

In the plant construction or process plants such as chemical, petrochemical, gas or power plants various disciplines are brought into contact and built on each other. Civil, mechanical, electro technical representatives are stipulated to see dependencies timely and to integrate it in design and schedule.

Already in the stage of foundation the civil engineer is required to include construction elements from the mechanical engineering and the electro-techniques. Heavy anchors, anchor groups or shear pockets are to provide for the mechanical, big cable pulling pipes and earthing for the electro technique. It is recommendable to include anchors and cable pulling pipes in the reinforcement drawing. Many times collisions between embedded parts and reinforcement bars need to be resolved on a roundabout way on site. This additional work and is leading to additional costly expenses.

### Embedded Parts and Reinforcement

The structural design of a typical foundation or base plate includes in the plant construction a formwork drawing, a reinforcement drawing together with the earthing design and if required an additional anchor plan if it is not already respected in the formwork drawing. Experienced structural designers give an input in their planning how to integrate anchors or cable pulling pipes in the reinforcement cage. Several solutions are arising such as displaying a detailed configuration of the reinforcement or simply increasing the percentage of the reinforcement in order to cut out the bars where required. Otherwise rebars need to be cut out manually and to be replaced beside which means a loss of static cross section that has to be replaced. Hence the density of rebars increases and often causes an unacceptable tight raster of reinforcement. Fig. 1 shows how a good solution could look like.

### ANCHORS

A variety of different anchor systems are used in machines foundations in the plant construction. The anchor is the link to the mechanical equipment. The demand to the civil is to provide a precise anchor fastening within a tolerance range of millimetres. The task in practise is to fasten an anchor in a length of 1.5m or an anchor group as an example in a 3m high foundation undisplaceable before and while pouring of concrete.

Inappropriate but often observed are fastenings at the reinforcement cage with welding butt straps. On one side welds at the reinforcement are incorrect and on the other side the rebar cage cannot be assumed as sufficient stabile. The cage risks moving by placing concrete with the concrete pump or by using the concrete vibrator. Threaded anchors of a higher tensile strength category are carbon containing alloys that change their microstructure under thermic stress due to welding and accordingly are loosing their tensile strength rapidly. Furthermore inappropriate are fastening anchors to the formwork because it cannot be assumed as sufficient stabile due to concreting works.

The below mentioned method is after a series of observations on different sites the most effective and precise. At first the lean concrete that has to be placed on the formation level in a strength of not less than 10cm in order to enable a later fastening of concrete dowels. Prior to any activity the site surveyor should mark all relevant centre points of the anchor at the lean concrete course. In order to realize a precise assembling the anchor group should be connected with each other by mounting a top and a bottom template of an at least 10mm strong pre drilled steel plate. Now the sub construction can be placed with dowels in line with the markers at the lean concrete to take the anchor-template-group or anchor box. A detailed design of this construction facilitates the surveyors and manufactures work on site. The steel plate of the sub construction should be fitted with stamped markers to locate the centre points of the anchors as a help to bring them in line with the markers of the lean concrete. Now the reinforcement works can launch and the rebar layers can be placed. Hairpins are arranged around the anchors and transfer the loads to the bottom of the foundation Abb. I. After placing the last layer of reinforcement the surveyor will re-check the accuracy of the embedded anchors and arranges if necessary an

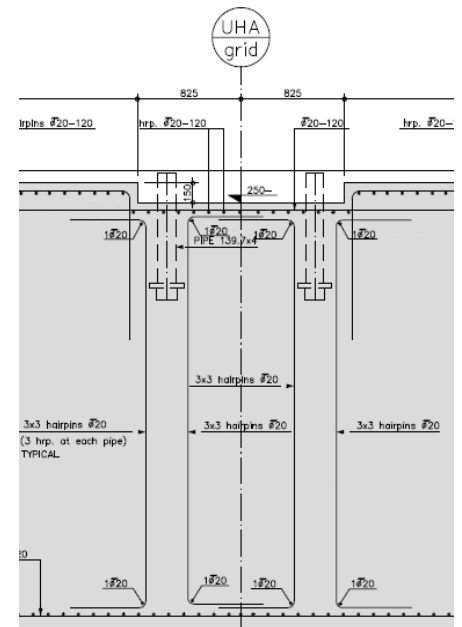


Fig. I Cut-out from a technical drawing. Arrangement of reinforcement to forward the loads to the bottom of the foundation

