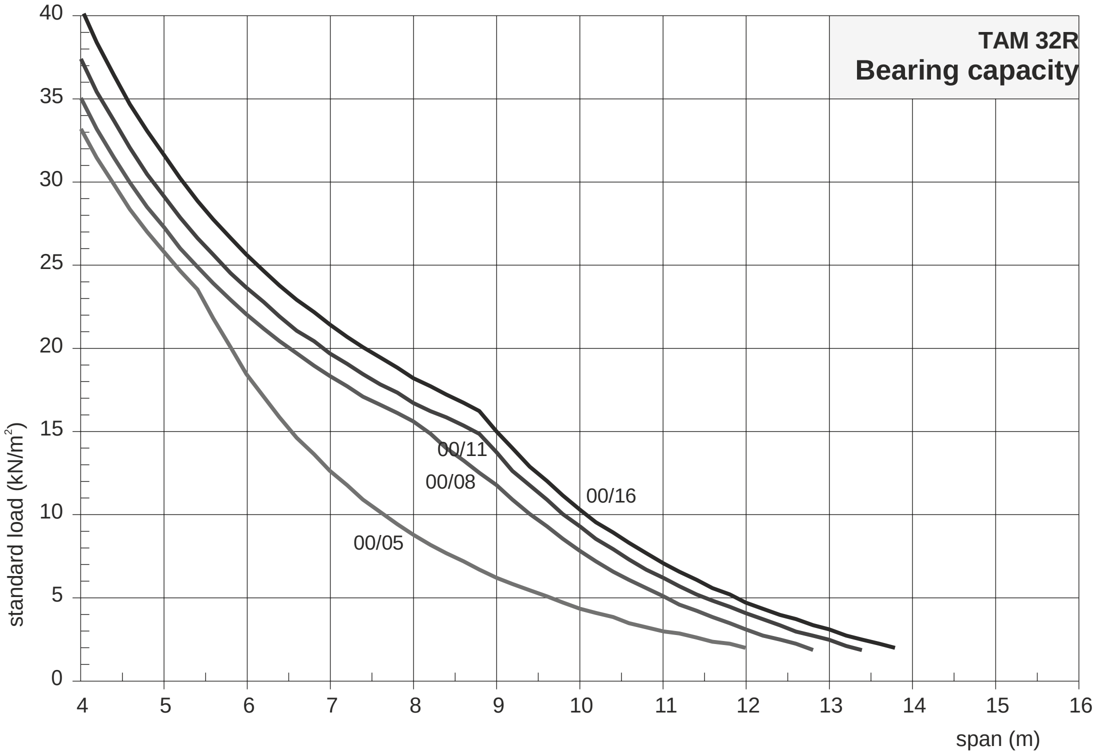
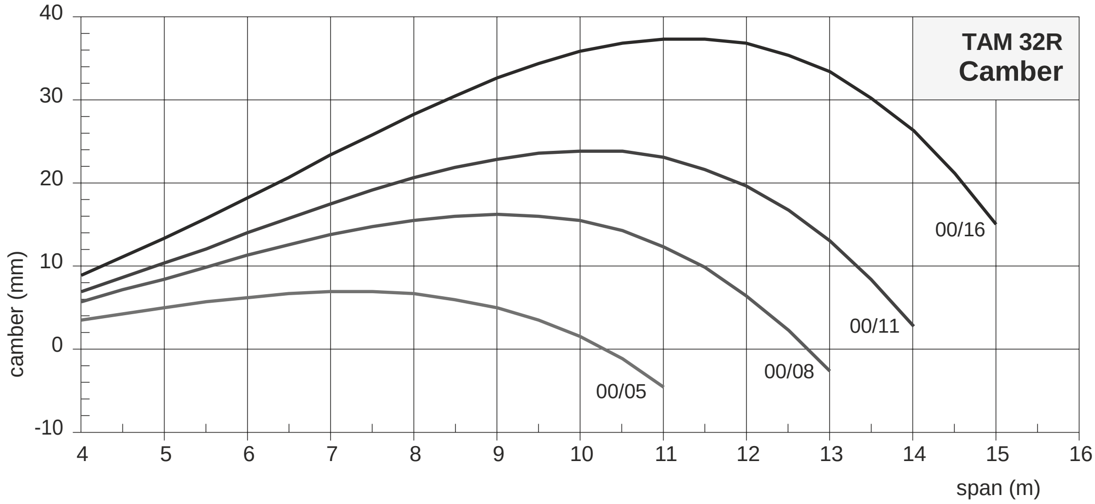
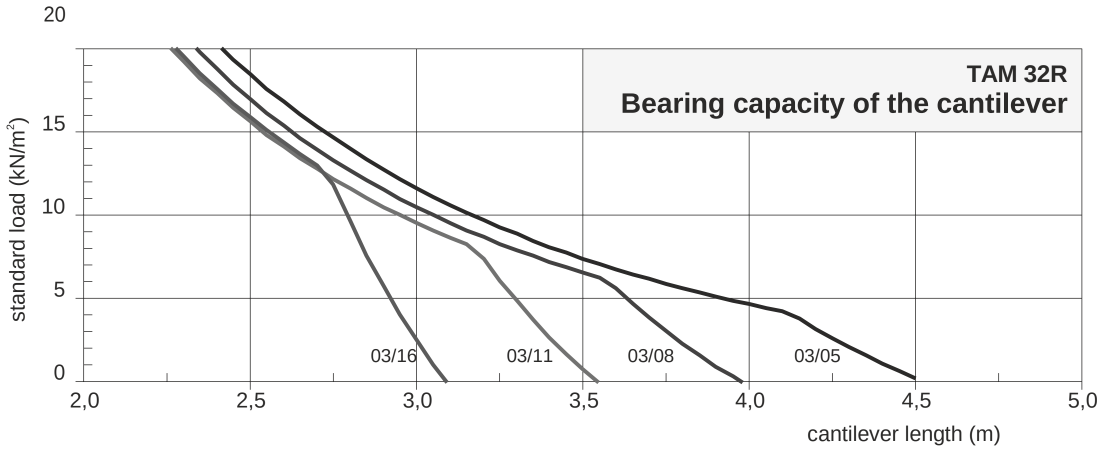


Figure 17. Bearing capacity and camber graphs of the slab TAM 32R
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load class **E:** combination factors R_0=1.0; cR_1=0.9; R_2=0.8

