

## PRE-STRESSED HOLLOW-CORE SLABS

# TAM

AS Tartu Maja Betoontooted manufactures pre-stressed hollow-core slabs with the product name TAM slab in conformity with the standards of EVS-EN 1168 and EVS-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.

### M A T E R I A L S

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

- normal-weight concrete with the strength class of at least C45/55 with the production and characteristics conforming to standard EVS-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 25 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 10 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.



**S O U N D I N S U L A T I O N , H E A T R E T E N T I O N  
A N D F I R E R E S I S T A N C E**

The sound insulation, heat retention and fire resistance of TAM slabs has been measured in conformity with the standard EVS-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 EVS-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 <sup>2</sup> K/W)	Fire resistance class
TAM 20	57	79	0,16	REI60
TAM 22	57	76	0,16	REI60
TAM 27	61	75	0,18	REI90
TAM 27E	61	75	0,18	REI90
TAM 32	61	74	0,20	REI90

**PRODUCTION TOLERANCES**

Production tolerances in Table 2 correspond to the product standard EVS-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).

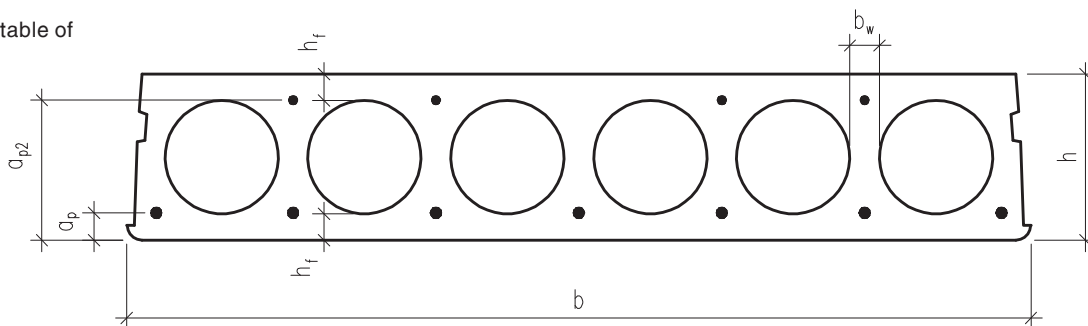
**Table 2.**

Production tolerances of TAM slabs

Dimensions	Tolerance (mm)
Length	+/- 25
Width (b) - full-width slab - slabs that have been cut narrower	+/- 5 +/- 25
Depth (h) - TAM 20 - TAM 22 - TAM 27, TAM 27E, TAM 32	+12; -10 +/-12 +/-15
Openings - made into fresh concrete - made into hardened concrete	+50; -0 +/- 15
Web thickness - single web ( $b_w$ ) - total per slab ( $\Sigma b_w$ )	-10 -20
Flange thickness (above and below the cores $h_f$ ) - TAM 22, TAM 27, TAM 27E, TAM 32 - TAM 20	-10; +15 -4; +15
Vertical position of pre-stressed strand at tensile side ( $a_p, a_{p2}$ ) - single strand - TAM 20 - TAM 22 - TAM 27, TAM 27E, TAM 32 - average per slab	+/- 10 -10; +12 -10; +15 +/- 7
Concrete cover of the pre-stressed reinforcement, including core edge (c)	- 10

**Figure 1.**

Symbols in the table of tolerances





### T Y P E I N D I C A T I O N S

The product name of pre-stressed hollow-core slabs manufactured in AS Tartu Maja Betoontooted is TAM slab.

The slab marking consists of a letter-number combination, where numbers indicate the type of the slab, number of pre-stressed strands and slab indication on the plan of ceiling slabs. The letters behind the type indication express the qualities and the scope of application of the slab.

An example of slab marking: **TAM27KS-04/08-101**, where

**TAM27** - slab type indication;

**K** - cantilever slab;

**S** - thermally insulated slab;

**04** - number of upper pre-stressed 12,5 mm strands (the letter x refers to 9,3 mm strand);

**08** - number of lower pre-stressed 12,5 mm strands (the letter x refers to 9,3 mm strand);

**101** - symbol on the plan of ceiling slabs.

**Table 3.**

Type indications of the main and special types of TAM slabs

Slab height (mm)	Main type	Cantilever slab	Thermally insulated slab	Thermally insulated cantilever slab	Cavity shape
200	TAM 20	TAM 20K	TAM 20S	TAM 20KS	round
220	TAM 22	TAM 22K	TAM 22S	TAM 22KS	round
265	TAM 27	TAM 27K	TAM 27S	TAM 27KS	round
265	TAM 27E	TAM 27EK	TAM 27ES	TAM 27EKS	oval
320	TAM 32	TAM 32K	TAM 32S	TAM 32KS	oval

### D E A D W E I G H T S A N D A R E A S O F C R O S S - S E C T I O N

**Table 4.**

Dead weights and areas of cross-sections of TAM slabs

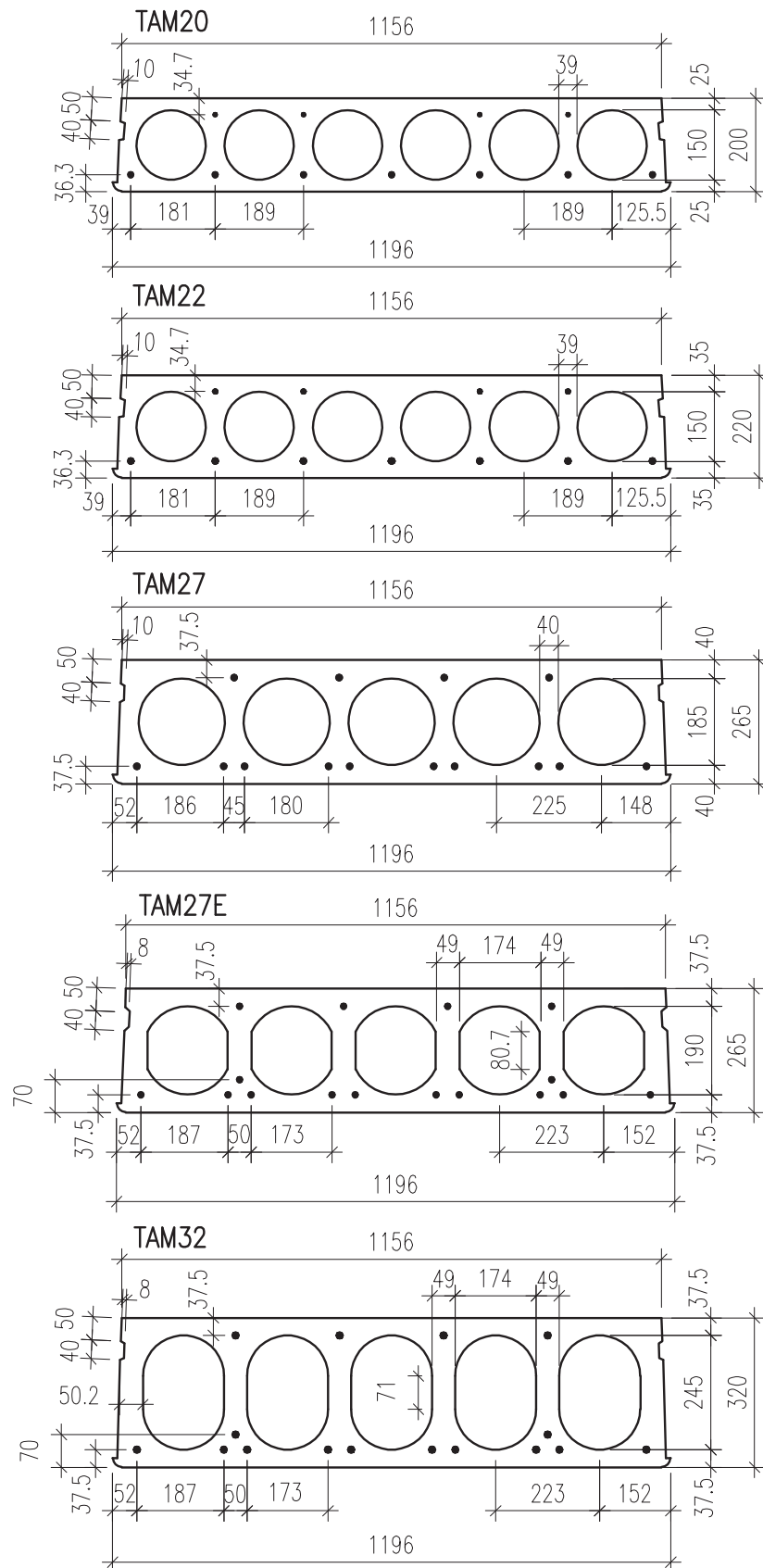
Slab type	Dead weight of a m <sup>2</sup> of the slab (kN)	Dead weight of one meter of length (kN)	Area of the cross-section of the concrete (m <sup>2</sup> )	(%) of cores in the cross-section of the slab
TAM 20	2.6	3.2	0.13	45
TAM 22	3.1	3.7	0.15	41
TAM 27	3.6	4.4	0.17	44
TAM 27E	3.6	4.3	0.17	44
TAM 32	4.0	4.8	0.19	48

### C R O S S - S E C T I O N S

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.

**Figure 2.**

Cross-sections of TAM  
slabs





## **B E A R I N G   C A P A C I T Y   A N D   C A M B E R   G R A P H S**

The graphs of the bearing capacity of TAM slabs (figures 3...17) have been calculated in accordance with the standards:

- EVS-EN 1990 "Eurocode. Basis of structural design";
- EVS-EN 1991-1-1 "Eurocode 1: Actions on structures.  
Part 1-1: General actions. Densities, self-weight, imposed loads for buildings";
- EVS-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 20, TAM 22, TAM 27, TAM 27E and TAM 32 can be used in case of residential, office, commercial, traffic and public gathering spaces and the graphs are valid on the following conditions:

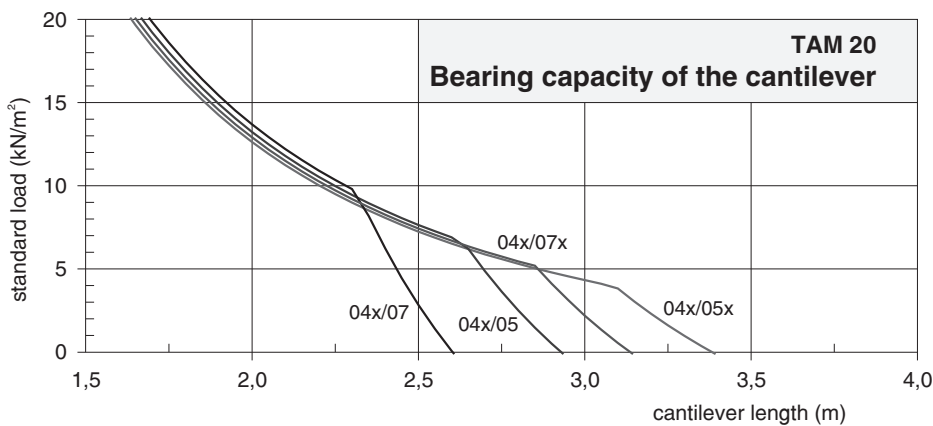
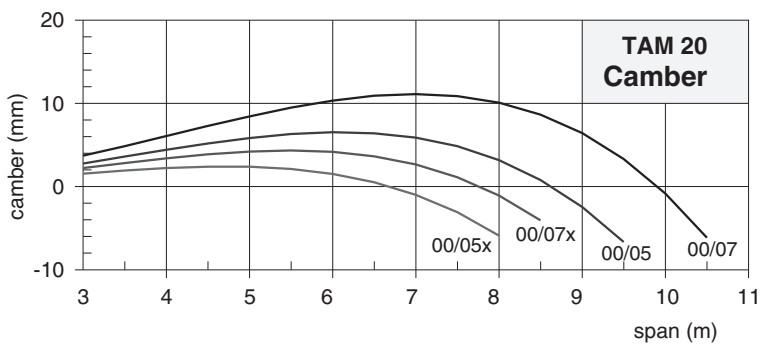
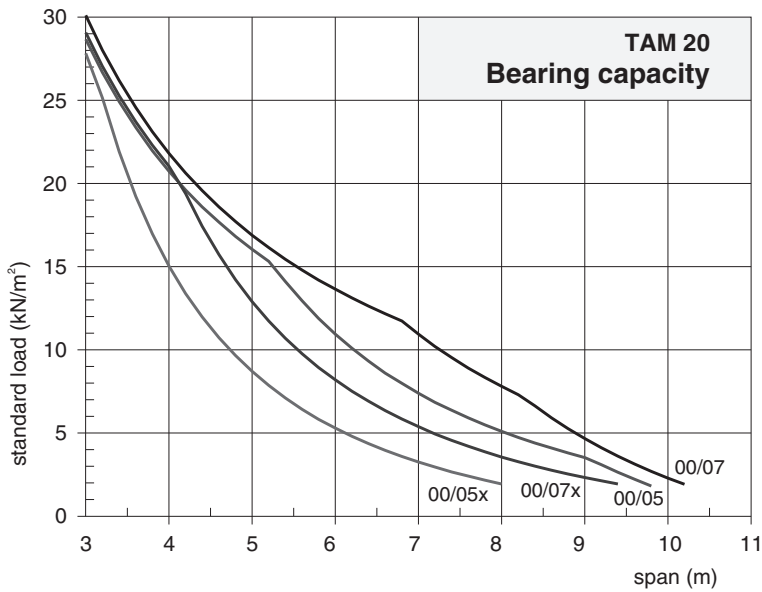
- the standard value of bearing capacity does not include dead weight;
- exposure class XC1 (dry environment);
- slabs are supported by rigid structures;
- the support length of the slab at designing  $\geq 65$ mm;
- ultimate deflection of the slab: span/250;
- ultimate deflection of the cantilever: 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 C45/55;
- the pre-stressed reinforcement is a  $\varnothing 9.3$  mm (marked x) or a  $\varnothing 12.5$  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):