additional adjustment. To minute a survey report before and after pouring the concrete and to handover it to the mechanical is often contractually determined or if not recommendable. In practice it proves as an advantage to bond anchors of a diameter less than 20mm after pouring the concrete with an adhesive agent.

**Type of anchors**

1) **Threaded anchor bolts** Pic.1.1, Pic.1.2 Pic. 1.3



Pic. 1.1 Threaded anchor bolt with template and foot plate



Pic. 1.2 Galvanized threaded anchor bolt



Pic.1.3 Sub construction to carry threaded anchor bolts

2) **T-anchors** used for bearing of heavy loads. The cylinders are embedded in concrete with a slotted base plate through which later the t-anchor will be inserted and then directly turned through 90°. The composite is realized by grouting with shrink free compound cement. The anchor box has to be built into the concrete. Anchor boxes are bundled up to 12 Cylinder Cells. (Fig. 2)



Pic.2.1 Anchors boxes at a pallet



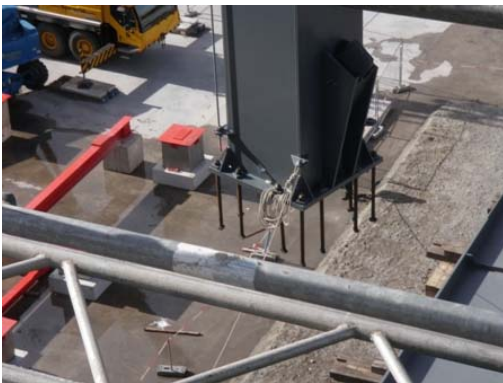
Pic.2.3 Sub-construction to carry the anchor box



Pic.2.4 Sub construction fixed at an anchor box



Pic.2.3 Anchor box in the foundation



Pic.2.4 T-anchors during assembling

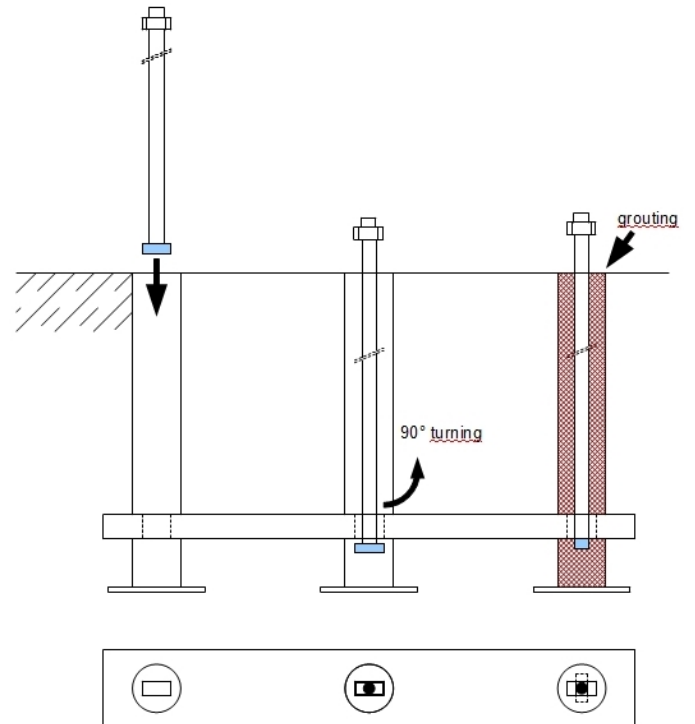
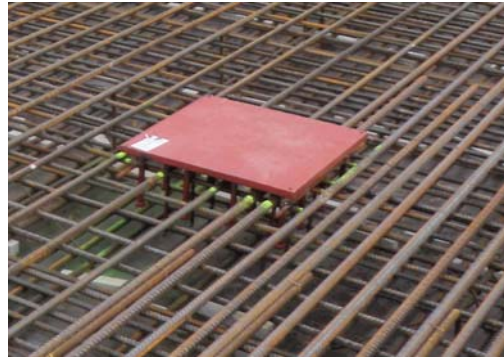