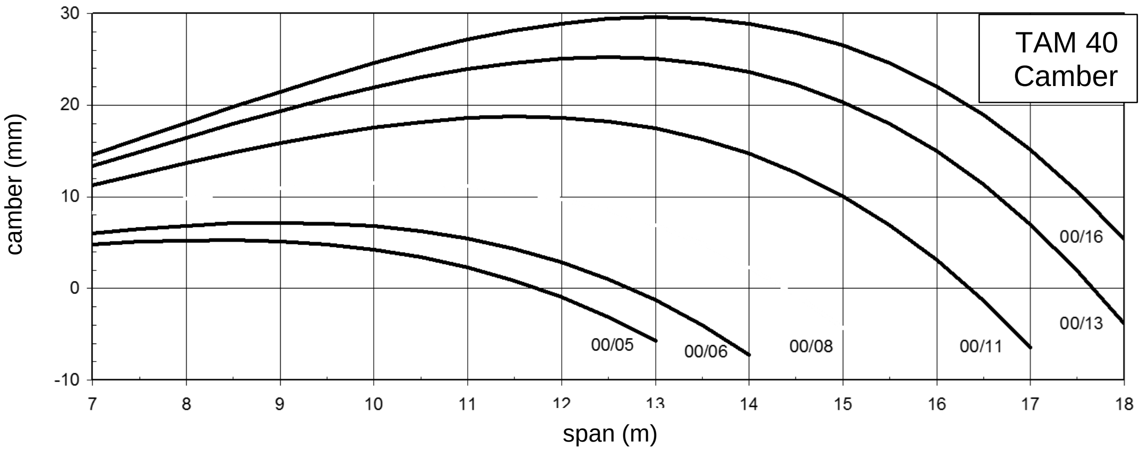


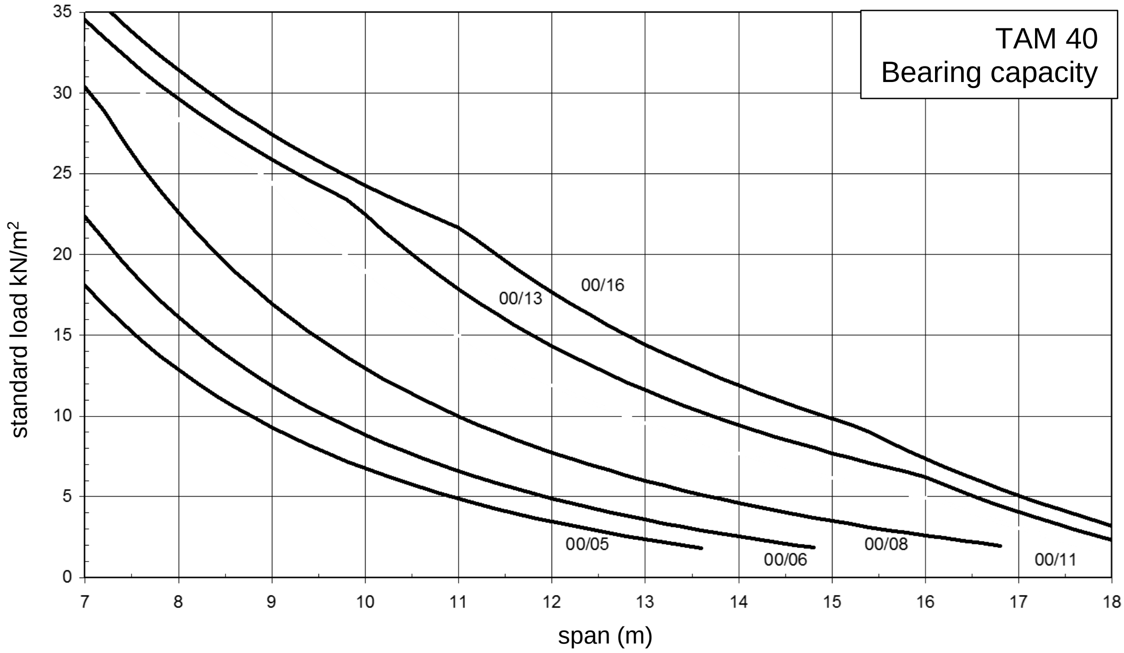


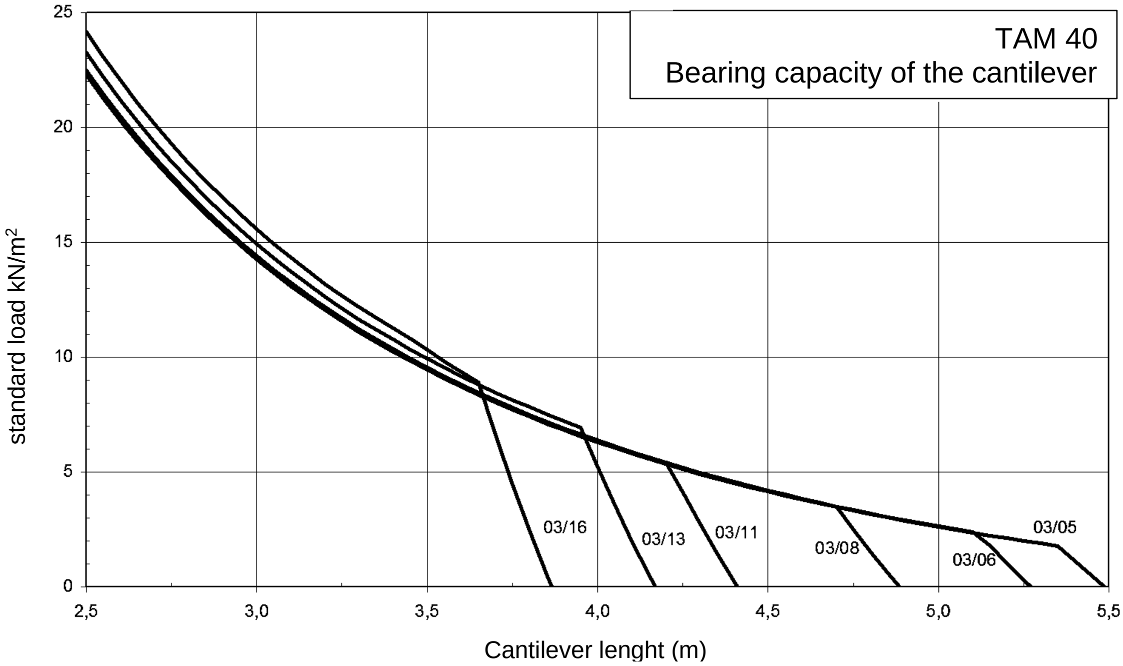


TAM40

Joonis 18. Bearing capacity and camber graphs of the slab TAM 40
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load class A, B, G: combination factors R_0=0.7; cR_1=0.5; R_2=0.3

