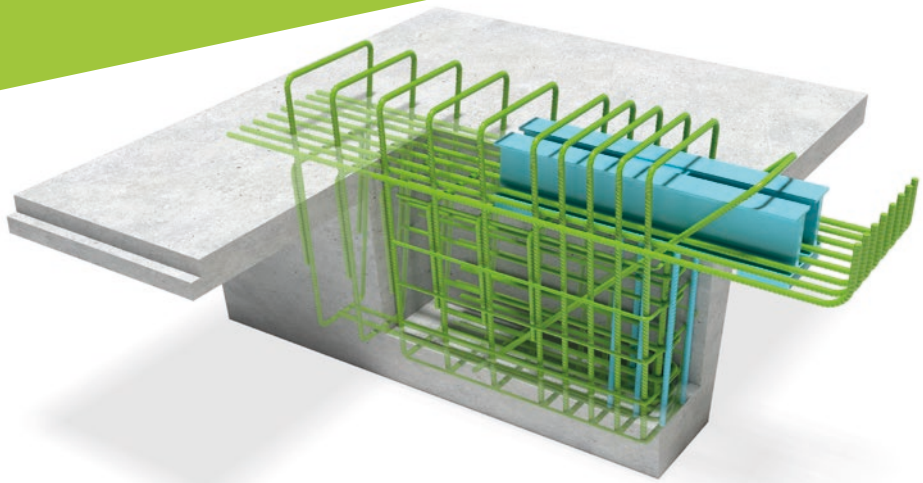

TWIN CORBEL — SUPPORT FOR TT SLABS AND SECONDARY BEAMS

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INTRODUCTION

Prestressed TT slabs are very popular for long span structures thanks to their economy, durability and ability to retain their properties and appearance over time. They are mainly used in building structures for industrial purposes or anywhere where a flat ceiling is not required.

TT slabs are usually supported by beams or girders. If TT slabs are placed on the top surface of supporting beams according to Figure 1, the structural height of the floor becomes quite uneconomical.

One of the possible solutions is to equip beams with flanges and create mortised ends on the TT slabs according to Figure 2. This solution often requires complex supporting beam cross-sections with additional load eccentricities and, at the same time, causes concrete cracking problems due to unfavorable concentration of stresses at the re-entrant corner of the supporting area of the TT slabs.

The same functional effect can be reached by using Peikko TWIN Corbel (see Figure 3.), which eliminates effectively the above stated problems. The DIBt approved TWIN Corbel has been recently launched as the successor product of Peikko's PBH Corbel system, providing an optimized reinforcement layout together with multiple application options for any kind of side beam constructions.

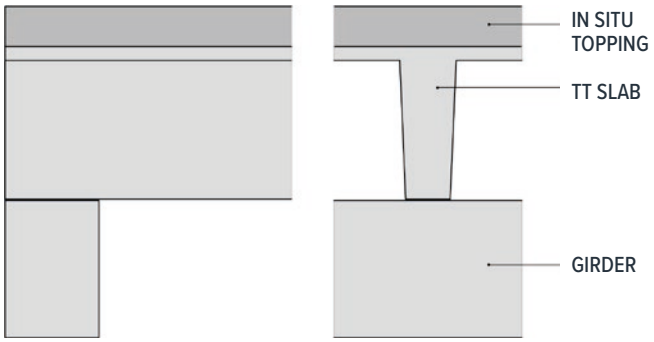


Figure 1: Stacked arrangement of TT slab and girder

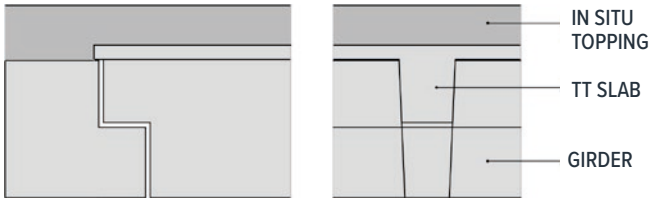


Figure 2: Flanged girder and TT slab with mortised ends

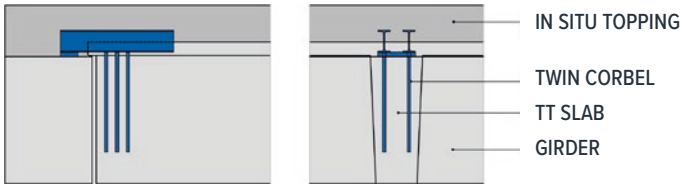


Figure 3: TT slab support with TWIN Corbel

DESCRIPTION AND FUNCTION OF THE TWIN CORBEL

TWIN Corbels are essentially steel assemblies allowing TT slabs to be placed on supporting girders or walls without the necessity to create girder flanges and mortised ends on the TT slabs. At the same time, they minimize the structural height of the floor structure. The assembly consists mainly of two vertical steel profiles mutually connected by a bearing plate and six vertical bars as anchoring reinforcement of the assembly to the TT slab.