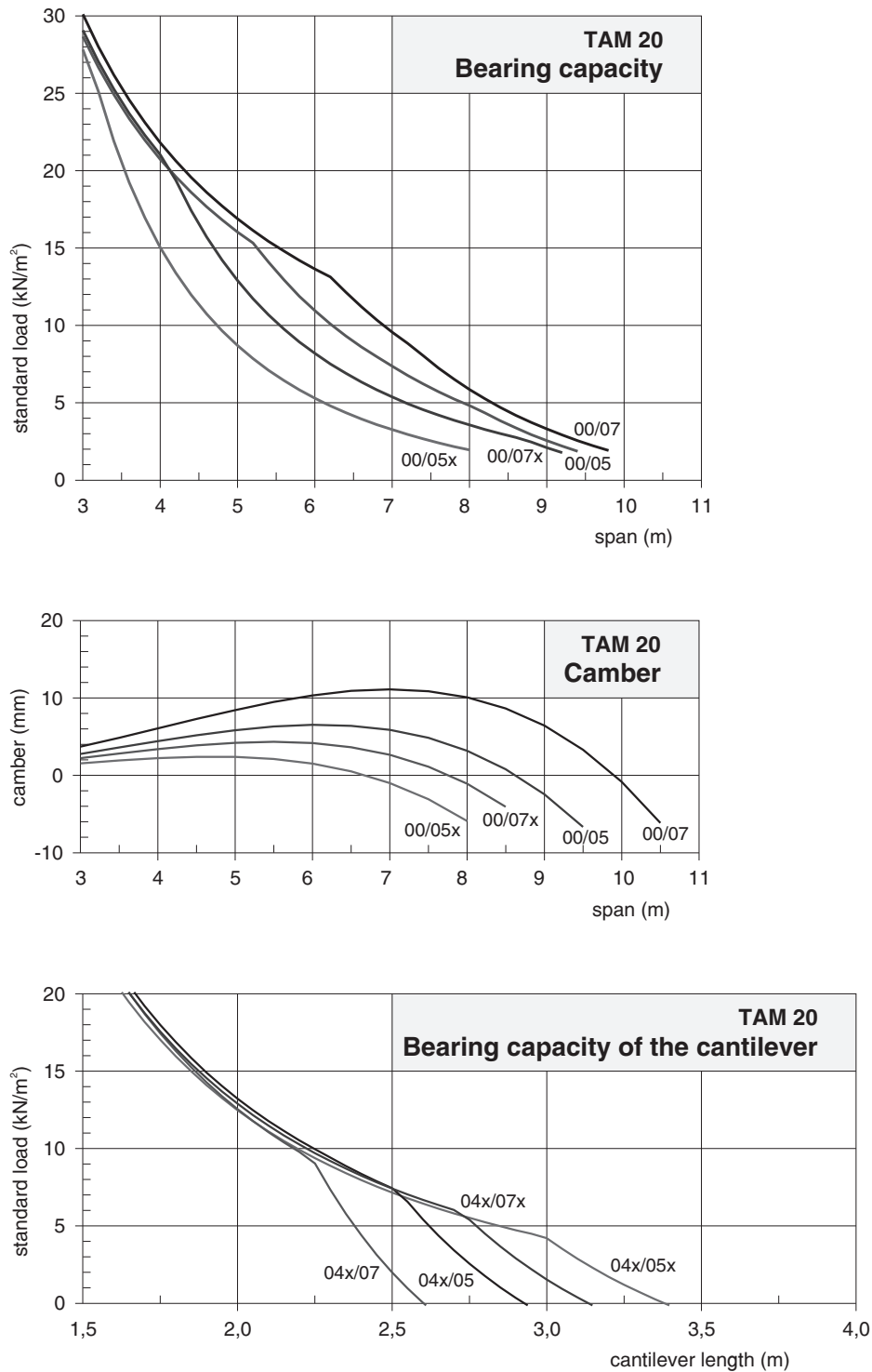
- Figures 3...7:  
classes A (residential space), B (office space), G (traffic space, 30 kN < weight of the vehicle 160 kN), combination factors  $\gamma_0=0.7$ ;  $\gamma_1=0.5$ ;  $\gamma_2=0.3$ ;
- Figures 8...12:  
classes C (public gathering space), D (commercial space), F (traffic space, weight of the vehicle 30 kN), combination factors  $\gamma_0=0.7$ ;  $\gamma_1=0.7$ ;  $\gamma_2=0.6$ ;
- Figures 13...17:  
class E (storage spaces), combination factors  $\gamma_0=0.7$ ;  $\gamma_1=0.7$ ;  $\gamma_2=0.6$ ;
- in case of roofing (snow pressure) use approximately figures 3 ... 7;
- 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.

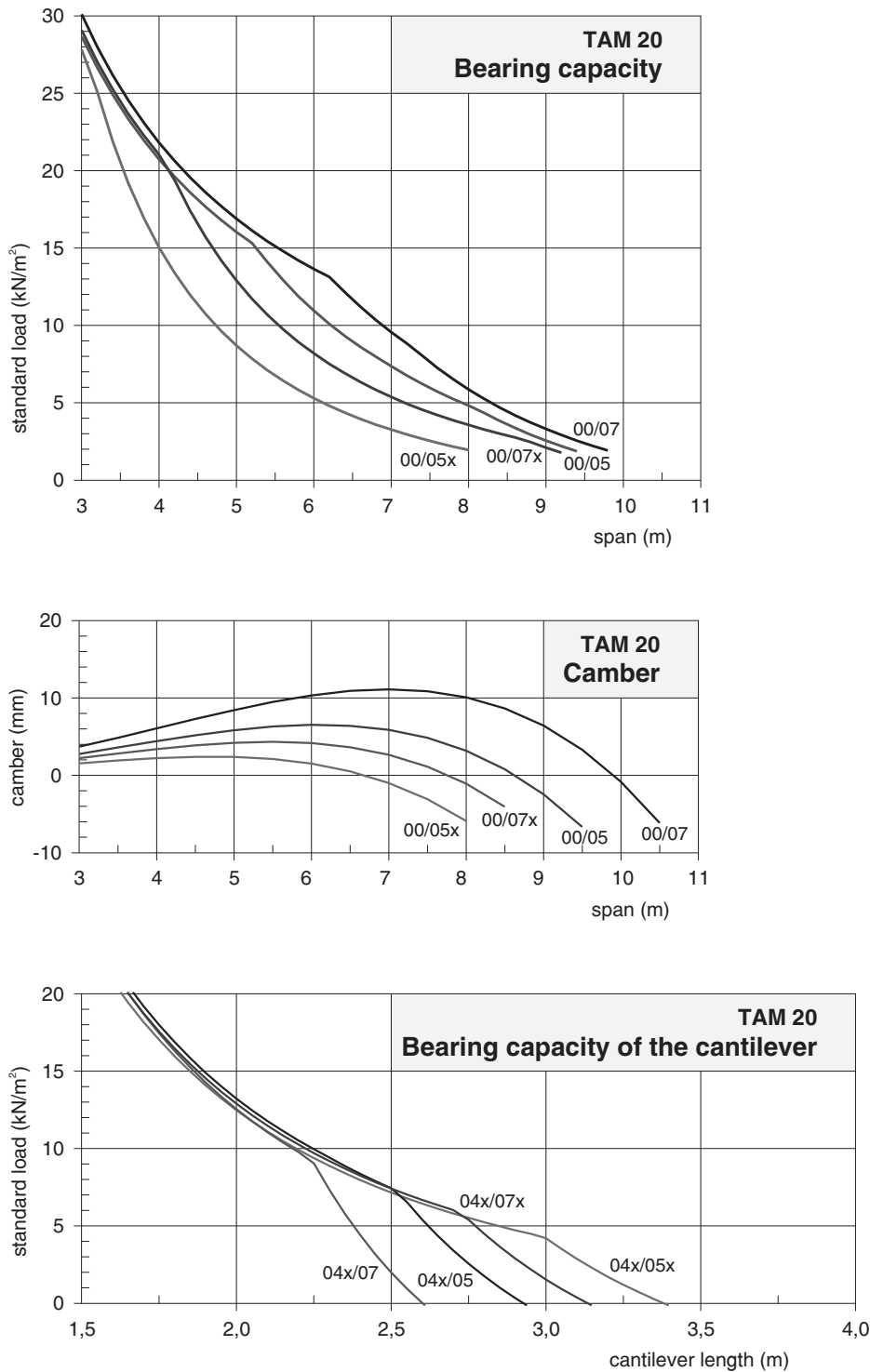
**Figure 3.** Bearing capacity and camber graphs of the slab TAM 20  
 - lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **A, B, G**: combination factors  $\psi_0=0.7$ ;  $c\psi_1=0.5$ ;  $\psi_2=0.3$