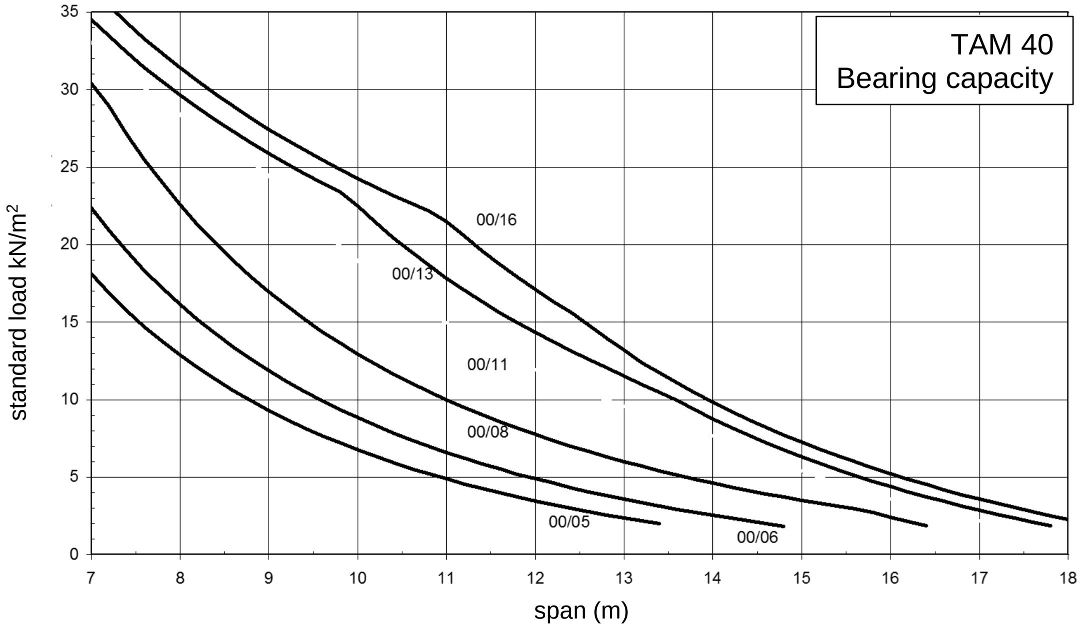


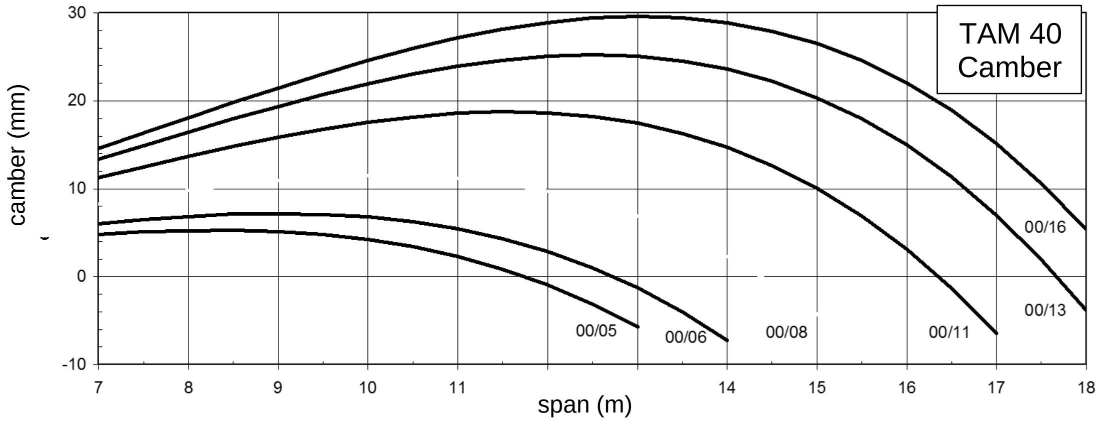


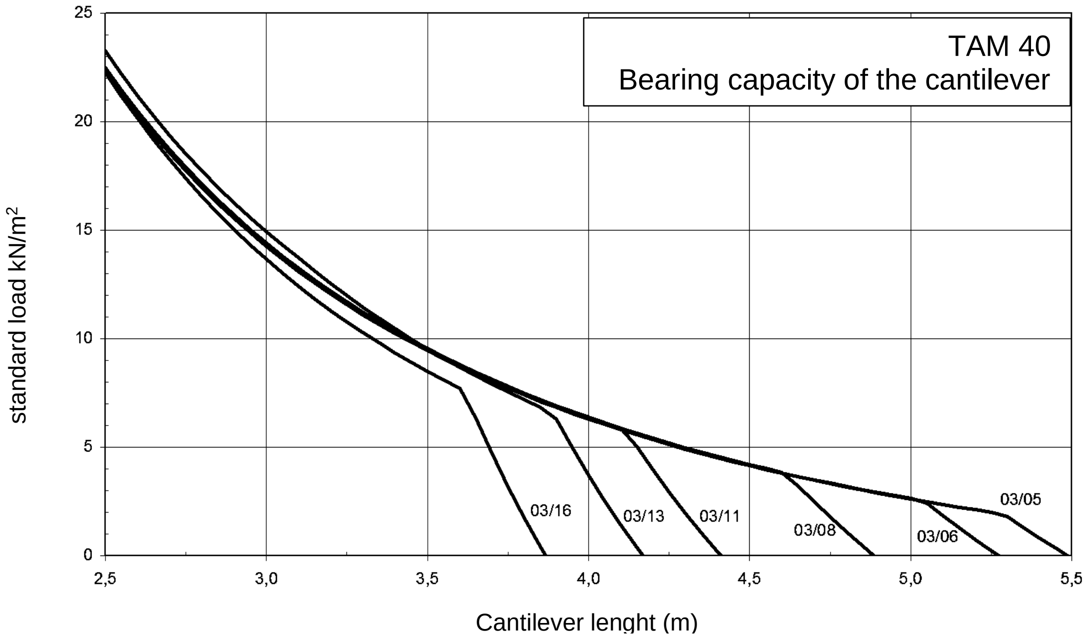


TAM40

Joonis 19. Bearing capacity and camber graphs of the slab TAM 40
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load class E: combination factors R_0=0.7; cR_1=0.7; R_2=0.6