The spacing of the steel profiles and anchor bars has been selected so that interference with the beam reinforcement is minimal, particularly with the lower strand layers.

The distance of steel profiles can be adapted for individual project cases at any time.

Dimensions and weights of the TWIN Corbel are given in Table 1.

TWIN Corbels consist of steel grade S355 for steel profiles and S235 for the bearing plate according to EN 10025-2 and B500B according to EN 10080 for the anchoring bars.

STRUCTURAL SYSTEM

TWIN Corbels are designed to carry out both transient situations during assembly of TT slabs (referred to as erecting state herein) and the final state, when cast in-situ concrete topping is hardened.

For the design these, two situations must be considered:

Erecting state:

The erecting state is defined as the period before the in-situ topping is completely hardened. Loads in this state result from dead load of the precast unit and the in-situ topping and potential additional loads during the casting process. All loads applied in this state are carried by the TWIN Corbel to the supporting structure. Resistances of the TWIN Corbel for the erecting state are given in Table 2.

The resistances includes a lateral force due to constraint in the range of 0.2 $V_{Rd,erect.}$

The constraint is caused by friction between the bearing plate and the concrete surface of a supporting girder in the cases wheren neoprene bearing pads are not used.

It has to be verified that:

$V_{Ed,erect} \leq V_{Rd,erect}$

where

$V_{Ed,erect}$ = Loading in erecting state

$V_{Rd,erect}$ = Resistance in erecting state

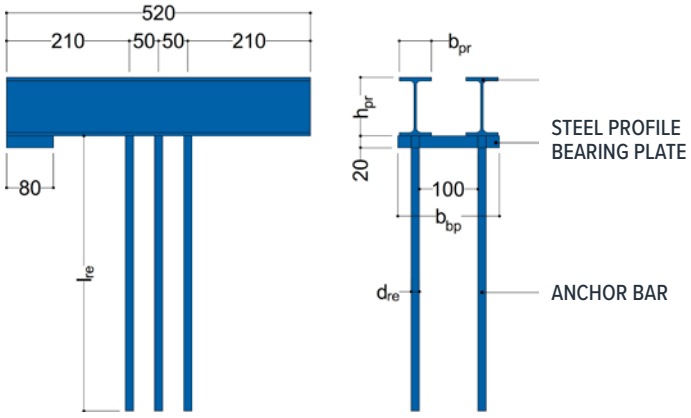


Figure 4: TWIN Corbel

Type of corbel		TWIN 65	TWIN 100	TWIN 145
h_{pr}	[mm]	80	100	120
b_{pr}	[mm]	46	55	64
b_{bp}	[mm]	168	179	188
l_{re}	[mm]	370	470	560
d_{re}	[mm]	12	14	14
Weight	[mm]	10.3	14.0	17.2

Table 1: Dimensions and weight of the TWIN Corbel

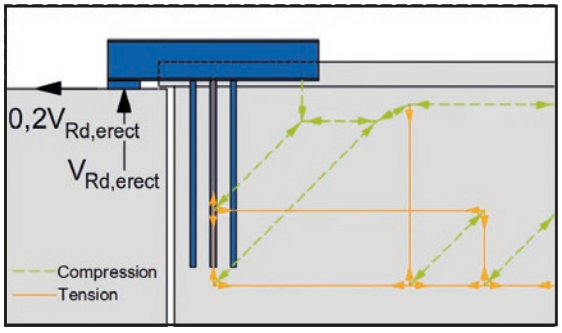


Figure 5: Structural system for erecting state

Type of corbel		TWIN 65	TWIN 100	TWIN 145
$V_{Rd,erect}$	[kN]	65	100	145

Table 2: Resistances of the TWIN Corbel in erecting state

Final state:
In the final state the TWIN Corbel participates related to its resistance during erecting state ($V_{Rd,erect}$) respectively its loading during assembling state ($V_{Ed,erect}$) to the total resistance of the construction. The total resistance of the system results from the sum of bearing resistance of the TWIN Corbel and bearing resistance of the concrete slab. All loads that are applied to the structure after hardening of the in-situ topping must be considered, such as flooring, live loads, etc. Values for total resistances of the construction are precalculated and given in the design tables in Annex A of the relevant technical manual of TWIN Corbel.

