Kaptor

Mechanical connection
by overlapping
**KAPTOR** is a mechanical system for prefabricated reinforced concrete structures, which allows creating type A, B, and C connections (see Section 7.4.5.2.1 NTC 2008).

The achievable connections are classified as follows:
- **KPP** Pillar-Pillar connection
- **KPF** Pillar-Foundation connection
- **KPF-T** Pillar-Foundation connection with anchor bolts

The connection is obtained from the link by screwing a metal insert (type A) inserted in the first part, and a metal insert (type B) in the second part.

The inserts to be connected are the following:

- **TIPO A:**
  - KSA (linear plate), with 2 bars KØ or KFØ with improved adherence;
  - K3A (angle plate), with 3 bars KØ or KFØ with improved adherence.

- **TIPO B:**
  - KSB (linear plate) with 2 bars KFØ with improved adherence, with thread and nut;
  - K3B (angle plate) with 3 bars KFØ with improved adherence, with thread and nut;
  - KT-M anchor bolt with improved adherence and emphasized on the base.

Two sets of inserts with plates and four types of anchor bolts are provided, in relation to the reinforcements that need to be remodeled by overlapping. The first set is used for reinforcement bars diameter 26 - 25 - 24, the second set is provided for reinforcement bars diameter 20 - 18 - 16. The improved adherence bars KØ and KFØ, which are specially shaped with calibrated end pads, are inserted in each plate and locked manually. The type A plates of K5 and K3 have holes, which allow the insertion of connecting screws with the identical plates of type B or of the anchor bolts, depending on the type of junction that is being used.

For connections, in the NTC 2008 Section 4.1.6.1.4, it is stated that: "forces are transmitted from a bar to the other by means of:
- overlapping of bars
- welding
- mechanical devices"

It is therefore excluded that forces can be transferred through “anchoring”. Kaptor reconstitutes the reinforcements of the two parts that are connected by overlapping. If we refer, for example, to the KPF connection, the reinforcement bars of the current section of the pillar are taken from the bars of equal diameter which transfer, by overlapping, the traction from the lower to the upper bars.

The use of the Kaptor system is simple and does not require calculations, because it allows the recovery by overlapping of the design bars. Based on the number and diameter of reinforcement rods, the number and the type of connection required is obtained. (See example in Section 5)

Kaptor inserts can be used in CD “A” and in CD “B”, depending on the type of design and the type of connection used, with the exception of diameter Ø26, for which the use should only be in CD “B”.

**2.2 DESIGN CRITERIA**

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Kaptor inserts can be used in CD “A” and in CD “B”, depending on the type of design and the type of connection used, with the exception of diameter Ø26, for which the use should only be in CD “B”.

**2.3 PLATE-BAR CONNECTION**

does not require welds; their coupling is done manually while reinforcements are erected.

This avoids handling very bulky and heavy inserts, by composing the connections with rods, the length and diameter of which is required by the design, directly on the formwork.

In special applications, it is anyhow allowed to weld directly the reinforcement rods to the plates, provided that the weld is made with high strength basic wire and by specialized personnel provided with a license. (See Section 4.3 for further details)
2.3.1. **Selection of Bars and Anchor Bolts**

Depending on the type of connection, there are different types of bars and anchor bolts:

1. **Bars KØ for Connections Outside the Critical Area**
   - where \( L_{\text{c}} = L + 50 \Omega \)
   - KØ26 \( L = 380 \text{ cm} \)
   - KØ25 \( L = 275 \text{ cm} \)
   - KØ24 \( L = 270 \text{ cm} \)
   - KØ20 \( L = 250 \text{ cm} \)
   - KØ18 \( L = 240 \text{ cm} \)
   - KØ16 \( L = 230 \text{ cm} \)

2. **Bars in Foundation KFØ for Connections in the Critical Area**
   - where \( L_{\text{KF}} = 22 \Omega + 5 \text{ cm} \)
   - KFØ26 \( L = 65 \text{ cm} \)
   - KFØ24 \( L = 55 \text{ cm} \)
   - KFØ20 \( L = 50 \text{ cm} \)

3. **Anchor Bolts Series 26-25-24**
   - KT-M24 \( L = 62 \text{ cm} \) provided with nuts and washers
   - KT-M33 \( L = 83.5 \text{ cm} \) provided with nuts and washers

4. **Anchor Bolts Series 20-18-16**
   - KT-M20 \( L = 50.5 \text{ cm} \) provided with nuts and washers
   - KT-M27 \( L = 66.5 \text{ cm} \) provided with nuts and washers

2.4 **Safety of Connection**

In the Kaptor system, the parts have been dimensioned with a large safety margin with respect to the yield of the bars.