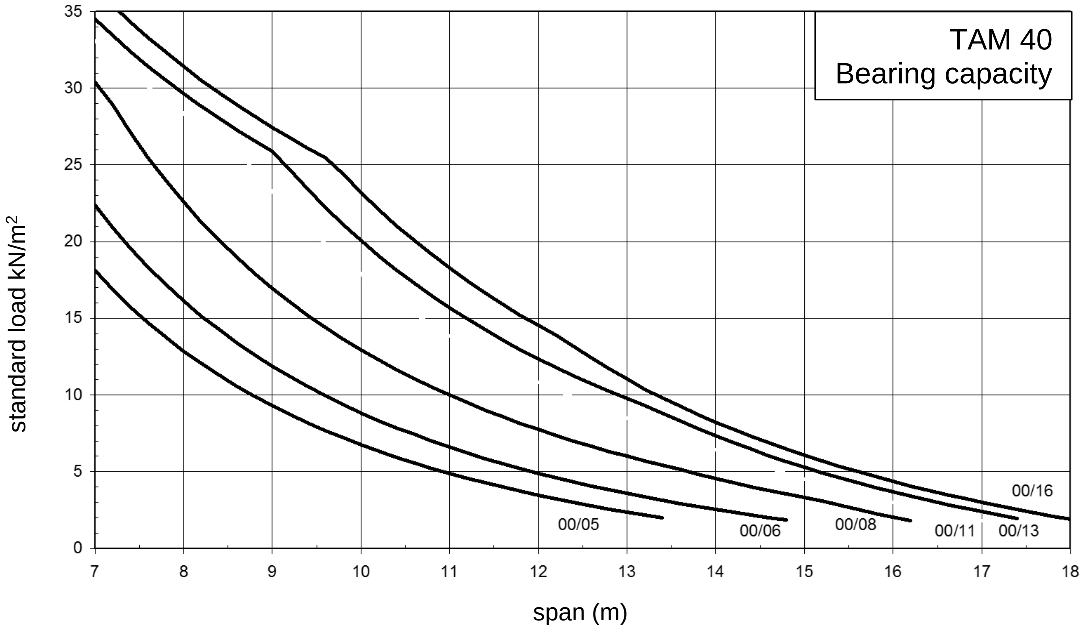


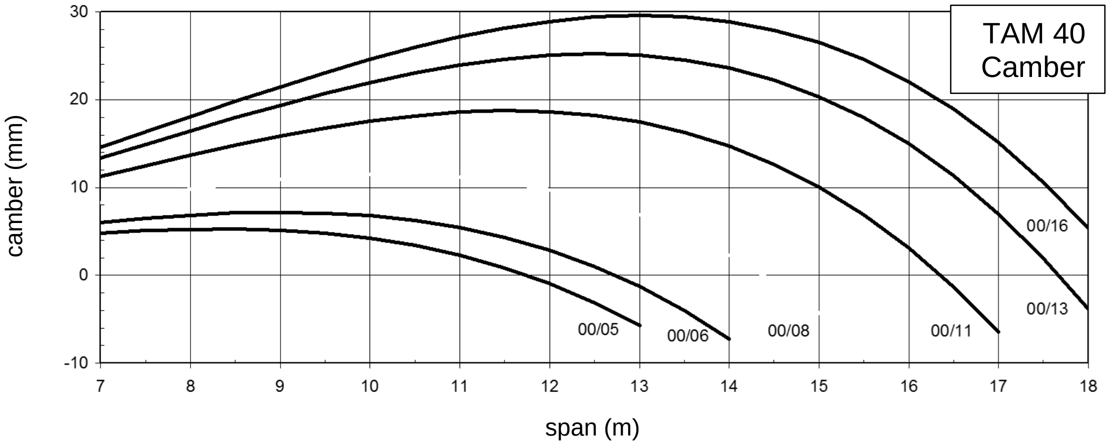


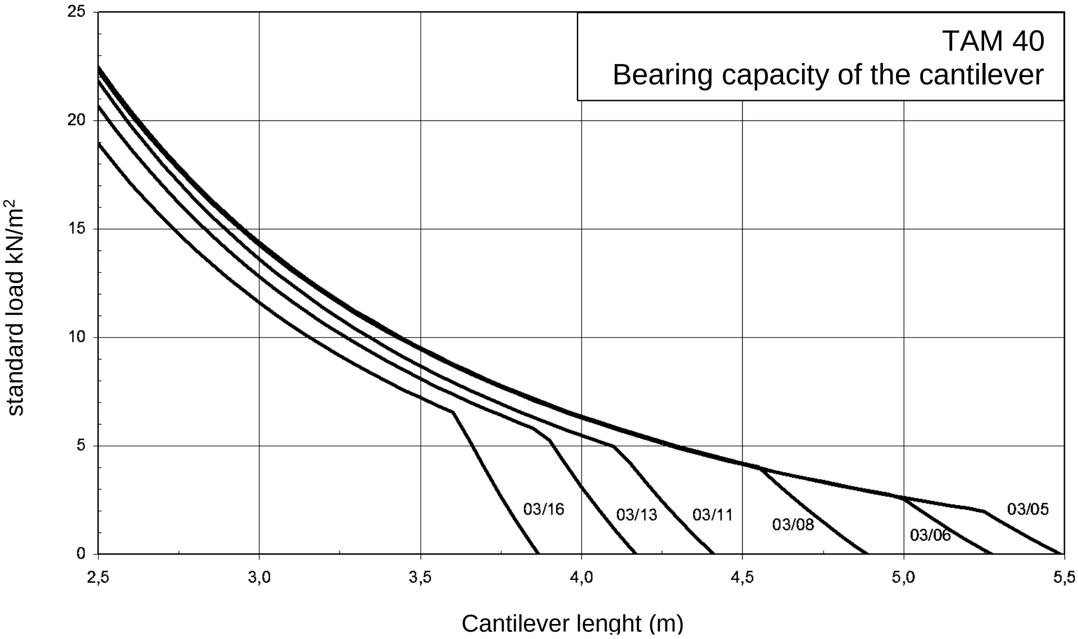


TAM40

Joonis 20. Bearing capacity and camber graphs of the slab TAM 40
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 Mpa**
- imposed load class E: combination factors R_0=1.0; cR_1=0.9; R_2=0.8







TAM

Openings and cavities

O P E N I N G S AND CAVITIES

The overall width of the cross-section of the openings and cavities that are made in the panel may be a maximum of 400 mm. The length of the opening or cavity depends on its location in the panel. The technological requirements for making and placing the openings and cavities in the panels are presented in **figure 21**. The minimal dimensions for the opening or the cavity in the middle of the panel are 100 x 100 mm and the maximal length is 400 mm. In special cases it is possible to design a longer opening, but that needs to be coordinated with the manufacturer beforehand.
The maximum number of openings above the hollow cores in TAM22, TAM27, AND TAM32 is up to 3 in a cross-section. Their locations and maximal widths are presented in **figure 22**.
In the factory, the openings are always done in fresh concrete.
If due to the design of the hollow-core panels, the openings or cavities are closer to the tips of the panel than:

- TAM22 – 1000 mm
- TAM27 and TAM27E – 1200 mm
- TAM32 and TAM32R – 1400 mm
- TAM40 – 1600 mm

then the locations of the openings and cavities are marked in the factory with paint, and the fitter cuts the openings and cavities in the marked places at their own expense.
In addition, the following things are marked on the panel with paint:

- the outermost rib on the edge of an opening or a cavity,
- in special cases, an opening or a cavity in the middle of the panel (small openings or cavities are made in the corners),
- some of the openings and cavities, if they are located in the same cross-section.