Fig. 2 mounting a t-anchor in an anchor box

3) **Anchor plates** to fasten contiguous welding fastenings with welded anchor pins Pic.3.1 or reinforcement bar. The steel plate should be fitted by four pre drilled holes to enable a fastening at the formwork. Should a fastening at the formwork be impossible in case of the closing shutter board and welds to the reinforcement cage not permitted additional auxiliary rebars need to be bended at the cage or at the anchor plate with which finally welded connection are permitted. If the anchor plate has to be placed horizontal at the top surface of the concrete a good fastening and height positioning is realized by bending these auxiliary rebars at the anchor plate pin (Pict.3.2) that keeps the plate in its designated position during the pour.



Pic. 3.1 Anchorplate with 9 rebar bolts



Pic. 3.2 Anchor plate at the top of concrete floor

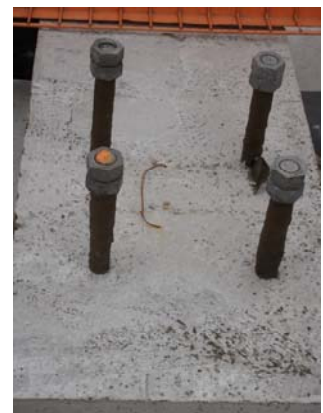
4) **Screwed connections** or rebar coupler systems are used to connect reinforcement or anchors. The system needs a recognized certificate.  
Pic. 4.1 - 4.3



Pic.4.1 Rebar coupler system straight and bended



Pic. 4.2 Two screwed connections with template



Pic.4.3 Anchor group protected temporarily with greased tape

#### **Galvanized anchors**

Anchors in particular from blank steel or untreated steel should have a temporarily basic coating to protect them from corrosion if they are exposed to weather. Still better is to wrap the anchor with a greased tape as shown in Pic 4.3. Nuts from hot dip galvanized or coated anchor pins have to be adapted to each other. Nuts of galvanized anchor systems are prior to the galvanizing process fitted with a deeper thread due to enable a smooth screwing. Increasingly coated anchor systems instead of galvanized come into operation. Coatings compared to galvanizing have the advantage that damages due to assembling and transport are better to repair on site. Damages on galvanized anchor pins can only be protected by liquid zinc which doesn't provide a durable protection against corrosion in an aggressive environment.

**Specific features for the cost estimation**

Various contract forms are possible to bring anchor systems together with the mounting to account. In the constellation of unit rate contract the expense for the sub construction should be considered. The supply and the need of topographical survey work are above average and should be implemented in the cost estimation. A topographical survey team of two workers can be considered over the entire time for completion.

**Work Method Statement**

It is common practice in the international plant construction that the client can request a work method statement prior to execution of any activity. In general such an arrangement is contractually agreed. The document will be provided by the contractor and approved, signed or in any case adjusted by the client. The WMS describes detailed the work sequences, the deployed materials and analyses the risk assessments deriving from the trade. It's used to ensure safety and quality prior to commencing an activity and is usually more comprehensive than an assembly instruction. The WMS is an instrument for the client to monitor and control an ongoing job if it's in line with the agreed specification. On demand of the client a WMS can be requested to any kind of job executed on site.

Regarding the assembly of anchor systems aspects of tolerances, ensuring a good practice of fastening and topographical survey procedures require a detailed description to ensure the necessary quality. It's advisable to include a determination in how far and on which conditions welds on site are acceptable.

release	Date	Item	Name
1st release	22.10.2010		M. Hartmann