The system was tested both to check for the correspondence to the calculation of plates, screws, and anchor bolts, and to check that the swaging of bars does not reduce their strength characteristics in the connection point.

2.5 **Use in Critical Area**

Please note that the critical zone is the energy dissipation area, where widespread cracks occur, assuming a structure factor (or behavior factor) \( q > 1 \) in the seismic calculation.

The NTC 2008 prescribe, at item 7, that in the “critical areas” of structures built in seismic areas, reinforcements must not overlap.

Kaptor allows moving the overlapping area over the critical zone, thus creating a link that does not increase the steel area required by the design in the critical zone.

2.6 **Stiffening of Bolts**

To tighten the screws and bolts in all Kaptor connections, there is a reduced torque of 150 N (15 kgf) with an arm of 20 cm.

The equivalent tightening moment is therefore equal to \( 150 \times 20 = 3000 \text{ Ncm} \).

Utilizzabili per lunghezze di zona critica ≤ 150 cm

threaded with nut at the end

provided with nuts and washers

Utilizzabili per lunghezze di zona critica ≥ 150 cm

threaded with nut provided with nuts and washers

Bar KØ
Kaptor plates are designed to be assembled with the longitudinal rods directly on the formwork. This system, therefore, solves the problem of weight, size, and handling, which are the typical issues of similar systems.

It is therefore obvious that the operations of insertion in the reinforcements and on the heads of the formworks are simpler.

The positioning of plates on the formwork can take place in the following ways:

1. Setting up the heads with special templates welded on the separator.
2. Piercing the separator and fixing the plates with screws.

The adhesion bars can be inserted and anchored to Kaptor plates by rotation on pre-drilled holes, making sure that the bar locks by friction after the rotation.

Welding shall be performed with a basic wire and by specialized personnel.

Place the "adjusting screws" on the plinth or bottom pillar. Lift the pillar and lower it hitting the "adjusting screws". Make the centering and verticality adjustments by acting on the specific low nut. Lock the "adjusting screws" on the plates with the upper nut. Insert and tighten all Allen screws. Make the completion cast with compensated shrinkage mortar Exocem G1.
KPF-T is the connection between the foundation plinth and pillar with anchor bolts, while KPP-T makes the connection between two pillars; both allow the continuity of current reinforcements by overlapping. The connection is made by placing always an angular item (K3A) in the four corners of the pillar and any internal KSAs. Each K3A plate can receive two or three anchor bolts, while the KSAs receive an anchor bolt of larger diameter. The KPF-T connection requires an $R_cK \geq 25$ N/m² in the foundation, while in the case of KPP-T connection an $R_cK \geq 50$ N/m² is required. The connection allows mounting allowance on the vertical line of $40 \pm 15$ mm, while the centering tolerance is of $\pm 5$ mm. The pillar is plumbed by acting on the four corner anchor bolts. Subsequently, all the other anchor bolts are also brought into position. At this point, the pillar is completely dry-anchored. Also in this case, the joint can be sealed with EXOCEM G1.

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- setting up the heads with special templates welded on the separator;
- piercing the separator and fixing the plates with screws.

The adhesion bars can be inserted and anchored to Kaptor plates by rotation on pre-drilled holes, making sure that the bar locks by friction after the rotation. It is also allowed to anchor the longitudinal rods by welding. Welding shall be performed with a basic wire and by specialized personnel.

3.2.2 Instructions for Use

- Lift the pillar and lower it hitting the anchor bolts.
- Make the centering and verticality adjustments by acting on the specific low nut.
- Lock the anchor bolts on the plates with the upper nut.
- Make the completion cast with compensated shrinkage mortar EXOCEM G1.

The advantages of the Kaptor system in the foundations can be summarized as follows:

- Possibility to build shallow foundations and connecting beams in the floor thickness.
- No item projecting from the foundation surface.
- Fast and accurate plumbing of the pillar.
- Dry anchoring.
- No contraindication for use in a critical area.

4. Advantages of Kaptor connection

4.1 In the Foundation

To date, the most used solutions to connect a pillar to the foundation are the following:

- Cup plinth;
- Corrugated tubes in the foundation in which the reinforcements outgoing from the pillar enter (reinforcement-tube).

Both solutions require deep foundations, which are more expensive and problematic.