Every cutting, opening, and cavity on the object needs to be coordinated with the manufacturer beforehand.

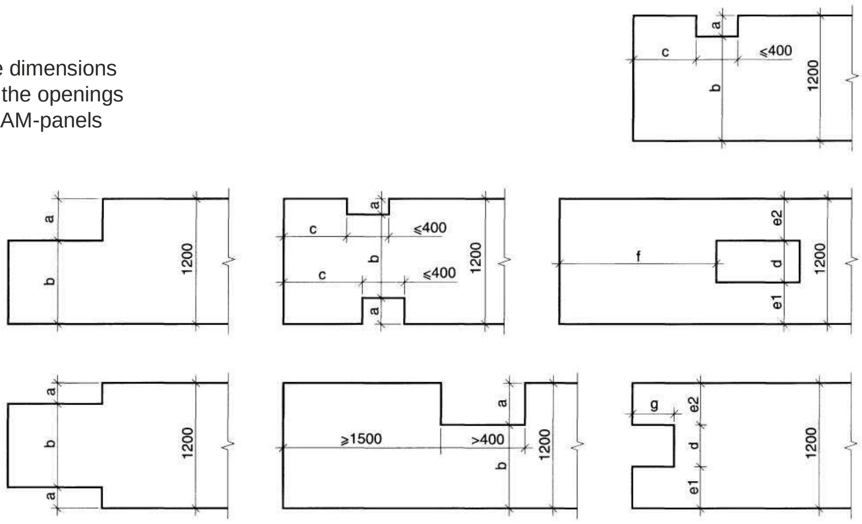


Figure 21. The dimensions and locations of the openings and cavities in TAM-panels

The requirements for making the openings and cavities:

1. Panels TAM 22:

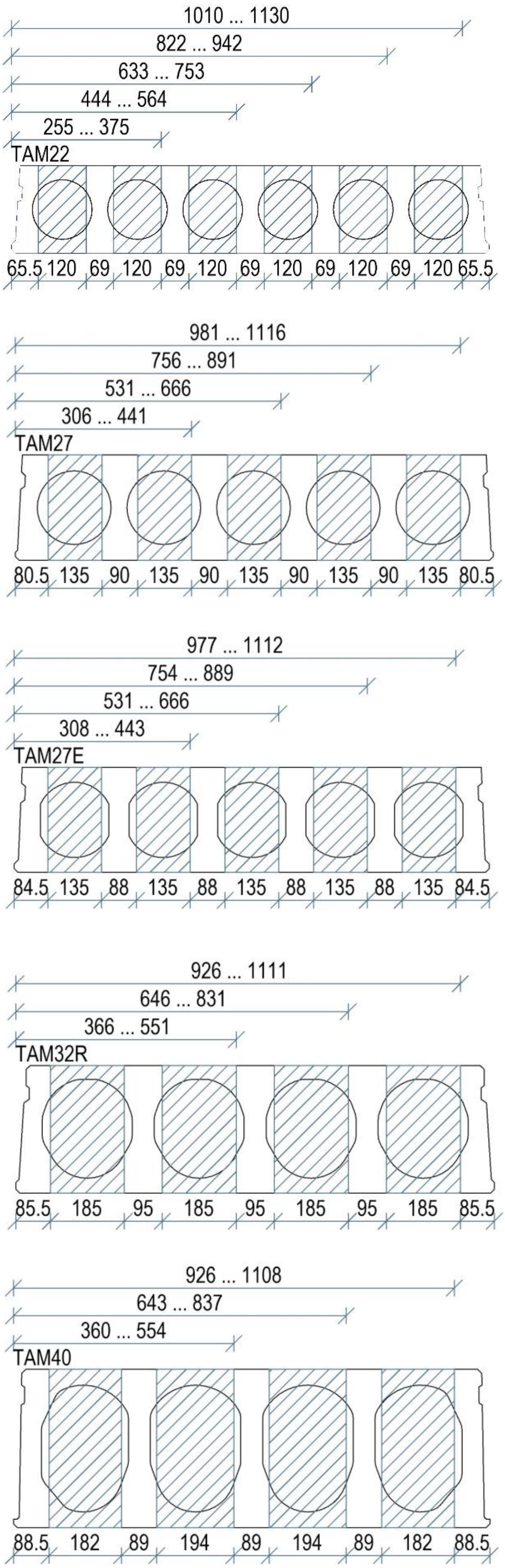
- 100 mm ≤ a ≤ 350 mm; b ≥ 850 mm; c ≥ 3 x a;
- d ≥ 200 mm; f ≥ 500 mm; e1, e2 ≥ 250 mm; (e1 + e2) ≥ 900 mm;
- 300 ≤ d ≤ 400 mm; f ≥ 1500 mm; e1, e2 ≥ 250 mm; (e1 +e2) ≥ 800 mm;
- g ≤ 400 mm; d ≤ 400 mm; e1, e2 ≥ 250 mm; (e1 + e2) ≥ 800 mm.

2. Panels TAM 27, TAM 27E, TAM 32 and TAM 32R, TAM 40

- 100 mm ≤ a ≤ 400 mm; b ≥ 800 mm; c ≥ 3 x a;
- d ≥ 200 mm; f ≥ 500 mm; e1, e2 ≥ 250 mm; (e1 + e2) ≥ 900 mm;
- 300 ≤ d ≤ 400 mm; f ≥ 1500 mm; e1, e2 ≥ 310 mm; (e1 +e2) ≥ 800 mm;
- g ≤ 400 mm; d ≤ 400 mm; e1, e2 ≥ 250 mm; (e1 + e2) ≥ 800 mm.

Figure 22.

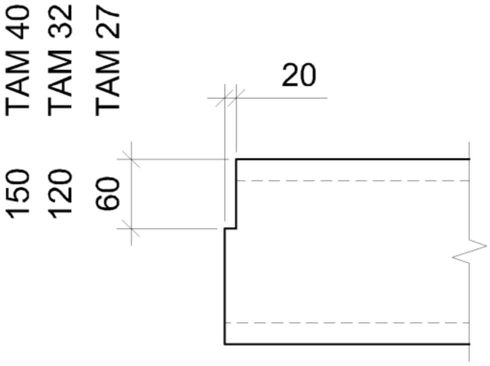
Widht and location of openings made at atthe cores area (striped area)



TECHNOLOGICAL CUTS

While cutting open the panels, technological cuts may appear on the upper edges of the panels’ tips, which do not reduce the load capacity of the panel. The maximal dimensions of the cutouts are presented in figure 23.