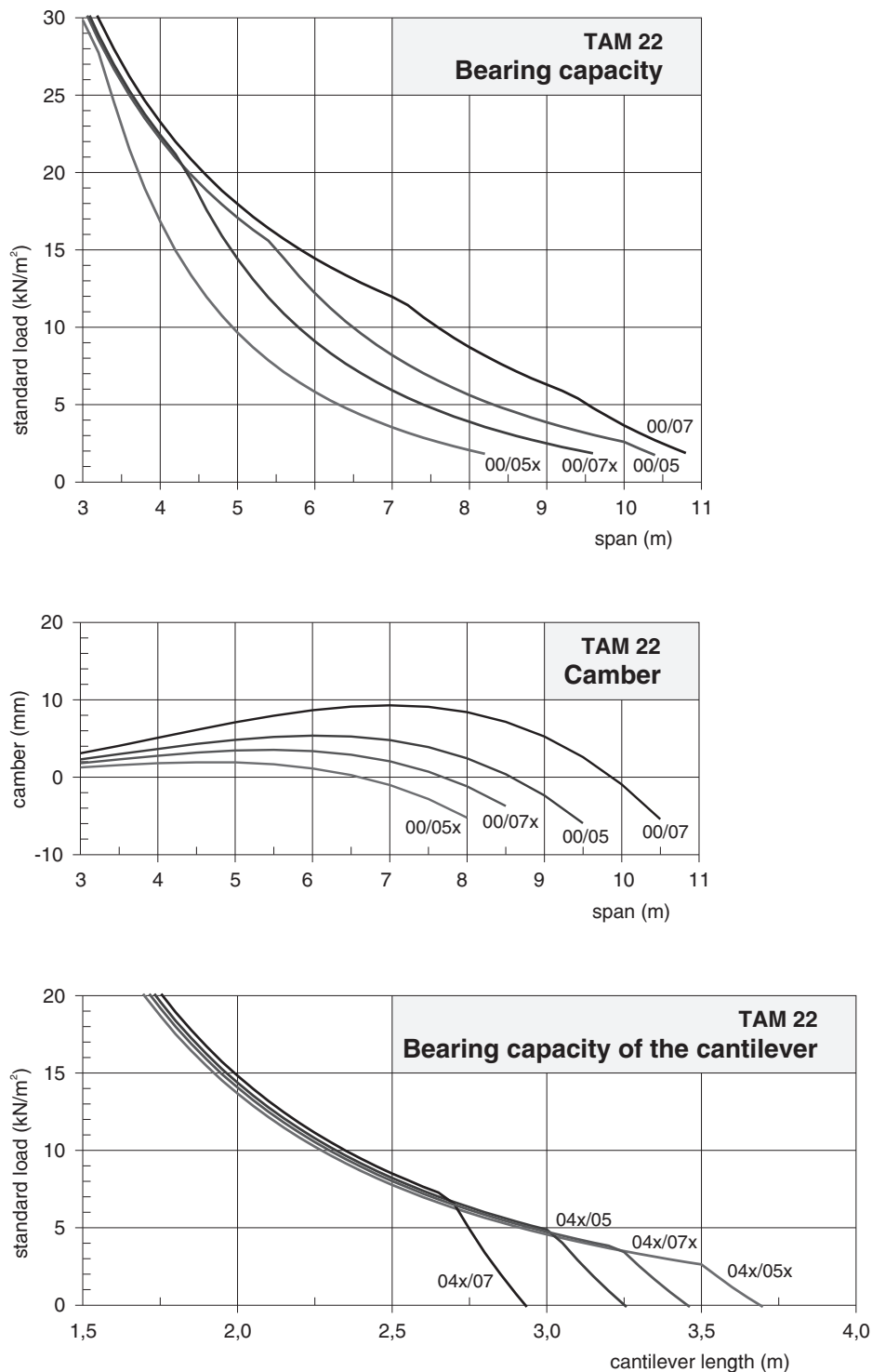
**Figure 4.** Bearing capacity and camber graphs of the slab TAM 20  
 - lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **C, D, F**: combination factors  $\psi_c=0.7$ ;  $c\psi_1=0.7$ ;  $\psi_2=0.6$



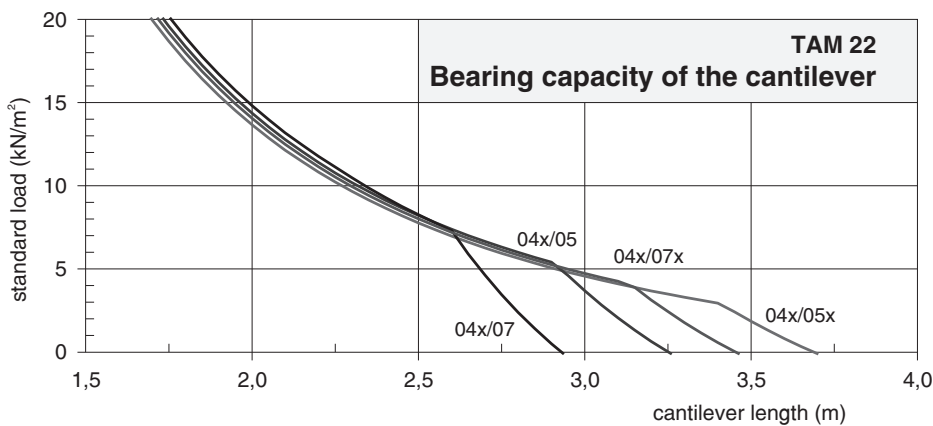
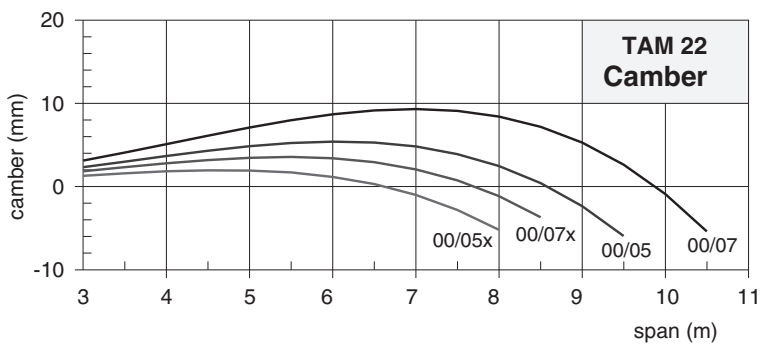
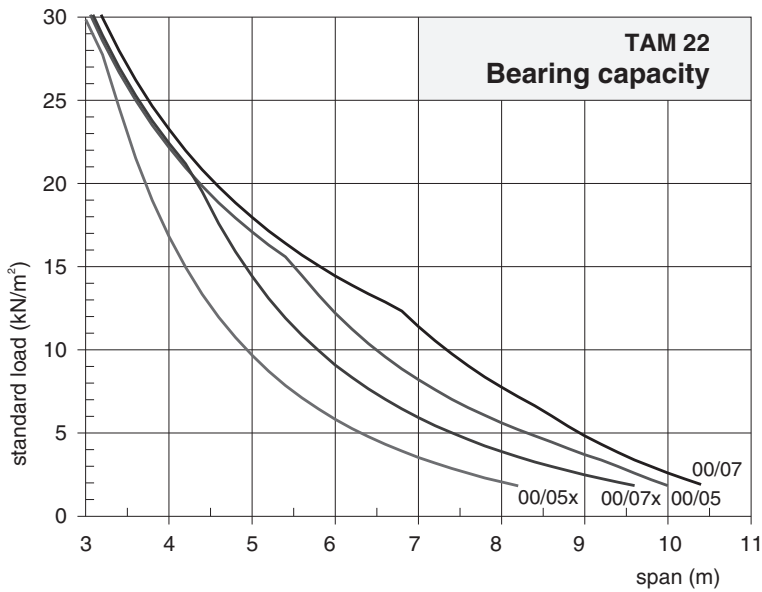
**Figure 5.** Bearing capacity and camber graphs of the slab TAM 20  
 - lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **E**: combination factors  $\psi_0=1.0$ ;  $c\psi_1=0.9$ ;  $\psi_2=0.8$



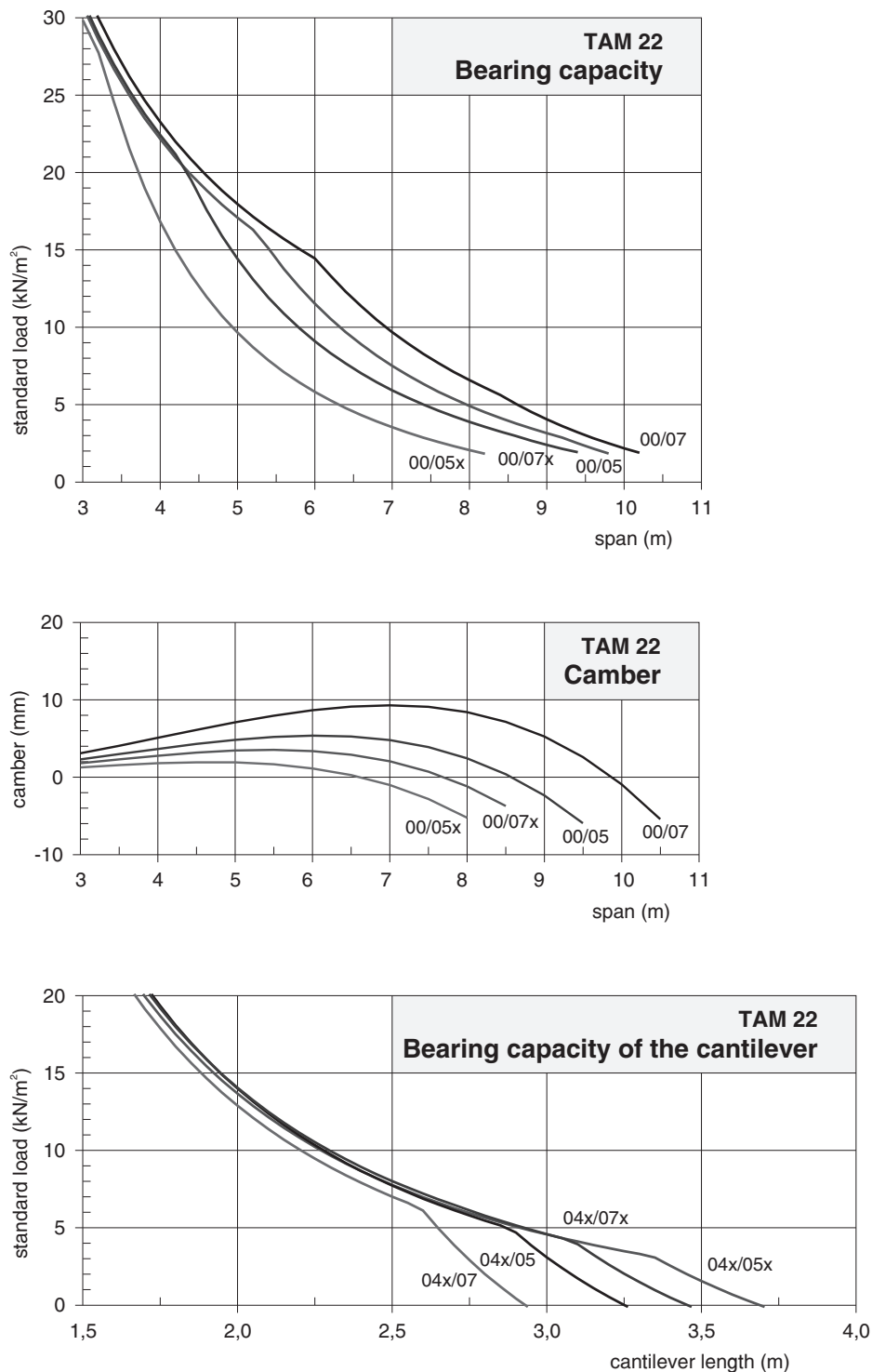
**Figure 6.** Bearing capacity and camber graphs of the slab TAM 22  
 - lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **A, B, G**: combination factors  $\psi_c=0.7$ ;  $c\psi_1=0.5$ ;  $\psi_2=0.3$