It has to be verified that:

$$V_{Ed,final} \leq V_{Ed,erect} + (V_{Rd,final} - V_{Rd,erect})$$

where

$V_{Ed,final}$ = Loading in final state
$V_{Ed,erect}$ = Loading in erecting state
$V_{Rd,final}$ = Resistance in final state
$V_{Rd,erect}$ = Resistance in erecting state

Predefined and DIBt approved reinforcement layouts and additional application instructions are given in Annex B of the relevant technical manual of TWIN Corbel.

PRACTICAL BENEFITS OF TWIN CORBEL APPLICATION

The use of TWIN Corbels has many advantages in comparison to other common solutions used:

a) Reduction of structural height of floor (or roof) structure
When the clear height of a structure is the same as the solution shown in Figure 1, the solution with TWIN Corbel (Figure 3) offers:

- Lower construction height
- Smaller area of external walls and consequently lower purchase and maintenance costs
- Less consumption of energy for heating during operation of a building (this is a long-term effect that benefits the user of the building)

b) Ease of formwork, smaller amount of concrete and reinforcement
When solutions shown in Figure 2 and Figure 3 are compared to applying TWIN Corbels:

- Simplified formwork of girders due to rectangular cross section
- Concrete for flanges is saved
- Reinforcement of flanges is not needed
- Cracking problems of mortised ends are avoided
- Reduction of load eccentricity means reduction of torsional moments of girders and consequently reduction of steel for stirrups

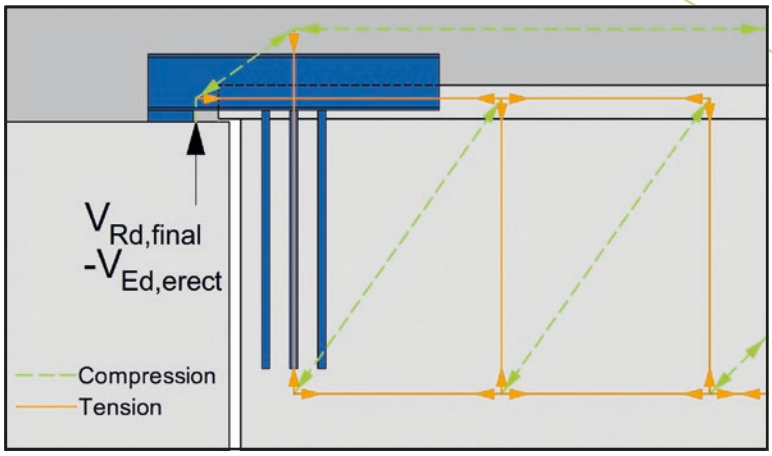


Figure 6: Structural system for final state

Figure 7: Technical manual of TWIN Corbel

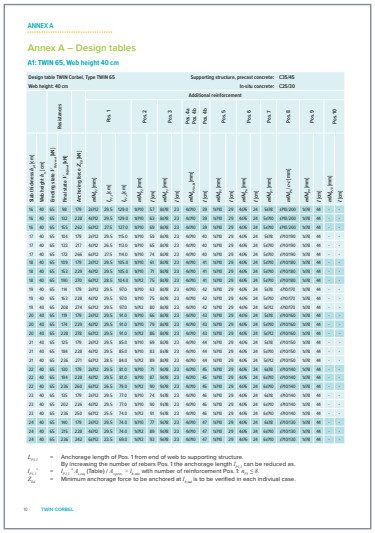
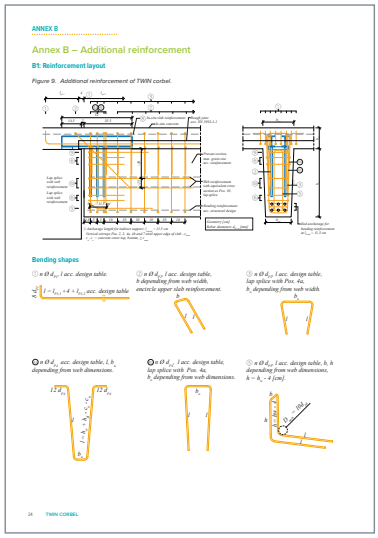