Figure 23. The dimensions of the technological cutouts on the tips of the TAM-panels (mm).



TAM

Usages, storage and transportation

USAGE

TAM slabs are used for construction of intermediate floors, roofing and walls in residential, industrial and non-residential buildings. Optional length of the slabs and a large variety of special-purpose slabs enables flexible designing to provide diverse planning and room solutions.

The slabs are supported in accordance with the design scheme of a simple beam or cantilever beam in buildings designed of prefabricated elements. The relevant graphs of bearing capacity and joint solutions are presented in the subdivisions “bearing capacity and camber graphs” and “assembly”. The bearing capacity and rigidity of the slabs can be increased, if the slab ceiling is covered with at least 40 mm thick topping of cast-in-place concrete. The strength class of concrete is at least C25/30. The topping has to be reinforced if the ceiling is loaded with variable or point loads.

In case of buildings designed partially or fully of cast-in-place concrete, rigid constraint can be used for supporting the slabs against the walls and beams (see Figure 27). Pre-stressed reinforcement in the upper part of the slab, reinforcing bars in longitudinal joints or cores or reinforced cast-in-place concrete topping is used for this.

The intermediate floors and roofing made of slabs, where the lateral assemblies of slabs are obstructed by outline and internal ties on the ceiling level and connection joints between the slabs transferring shear force, can be used as horizontal diaphragms of rigidity, also for dividing line and point load from the directly loaded slab to the adjacent slabs and for making big openings.

Special-purpose slabs can be used in the realisation of various plan and room solutions. Thus cantilever slabs are used for the diversification of the fa?ade surfaces of buildings with cantilever elements. Cantilever slabs are reinforced with pre-stressed strands in the top flange. The bearing capacity of such slabs is specified in accordance with the graphs presented in the subdivision “bearing capacity and camber graphs”.

If slabs with different lengths are used side by side, then different cambers of slabs must be taken into account when designing the height of supporting surface.

The slabs can also be cut narrower or bevelled, if necessary. Slabs with bevelled ends are used for the construction of areas with irregular main plan. Technically, it is not recommended to use a sharper angle than 30°. Narrower slabs are produced by longitudinal cutting of standard width slabs (1200 mm), whereas the cutting point remains above the core. The slabs cut narrower should be placed with the cut edge against the wall.

The cores of TAM slabs can be used as air ducts. Also, water supply pipeline, sewer ducts and wiring can be installed into the cores.

STORAGE AND TRANSPORTATION

The slabs are stored and transported in horizontal piles, sorted by types. Eight TAM 22, six TAM 27 and five TAM 32 and TAM 32R and four TAM 40 slabs can be placed in one pile.

It is not allowed to turn the slabs over.

The slab piles are stored on at least 100 mm thick and at least 100 mm wide squared timbers placed on compact horizontal ground. Intermediate battens with the thickness of not below 20 mm and the width of not below 70 mm are placed between the slabs, 300 mm from the ends of the slabs. In case of storage of slabs with hoisting eyes, the intermediate battens must be enough high for the upper slab not to support on the lower slab’s hoisting eye. The cantilever slabs are stored with intermediate battens placed according to working drawings. The intermediate battens remain above each other in the pile.

The slabs are hoisted with a traverse supplied with grippers (see Figure 24). The distance of the grippers from the ends of the slab is same as the distance of the intermediate battens at the storage of the slabs. Slabs with the weight of above 6 T are hoisted with four grippers (see Figure 25). The slabs cut narrower and slabs with cuts in corners are hoisted from four points from hoisting eyes (see Figure 26).

Safety chains have been fastened to the grippers, which will be put under slab ends for hoisting. The slab must not be hoisted higher than 100 mm and the chains must not be released until the slab is 100 mm from the support.

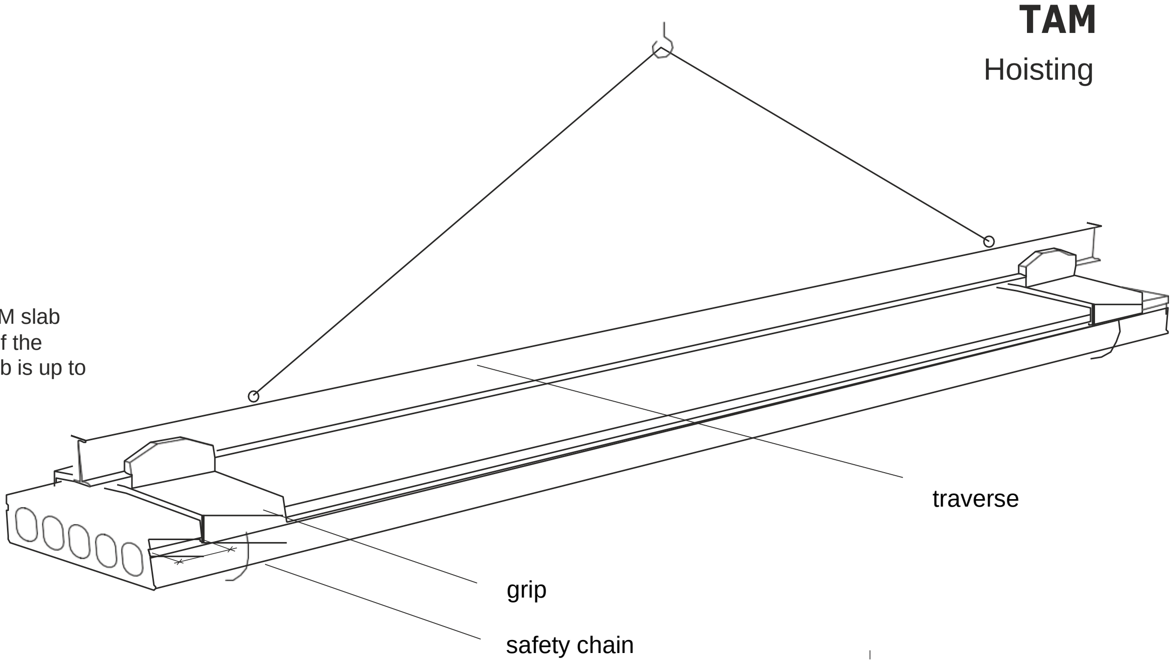


Figure 24.