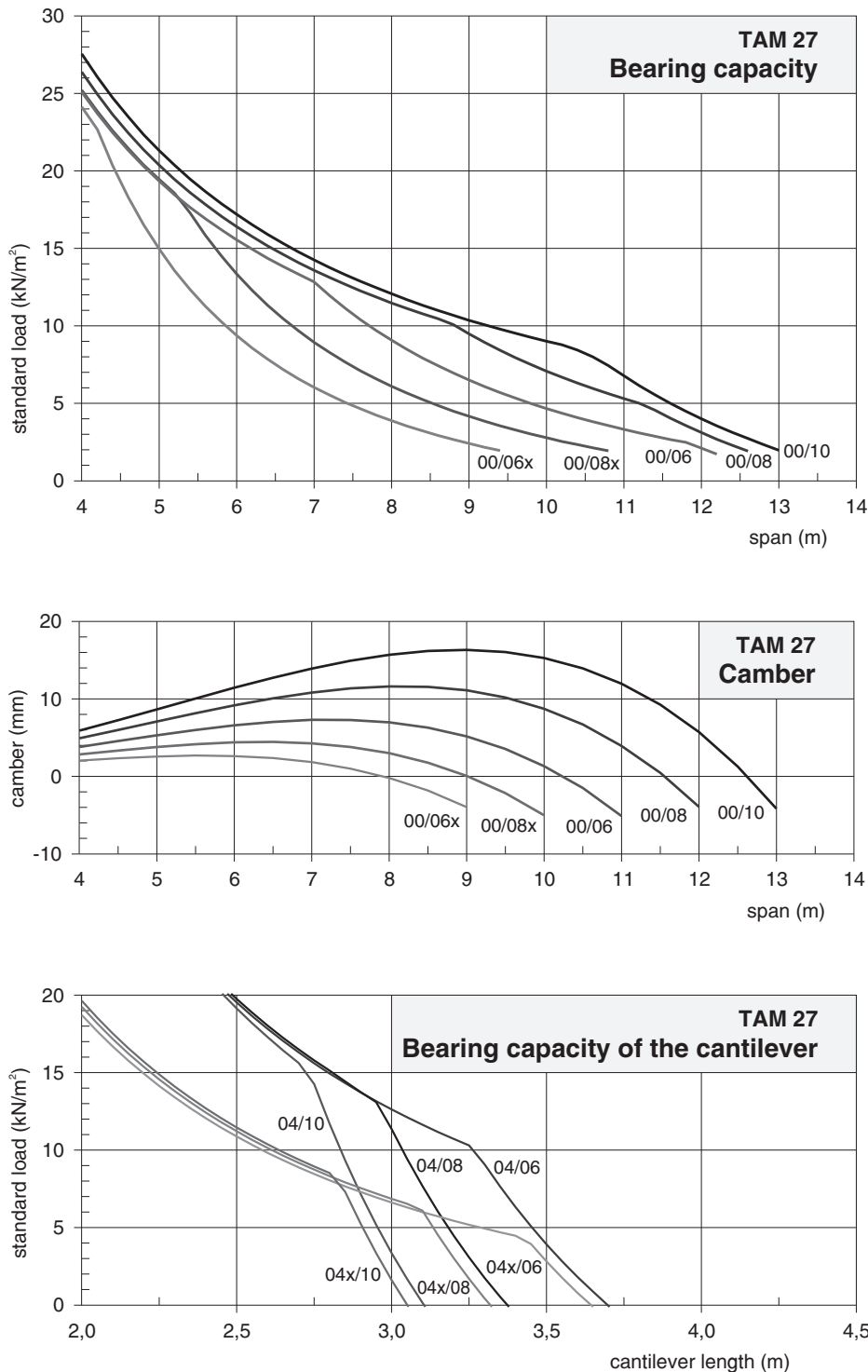
**Figure 7.** Bearing capacity and camber graphs of the slab TAM 22  
 - lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **C, D, F**: combination factors  $\psi_0=0.7$ ;  $c\psi_1=0.7$ ;  $\psi_2=0.6$



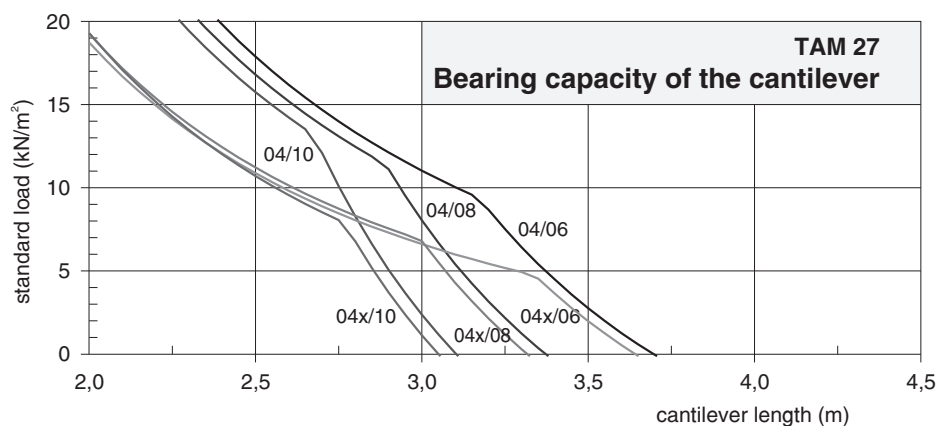
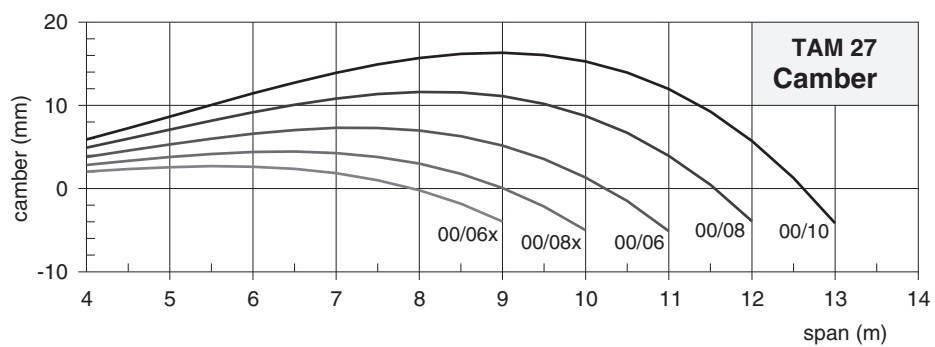
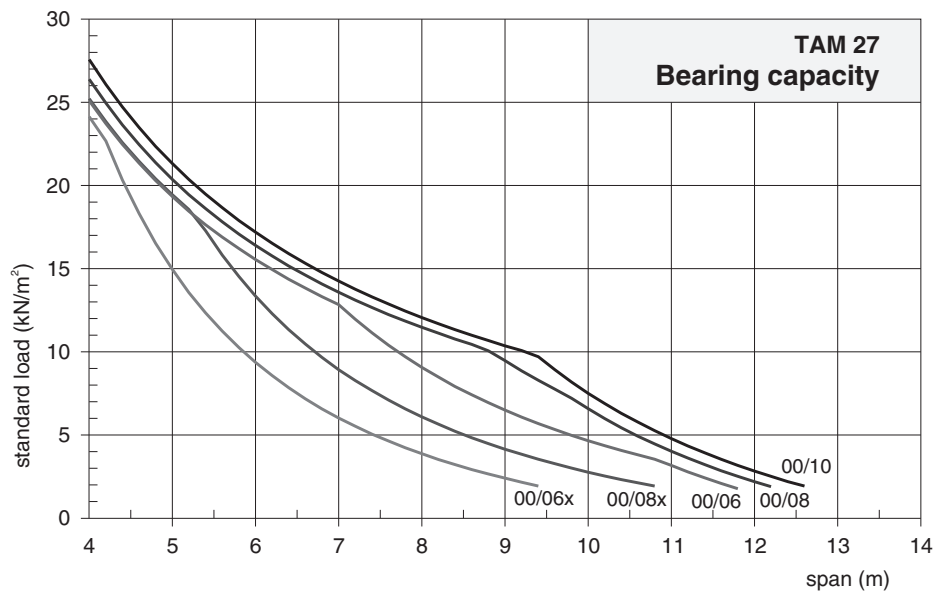
**Figure 8.** Bearing capacity and camber graphs of the slab TAM 22  
- lower strands' initial pre-stress of **900 MPa**, upper strands' initial pre-stress of **700 MPa**  
- imposed load classes **E**: combination factors  $\psi_0=1.0$ ;  $c\psi_1=0.9$ ;  $\psi_2=0.8$



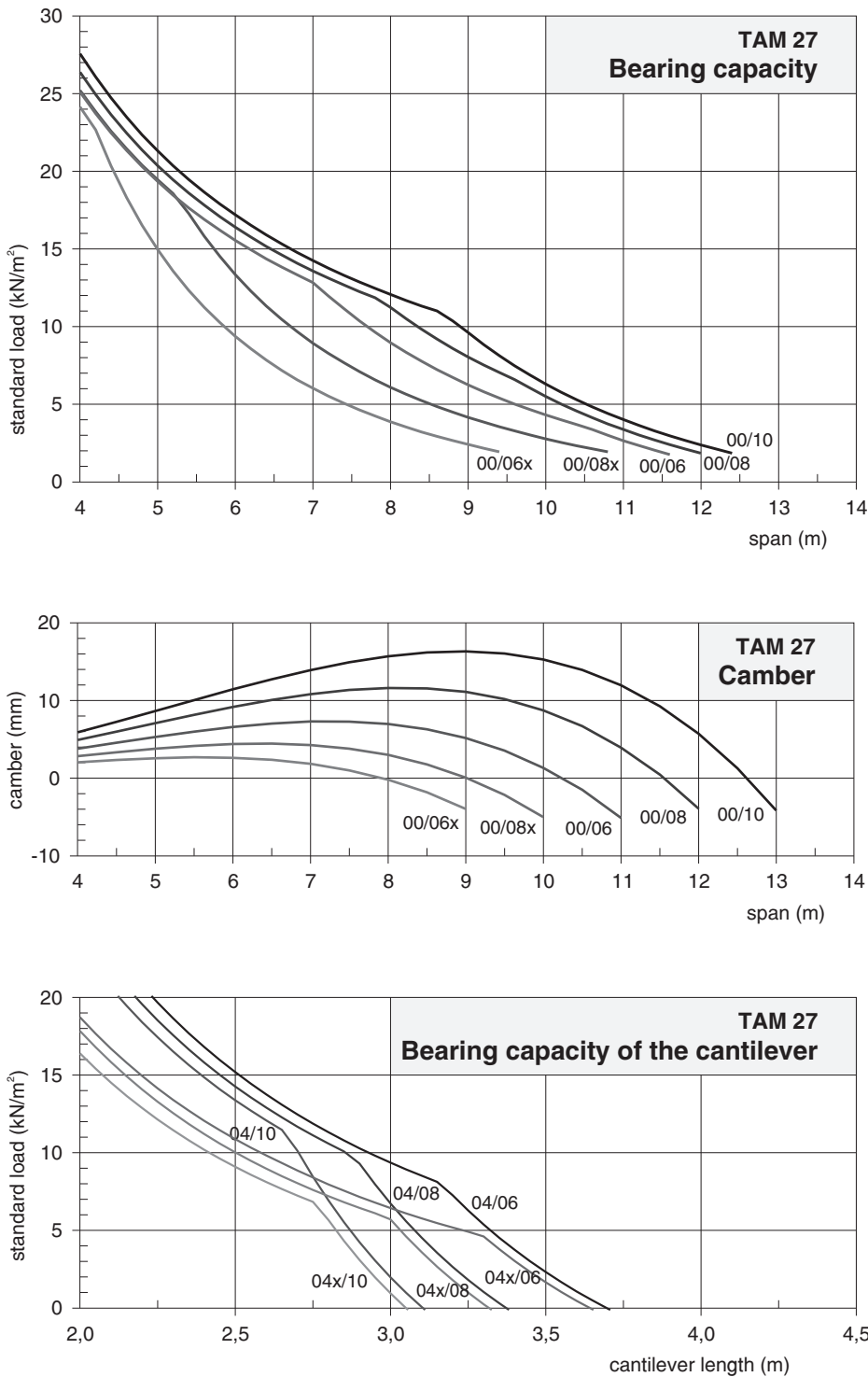
**Figure 9.** Bearing capacity and camber graphs of the slab TAM 27  
- lower strands' initial pre-stress of **1000 MPa**, upper strands' initial pre-stress of **700 MPa**  
- imposed load classes **A, B, G**: combination factors  $\psi_0=0.7$ ;  $c\psi_1=0.5$ ;  $\psi_2=0.3$