Figure 8: Design tables acc. Annex A of technical manual



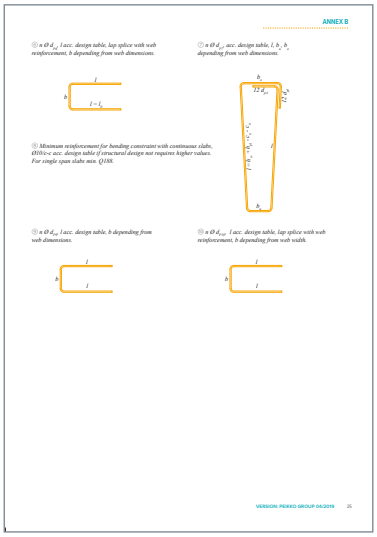


Figure 9: Reinforcement layout acc. Annex B of technical manual

c) Cost savings
Apart from the cost reduction already mentioned in point a), further cost reduction results from the benefits mentioned in point b) regarding:

- Smaller amount of concrete
- Smaller amount of girder and TT slab reinforcement
- No additional support during erecting state required

d) Entirely approved system by Deutsches Institut für Bautechnik (DIBt), Berlin
DIBT approval TP-14-0002 guarantees safety with regard to building laws due to complete approved system with:

- Optimized and predefined reinforcement layouts
- Easy dimensioning with design tables
- High resistances

5. CONCLUSIONS

TWIN Corbels are steel assemblies that simplify floor structures, consisting of TT slabs and supporting girders. TWIN Corbels eliminate the need for sensitive mortised ends of TT slabs and flanges of girders. This creates favorable conditions for cost savings of materials and, in addition, maintenance costs can be reduced when TWIN Corbels are applied because traditionally the danger of cracks in the re-entrant corners of mortised ends of TT slabs may need the application of adequate repair methods to satisfy durability requirements.

6. EXAMPLES OF TWIN CORBEL APPLICATION

TWIN Corbels have been developed particularly for TT slabs that are currently covered by a DIBt approval. Also the most common structural alternatives of TT slabs equipped with structural topping, like trough units or secondary beam constructions (Figure 10), are covered by this approval.

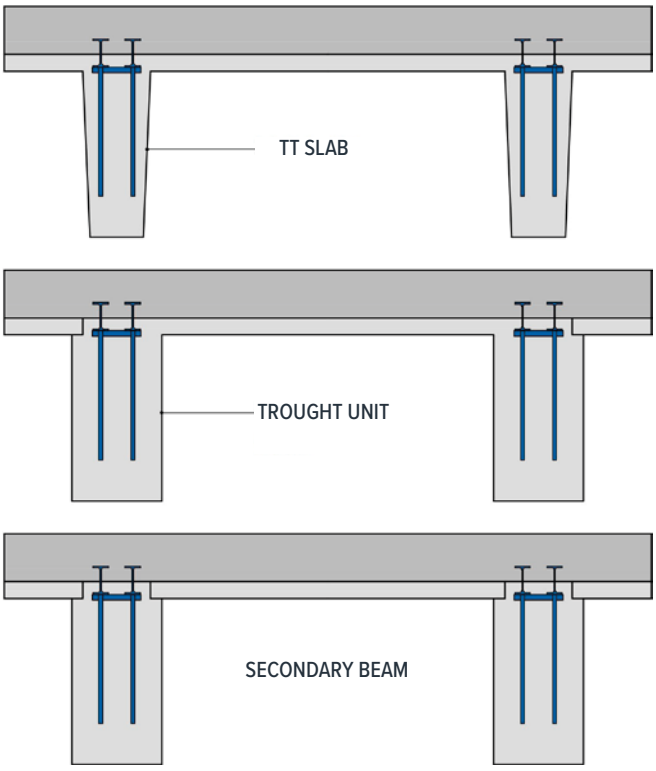


Figure 10: Structural alternatives for TT slabs


Figure 11: TT slabs equipped with TWIN Corbel


Figure 12: TWIN Corbel


Figure 13: Assembled TT slab with TWIN Corbel