Hoisting of a TAM slab with a traverse, if the weight of the slab is up to 6 T

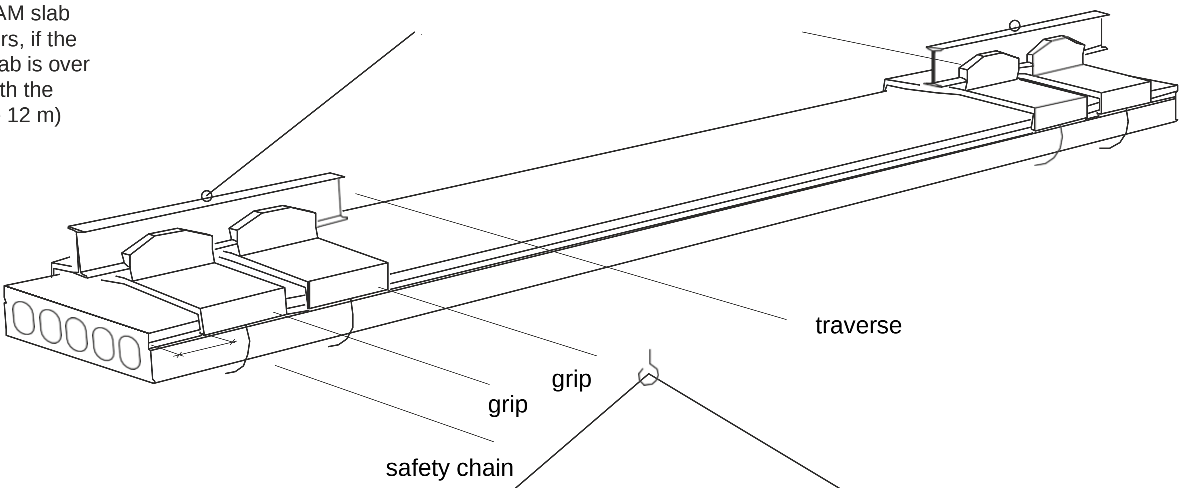


Figure 24.

Hoisting of a TAM slab with four grippers, if the weight of the slab is over 6 T (TAM 32 with the length of above 12 m)

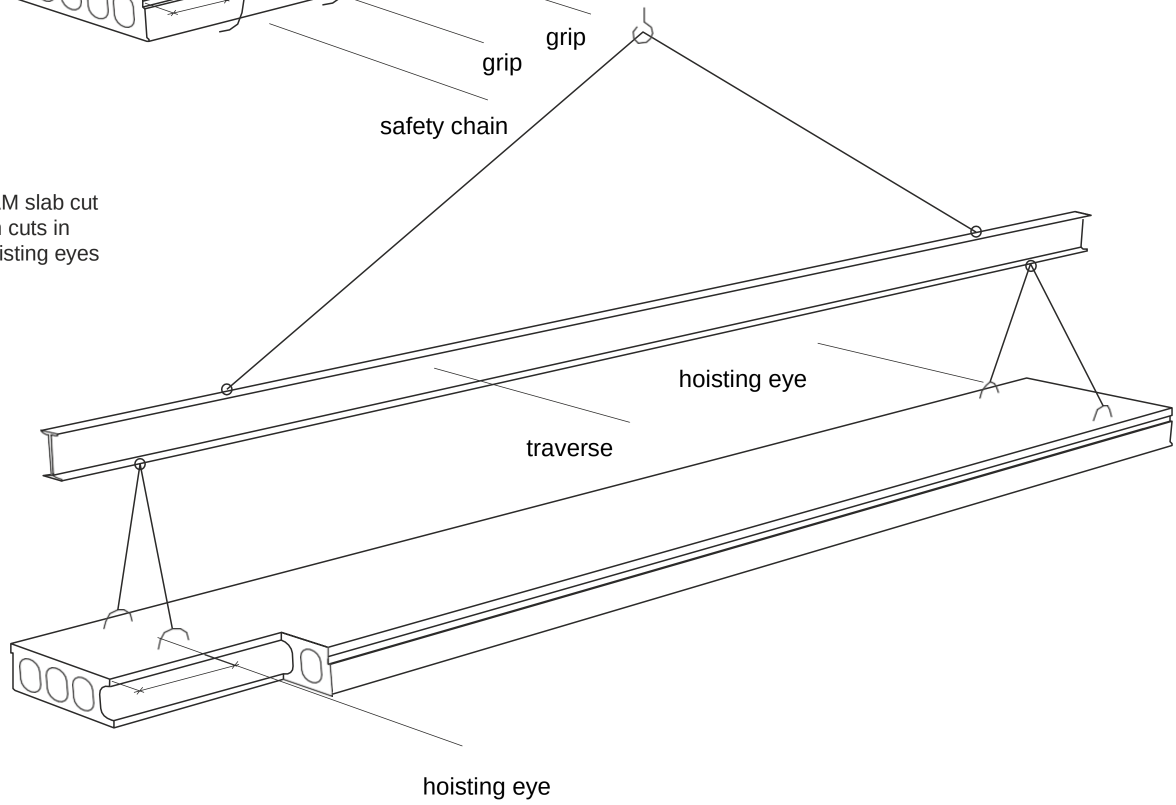


Figure 25.

Hoisting of a TAM slab cut narrower or with cuts in corners from hoisting eyes

ASSEMBLY

The slabs are placed on a cement levelling course, rigid neoprene strip or similar materials in order to fix the location of support reaction and improve the supporting conditions, if the bearing surfaces are uneven or the supporting tensions are big. In case of small loads (e.g. dwelling houses) these methods are not always structurally necessary and the slabs can often be supported directly against the support.
The thickness of a bearing pad in case of brickwork is 10...20 mm, in case of prefabricated reinforced concrete elements and steel beams 10 mm.

The minimum net bearing length of continuous and separate slabs is 40 mm and 60 mm respectively. By taking building tolerances, the strength of the slab and the support into consideration, the nominal bearing length of a slab is usually 70...100 mm and not less than 60 mm.

In order to ensure cooperation between the slabs, they should be tied with peripheral and internal ties.

The ties can be reinforced either with ordinary reinforcing bars (high-bond bar Ø10...25 mm) or a 7-wire pre-stressed strand. The reinforcement must be continuous.
The anchor length of tie bars in longitudinal joints is 1.0 .... 1.5 m, depending on the type and diameter of the bar and the strength class of concrete.
The strength class of the concrete of ties is not less than C20/25.

A selection of connection joints used at the assembly is presented in figures 27, 28, 29.

Figure 27.