The KPF connection provides substantial advantages compared to these solutions, the first advantage being that it is possible to create a "shallow" foundation. Shallow foundation is advantageous especially in seismic areas, where the foundations must be connected with a grid of beams. The possibility to make them in the floor thickness, having foundations that do not exceed 80 cm in height, means significant cost savings. Compared to traditional solutions, Kaptor allows dry anchoring without props.

In the connection with anchor bolts, the advantage is even greater, because the structure can be immediately loaded without waiting for the completion cast with expansion mortar. The rods protruding from foundations that pass through sleeves positioned in the pillar, or the systems with protruding threaded bars from the foundations, which are locked with nuts with plates anchored in the pillar, with positions and diameters that cannot be overlapped to the current pillar bars, cannot be used in a 'critical area', as overlaps in critical areas are prohibited by law.
Kaptor can also be used partially, to facilitate only plumbing of the pillar, connected to the foundation or to the upper pillar with a traditional system (known as a reinforcement-tube); in this case, the adjustment screws can be used, which are inserted in the 3 or 4 linear KS items placed at the center of the pillar sides.

4.3 Using welded bars

4.3.1 Welding of bar Ø with a bar of the same diameter

Welding between bars of the same diameter must be performed on the vertical line between the bars and must be symmetrical. Welding requirements are similar to those seen above (see Section 2.2).

Example of welding between two bars Ø 26 (thickness of welding bead H = 15 mm)
Therefore, there is:

\[ L \times 1.5 = A_{26} \times 4 \]

from where:

\[ L = \frac{5.3 \times 4}{1.5} = 14.1 \text{ cm} \]

Therefore \( L = 15 \text{ cm} \)

Example of welding between two bars Ø 20 (thickness of welding bead H = 12.5 mm)

\[ L_1 = A_{20} = 4 \times 10 \text{ cm} \]

There \( L = 10 \text{ cm} \)

Welding between bars of the same diameter is possible also in a critical area.

4.3.2 Welding of bar Ø with two bars of smaller diameter

It is also possible to weld two bars having a total area not less than that of the Ø bar to a bar Ø already locked to the plate.

These welds must be avoided in a critical area.

The length \( L \) and the height \( H \) of welding are defined as follows:

Example of welding of the bar Ø 26 with two bars Ø 20 (H = 12.5 mm)

\[ L_1 = A_{26} = 4 \times \frac{1.25 \times 2}{4} = 8.48 \text{ cm} - 10 \text{ cm} \]

Example of welding of the bar Ø 20 with two bars Ø 16 (H = 10 mm)

\[ L_1 = A_{20} = 4 \times \frac{1.25 \times 2}{4} = 6.28 \text{ cm} - 6.5 \text{ cm} \]

4.3.3 Calculation of welds on the bars

It is assumed that the weld can arrive at an operating stress of 60 N/mm², that is, equal to 1/4 of the stress of bars.

5. Example of design

5.1 Design data

Pillar 50x50 with central downpipe Ø 150 mm. Current reinforcement = q.ty 12 Ø 24
Concrete cover 3 cm
Bracket’s QR
Coefficient of the structure \( q = 2.5 \)
Height of critical area \( L_c = 90 \text{ cm} \)

Solution Kaptor KPF

- In the pillar:
  - q.ty 4 K3A 26-25-24
  - q.ty 12 K3 Ø 24, L = 270 cm (Lc + Ls = 90 + 240)
- In the foundation:
  - q.ty 4 Styrofoam boxes K3 26-25-24
  - q.ty 12 KFO 26, L = 65 cm

Solution Kaptor KPF-T

- In the pillar:
  - q.ty 4 K3A 26-25-24
  - q.ty 12 K3 Ø 24, L = 270 cm (Lc + Ls = 90 + 240)
- In the foundation:
  - q.ty 12 bars KT M24 = 62 cm

Each user can receive technical support to design provided by Ruredil free of charge.
The brackets in the critical area are crucial to ensure adaptability at the base of the pillar in the foundations. Three areas can be identified:

1) Area 1, where the brackets are configured as a needle engaging all the bars with small diameters (6 or 8 mm) and with pitch required by the calculation. This area is about 20 cm high and it is not possible to have the typical perimeter brackets;

2) Area 2, also critical area, where there are only the bars of the Kaptor system, and where it is possible to obtain the perimeter bracket system with the pitch required by calculations;

3) Area 3 of overlap, where all Kaptor bars overlap with those of the pillar, and where the perimeter brackets contain both;

4) Area 4, current section.

5.2 PILAR BRACKETS

6. Description of items

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6. Description of items

### CONNECTION FOR REINFORCEMENT RODS 20-18-16

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