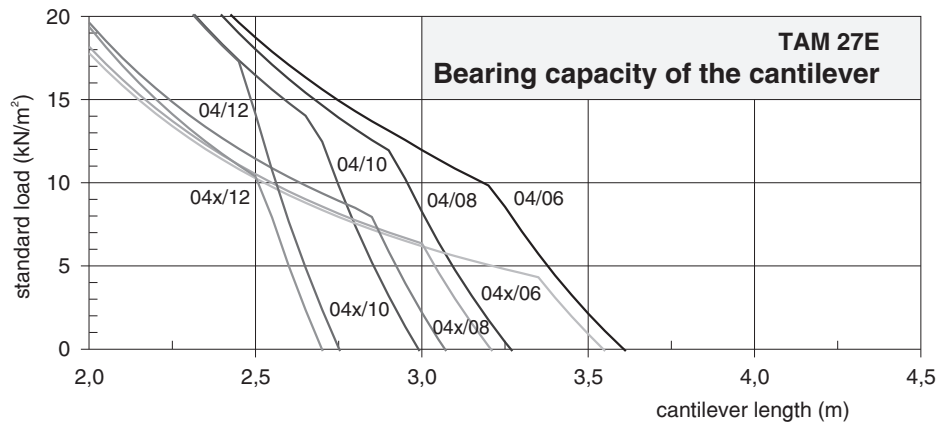
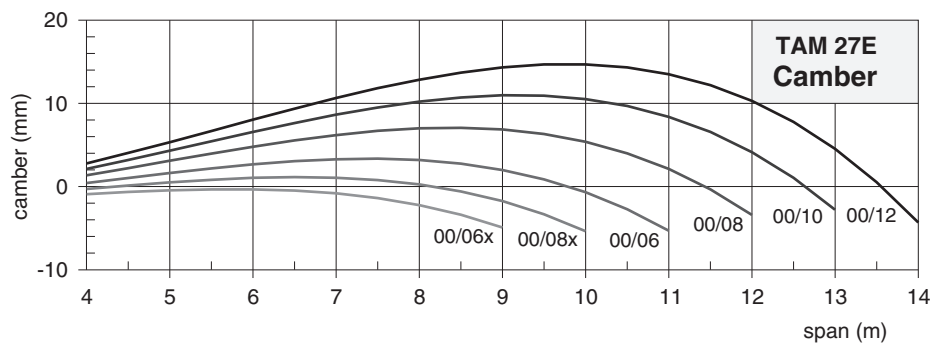
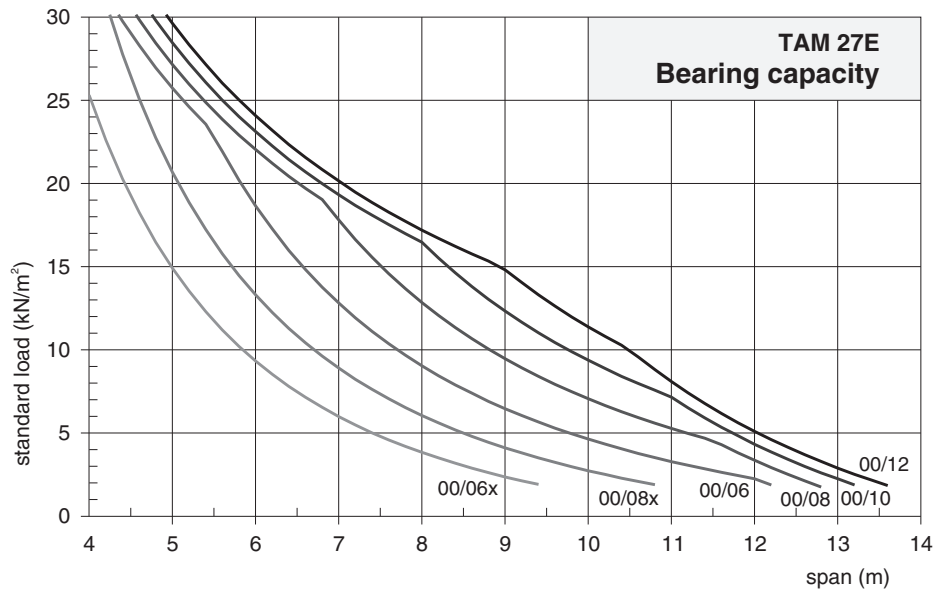
**Figure 10.** Bearing capacity and camber graphs of the slab TAM 27  
 - lower strands' initial pre-stress of **1000 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **C, D, F**: combination factors  $\psi_c=0.7$ ;  $c\psi_1=0.7$ ;  $\psi_2=0.6$



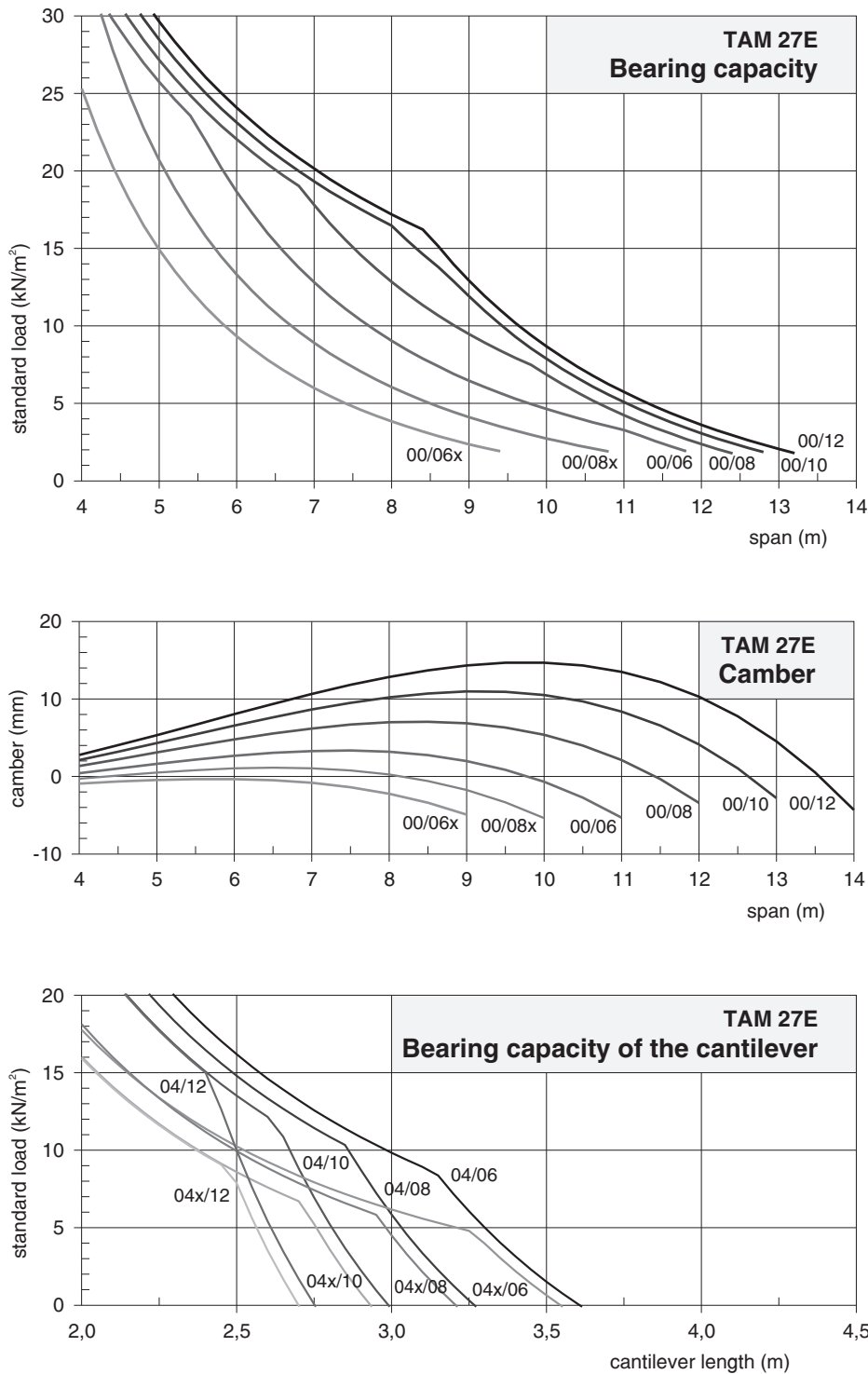
**Figure 11.** Bearing capacity and camber graphs of the slab TAM 27  
 - lower strands' initial pre-stress of **1000 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **E**: combination factors  $\psi_0=1.0$ ;  $c\psi_1=0.9$ ;  $\psi_2=0.8$



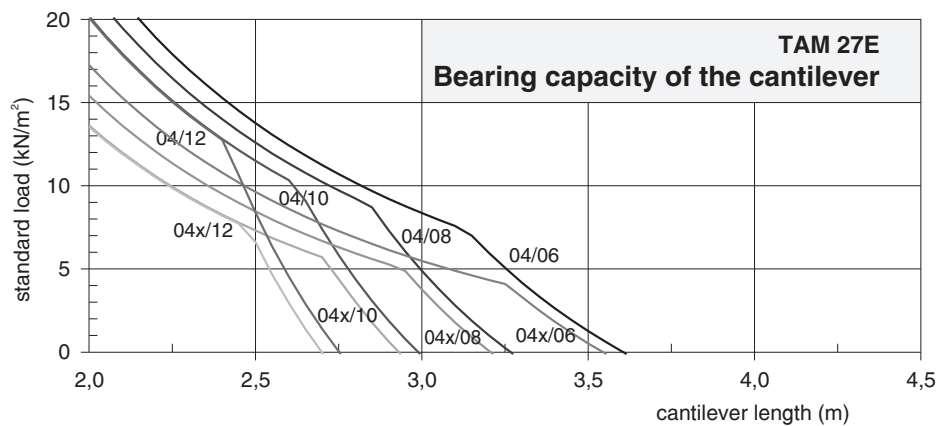
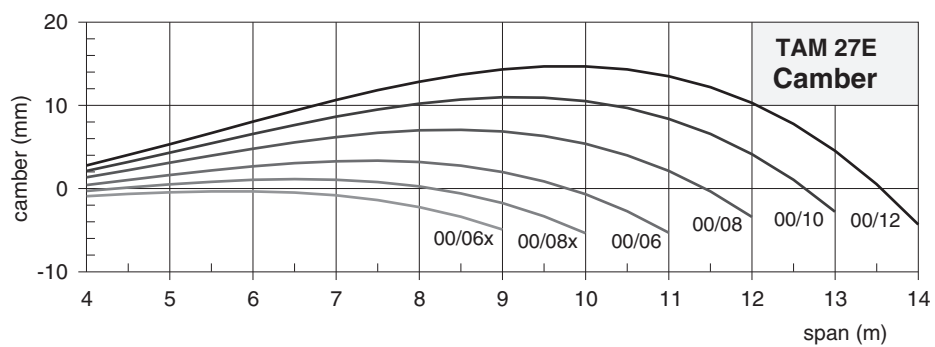
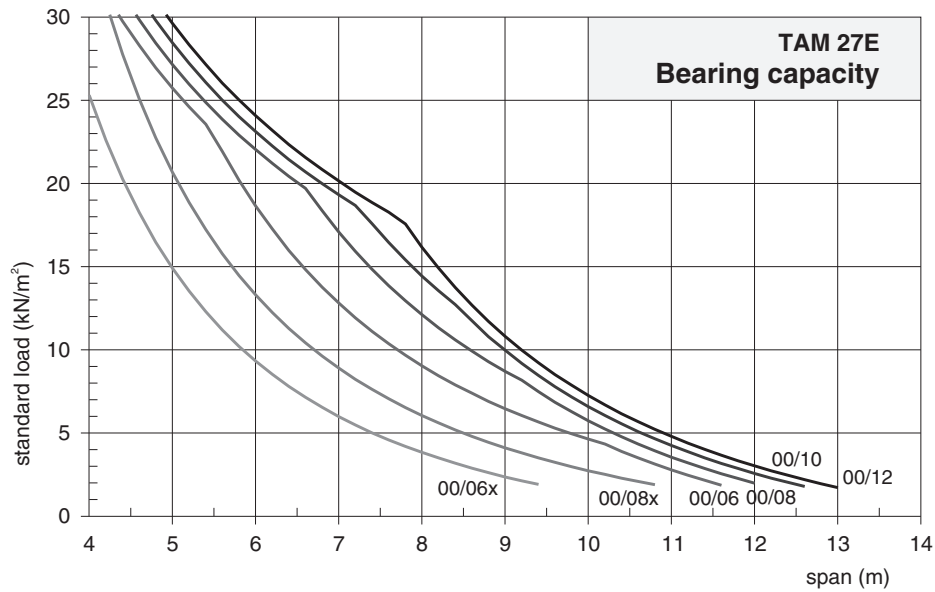
**Figure 12.** Bearing capacity and camber graphs of the slab TAM 27E  
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 MPa**  
- imposed load classes **A, B, G**: combination factors  $\psi_c=0.7$ ;  $c\psi_1=0.5$ ;  $\psi_2=0.3$