A selection of hollow-core slab assembly joints: supported against wall

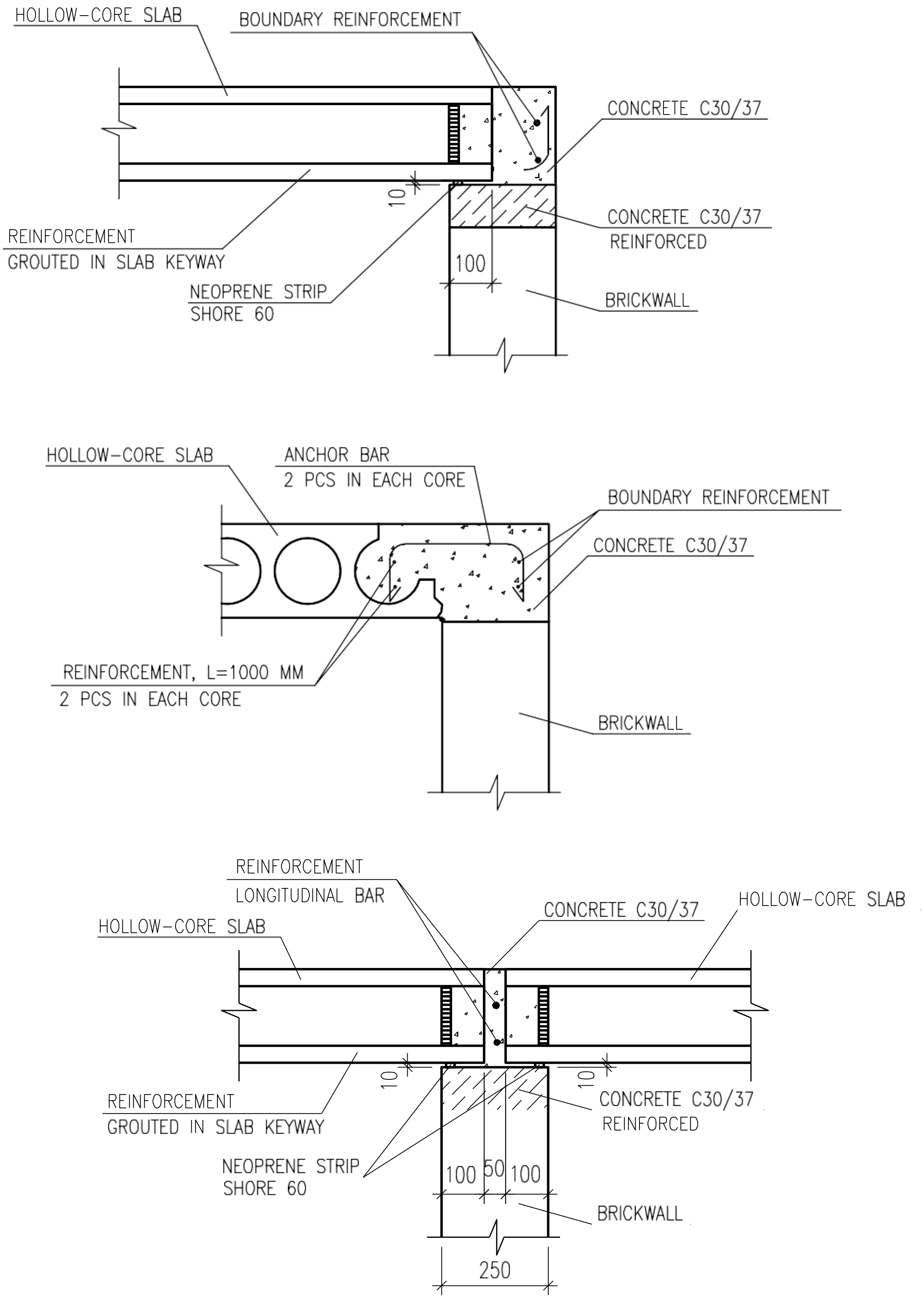
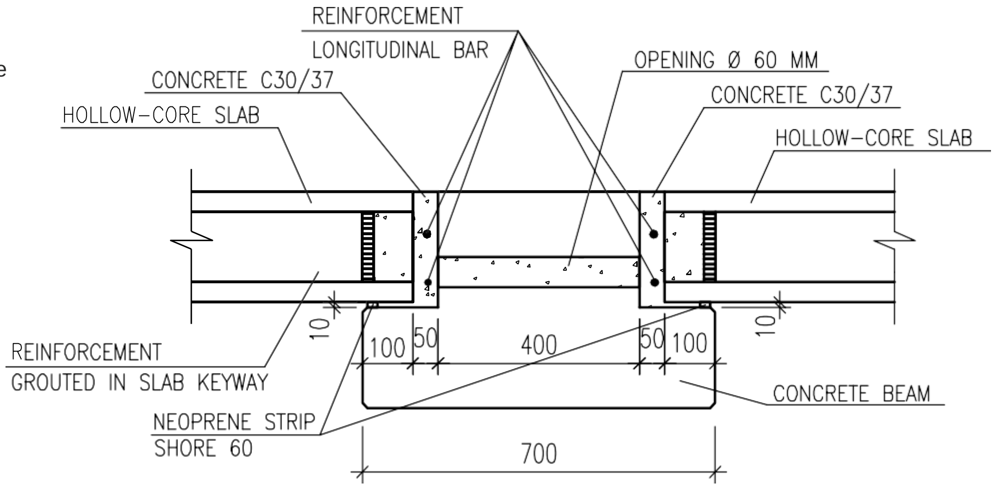


Figure 28.

A selection of hollow-core slab assembly joints: supported against cross-bar



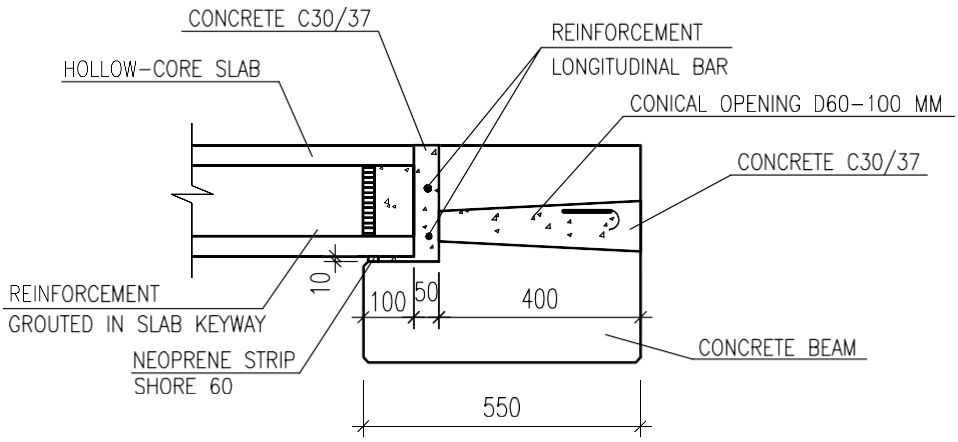


Figure 29.

A selection of hollow-core slab assembly joints: supported against adjacent slabs