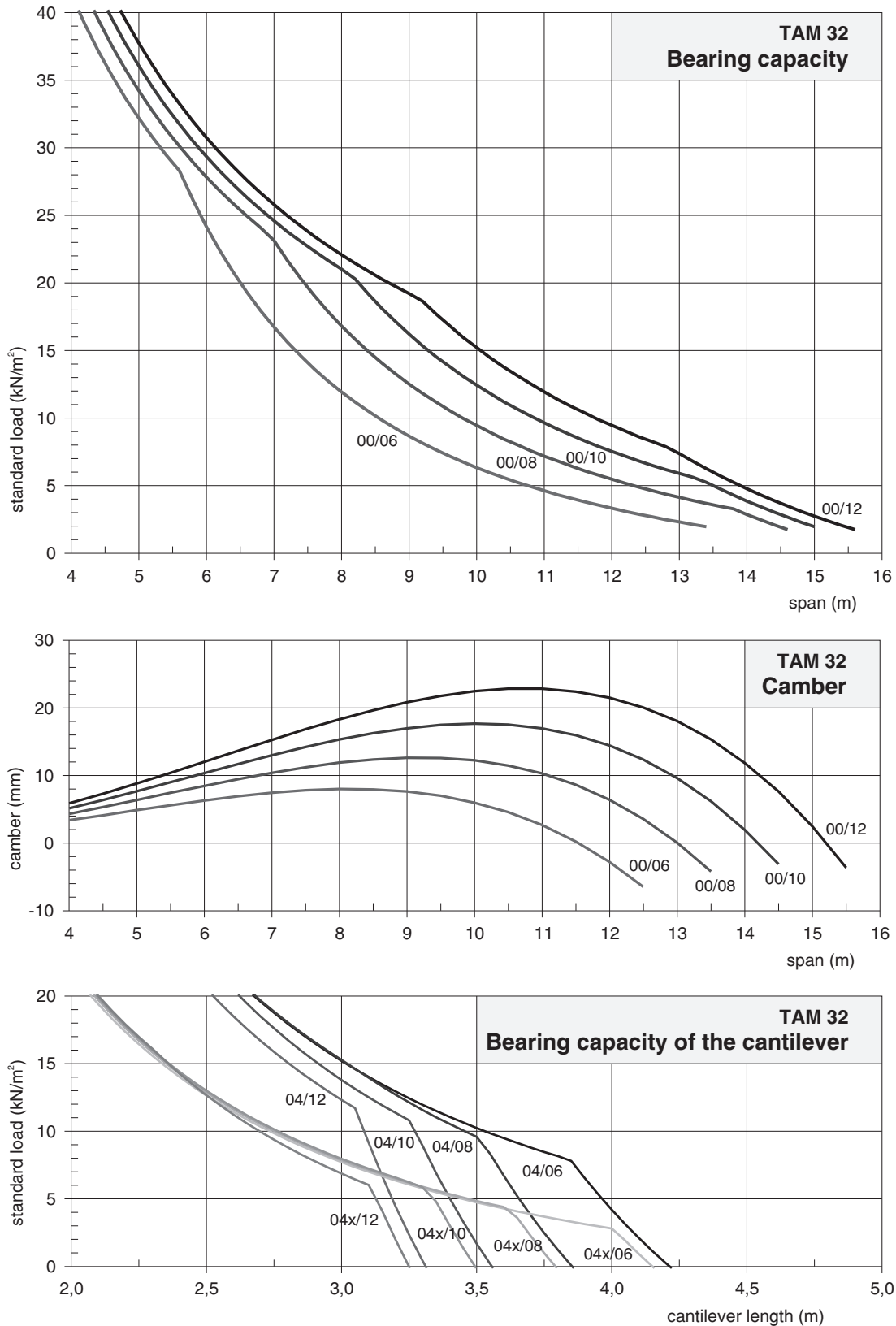
**Figure 13.** Bearing capacity and camber graphs of the slab TAM 27E  
 - lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **C, D, F**: combination factors  $\psi_0=0.7$ ;  $c\psi_1=0.7$ ;  $\psi_2=0.6$



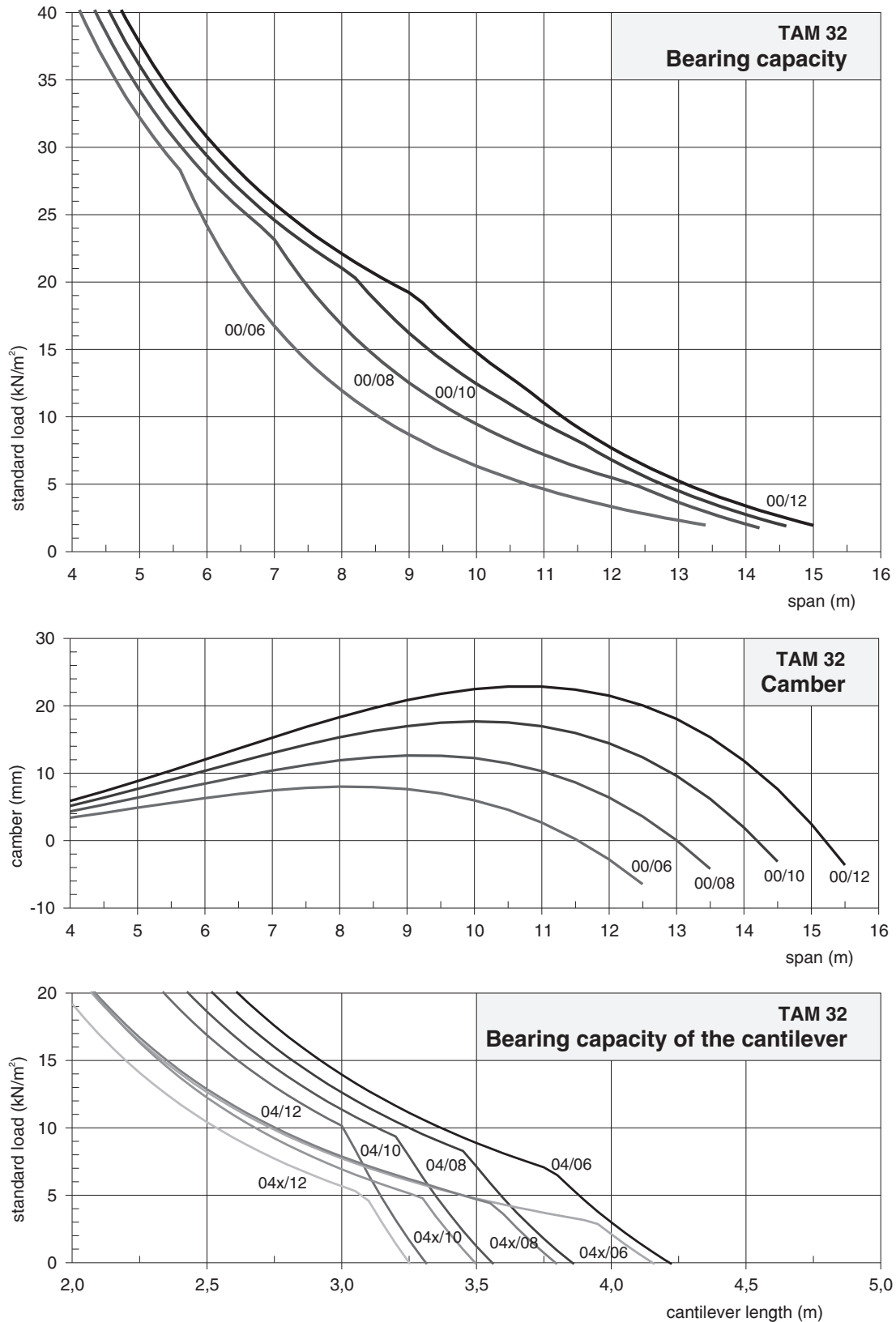
**Figure 14.** Bearing capacity and camber graphs of the slab TAM 27E  
 - lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 MPa**  
 - imposed load classes **E**: combination factors  $\psi_0=1.0$ ;  $c\psi_1=0.9$ ;  $\psi_2=0.8$



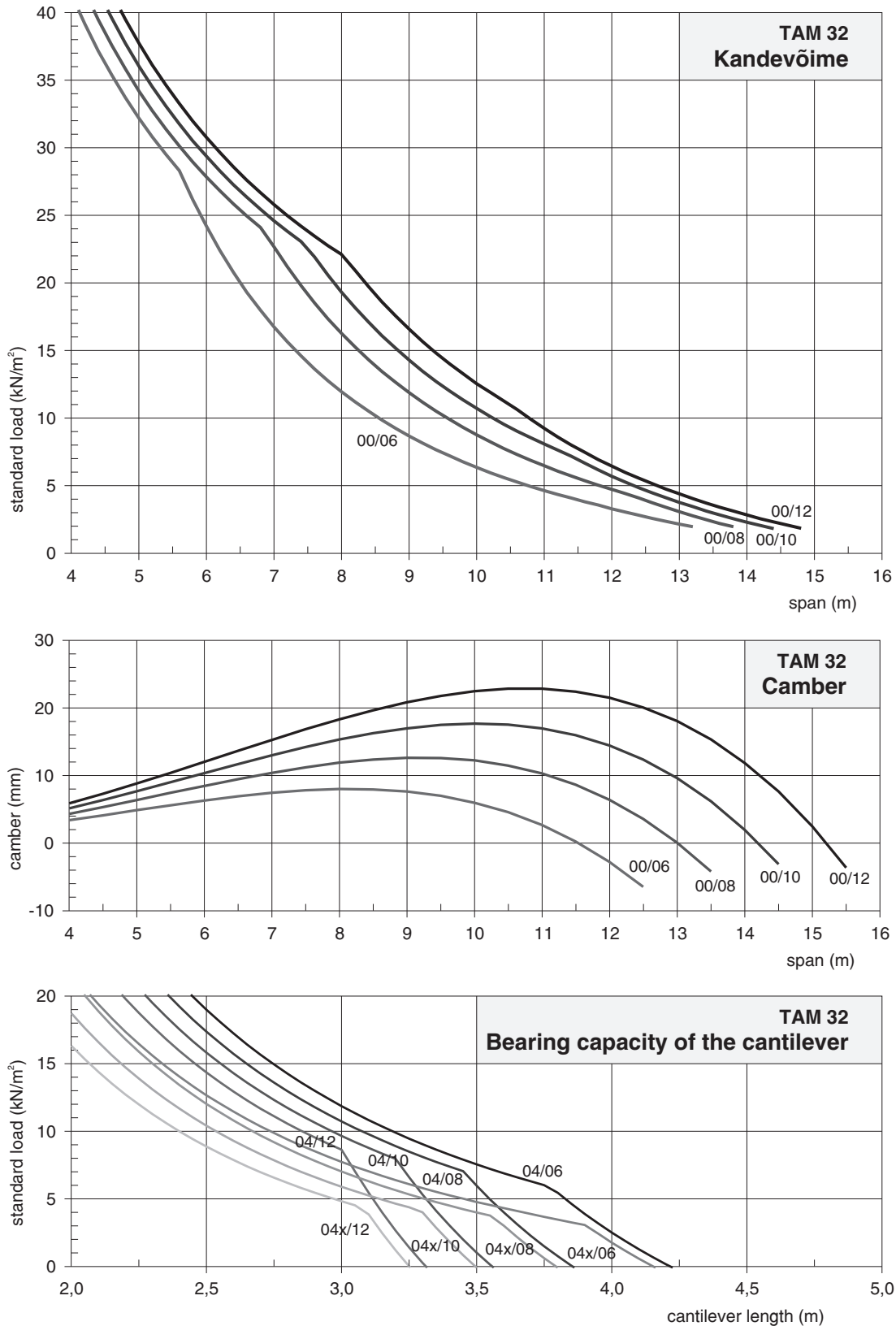
**Figure 15.** Bearing capacity and camber graphs of the slab TAM 32  
- lower strands' initial pre-stress of **1100 MPa**, upper strands' initial pre-stress of **700 MPa**  
- imposed load classes **A, B, G**: combination factors  $\psi_0=0.7$ ;  $c\psi_1=0.5$ ;  $\psi_2=0.3$



**Figure 16.** 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  $\psi_0=0.7$ ;  $c\psi_1=0.7$ ;  $\psi_2=0.6$



**Figure 17.** 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  $\psi_0=1.0$ ;  $c\psi_1=0.9$ ;  $\psi_2=0.8$



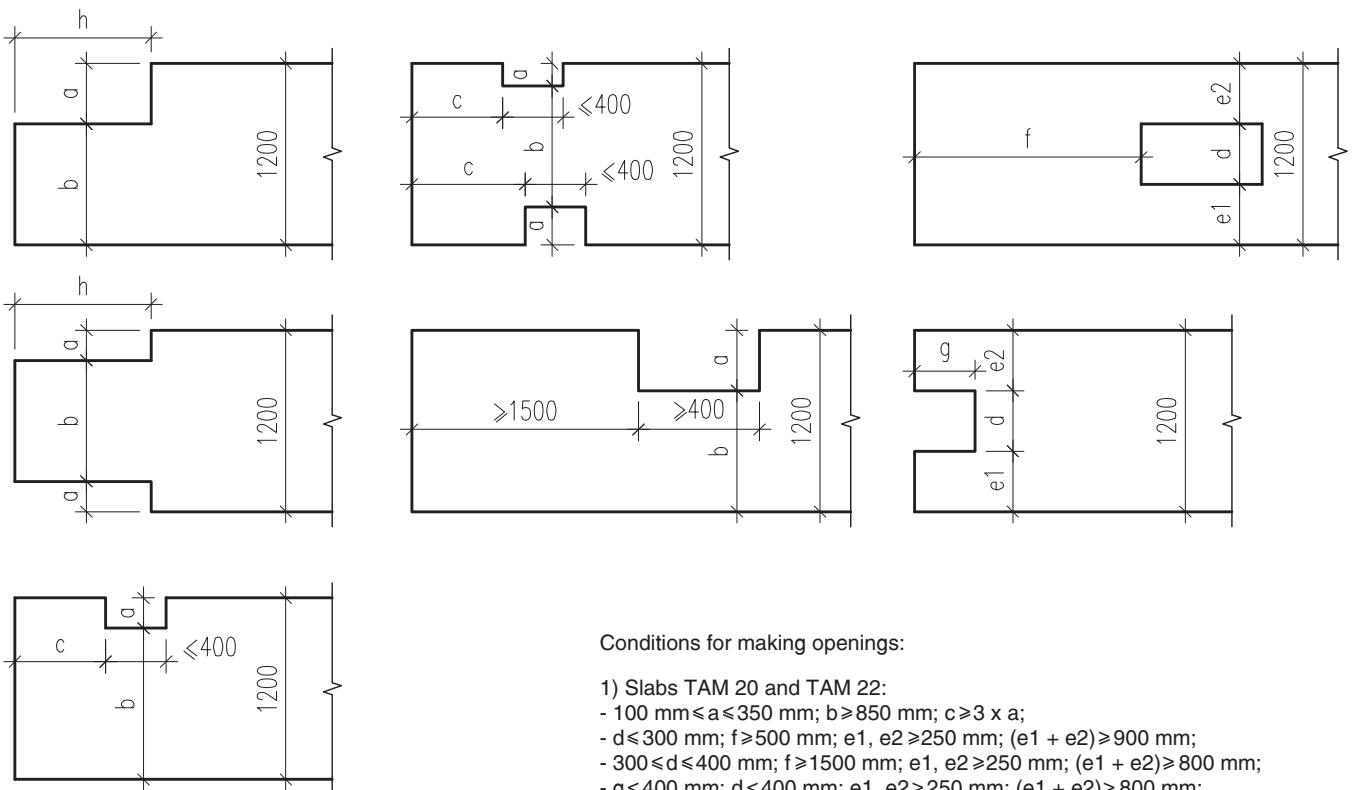
**OPENINGS**

The width of an opening made in the factory can be up to 400 mm. The length of the opening depends on the location of the opening in the slab. Conditions for making openings and their location in the slabs are presented in figure 18.

Three openings placed only at the cores area can be made into one cross-section. The location of the openings is presented in figure 19. The openings are made into wet concrete. Hoisting eyes will be installed into slabs with cut openings or slabs cut narrower.

**Figure 18.**

Dimensions and location of openings made in TAM slabs in the factory



Conditions for making openings:

1) Slabs TAM 20 and TAM 22:

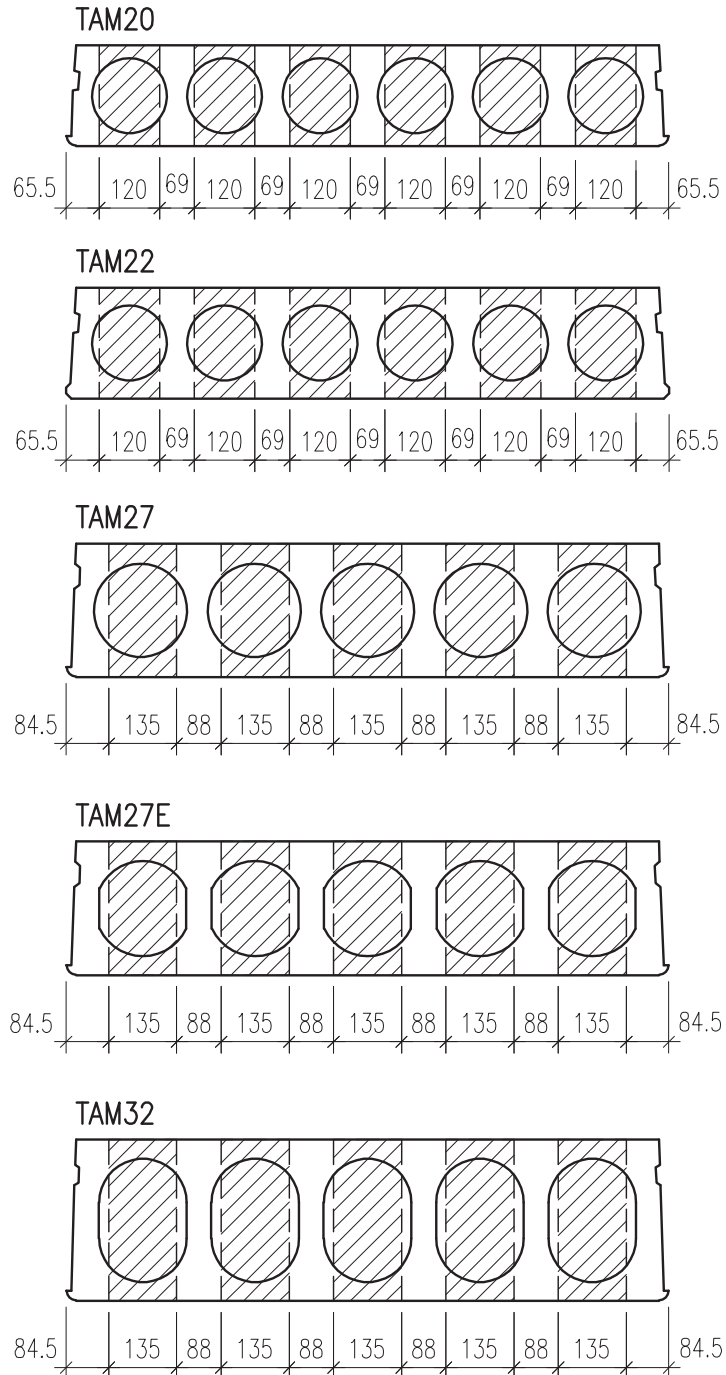
- $100 \text{ mm} \leq a \leq 350 \text{ mm}$ ;  $b \geq 850 \text{ mm}$ ;  $c \geq 3 \times a$ ;
- $d \leq 300 \text{ mm}$ ;  $f \geq 500 \text{ mm}$ ;  $e_1, e_2 \geq 250 \text{ mm}$ ;  $(e_1 + e_2) \geq 900 \text{ mm}$ ;
- $300 \leq d \leq 400 \text{ mm}$ ;  $f \geq 1500 \text{ mm}$ ;  $e_1, e_2 \geq 250 \text{ mm}$ ;  $(e_1 + e_2) \geq 800 \text{ mm}$ ;
- $g \leq 400 \text{ mm}$ ;  $d \leq 400 \text{ mm}$ ;  $e_1, e_2 \geq 250 \text{ mm}$ ;  $(e_1 + e_2) \geq 800 \text{ mm}$ ;
- $h \leq 400 \text{ mm}$ .

2) Slabs TAM 27, TAM 27E and TAM 32:

- $100 \text{ mm} \leq a \leq 400 \text{ mm}$ ;  $b \geq 800 \text{ mm}$ ;  $c \geq 3 \times a$ ;
- $d \leq 300 \text{ mm}$ ;  $f \geq 500 \text{ mm}$ ;  $e_1, e_2 \geq 310 \text{ mm}$ ;  $(e_1 + e_2) \geq 900 \text{ mm}$ ;
- $300 \leq d \leq 400 \text{ mm}$ ;  $f \geq 1500 \text{ mm}$ ;  $e_1, e_2 \geq 310 \text{ mm}$ ;  $(e_1 + e_2) \geq 800 \text{ mm}$ ;
- $g \leq 400 \text{ mm}$ ;  $d \leq 400 \text{ mm}$ ;  $e_1, e_2 \geq 310 \text{ mm}$ ;  $(e_1 + e_2) \geq 800 \text{ mm}$ ;
- $h \leq 400 \text{ mm}$ .

**Figure 19.**

Width and location of openings made at the cores area (striped area)





## U S A G E

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 24). 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 facade 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.

## S T O R A G E   A N D   T R A N S P O R T A T I O N

The slabs are stored and transported in horizontal piles, sorted by types. Seven TAM 20 and TAM 22, six TAM 27 and five TAM 32 slabs can be placed in one pile.

It is not allowed to turn the slabs over.

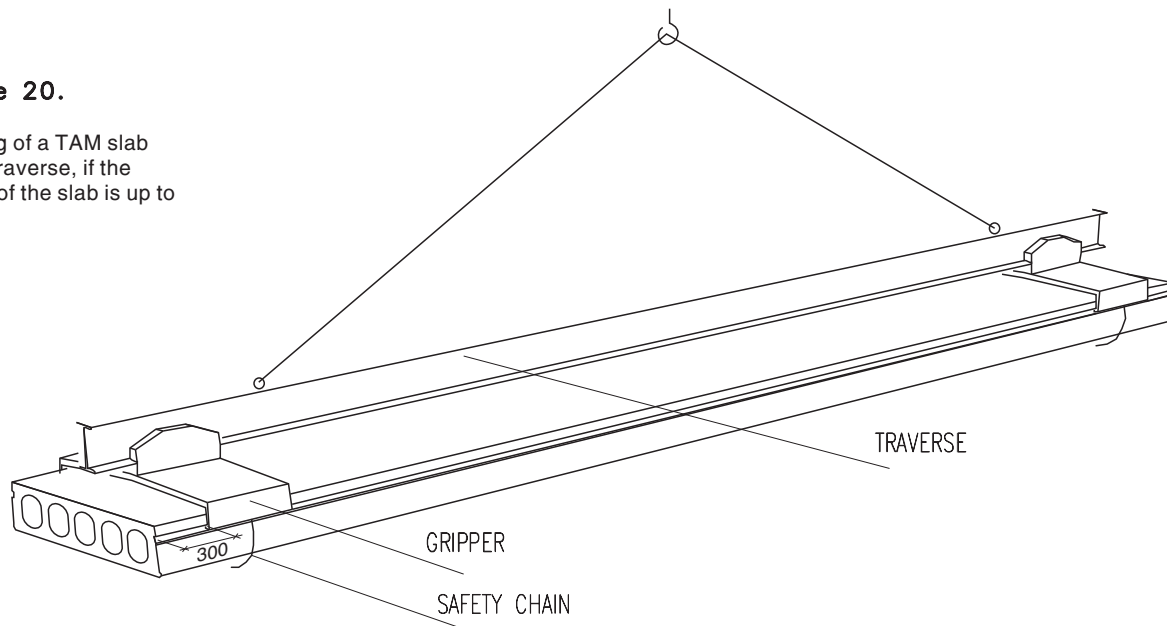
The slab piles are stored on at least 100 mm thick and at least 100 mm wide squared timbers placed on compact horizontal ground. Intermediate battens with the thickness of not below 20 mm and the width of not below 70 mm are placed between the slabs, 300 mm from the ends of the slabs. In case of storage 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 20). 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 21). The slabs cut narrower and slabs with cuts in corners are hoisted from four points from hoisting eyes (see Figure 22).

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

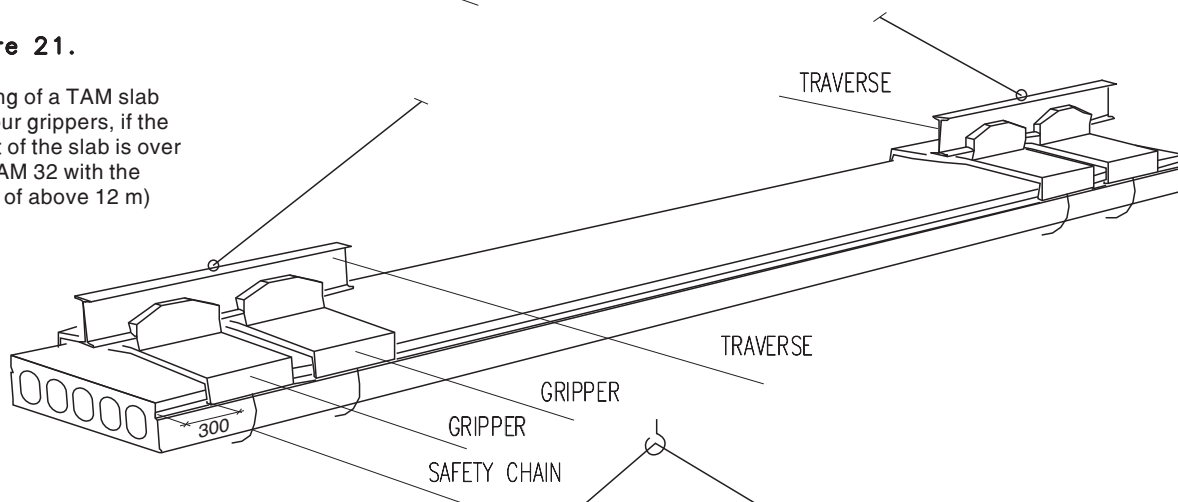
**Figure 20.**

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



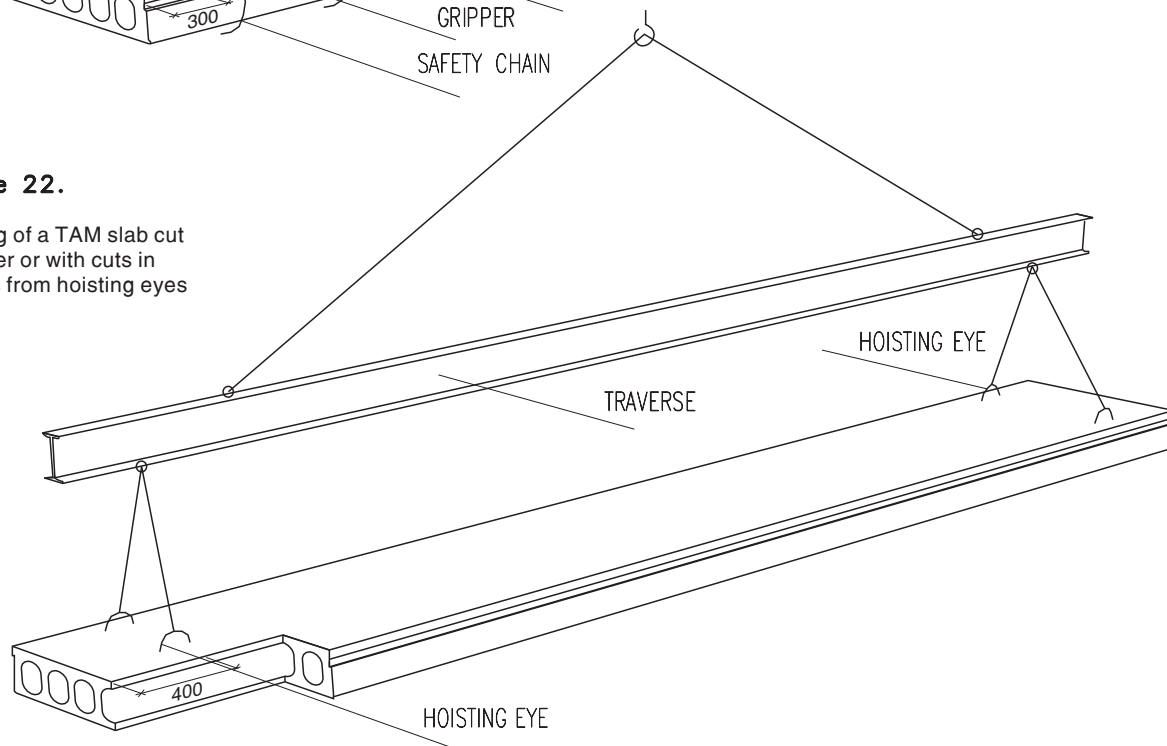
**Figure 21.**

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 22.**

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





## **A S S E M B L Y**

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  $\sim$ 10...25 mm) or a 7-wire pre-stressed strand. The reinforcement must be continuous.

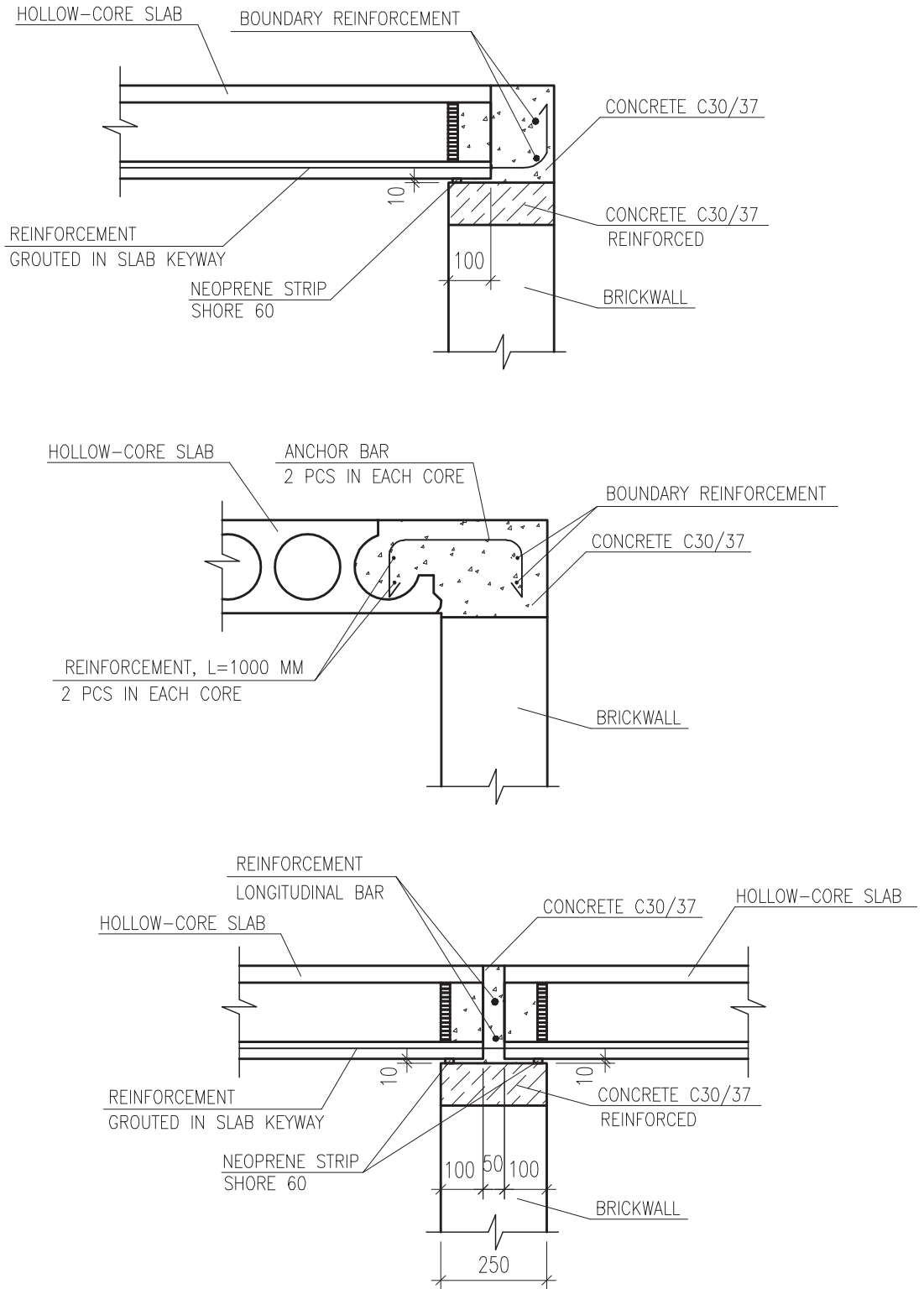
The anchor length of tie bars in longitudinal joints is 1.0 ... 1.5 m, depending on the type and diameter of the bar and the strength class of concrete.

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 23...25.

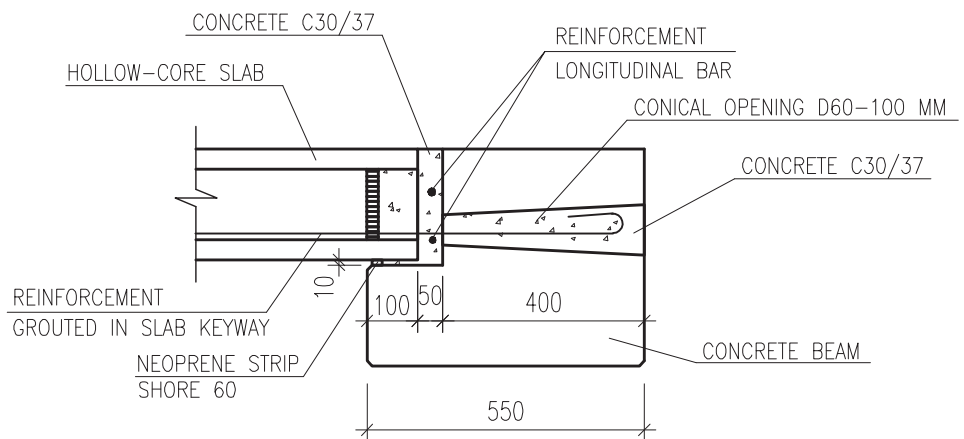
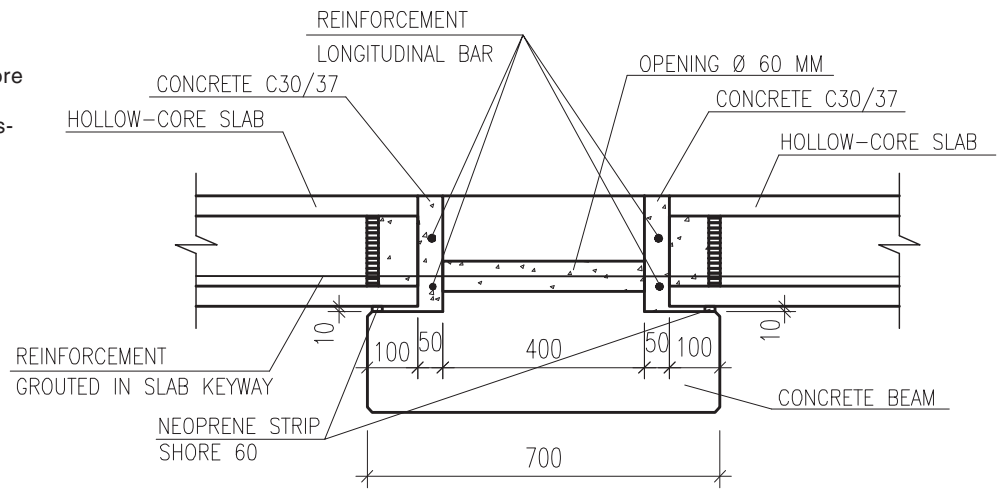
**Figure 23.**

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



**Figure 24.**

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



**Figure 25.**

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

