SPECIAL CONCRETE STAND STRUCTURE



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For a coking plant, a tower-like steel structure had to be built the top of which is at a height of 100m. The paper describes the reinforced concrete structure which supports the steel structure. It is a spatial frame having special foundation and joints. Both the design and the construction was meaning unusual tasks for the responsible engineer, because the extraordinary forces acting on the foundation and the superstructurer.

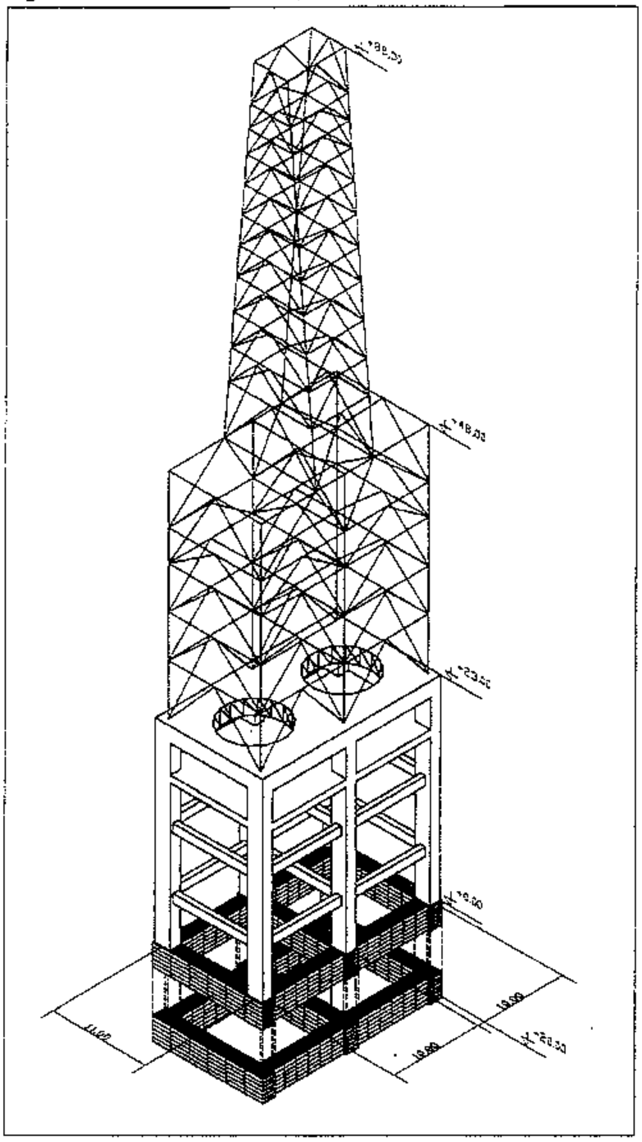
Keywords: Coking plant, special RC stand, joints

1. INTRODUCTION

MOL Inc., Danube Refinery (MOL Co. Dunai Finomító) erected a delayed coking plant for processing by-pass oil.

For placing the complete equipment, a 23.00 m high reinforced concrete stand structure was necessary upon which a 70.00 m high steel structure tower was erected with the process equipment fixed to it.

Fig. 1 Schematic view of the complete stand structure



The conceptual plans for the required deep foundation, reinforced concrete and steel structures were prepared by FOSTER WHEELER IBERIA in co-operation with the process designer.

The detailed design of the reinforced concrete structures were performed by CAEC Ltd. (Cronauer Almási Engineering Consulting Ltd.) under the leadership of OLAJTERV Co. The contractor was VÍZÉP Ltd. who implemented the plans.

Structural solution

Fig. 1 shows the schematic of the complete stand structure. *Three main parts of the structure can be distinguished:*

- *The foundation* is a diaphragm wall system supporting the reinforced concrete frame of box-like design bearing down the terrain level for 20.00 m. The thickness of diaphragm walls in the cross-direction is 1.20 m and that of the long direction is 0.8 m. This 1.2 m thick diaphragm wall was constructed for the first time in Hungary. The type of the dipper was STEIN 810/1200 with 18 t weight.

Welded steel reinforcement was put in place with balances manufactured for this purpose enabling both lifting and tilting.

The ready made diaphragm walls are kept together by a reinforced concrete girder lattice of 2.00 m structural height. The stirrups of the girder lattice permitted mounting of the longitudinal reinforcement from above. Assembly was performed by workers moving within the large girder lattices after which the open stirrups were closed. The precise position of starter bars for columns was given by rigid steel lacing bonds and geodesic checking.

The built-in formwork of the reinforced concrete girder lattice was performed by cleaned slot guide-beams.

Concreting was performed in a single stage without a working joint, in layers according to the "fresh on fresh" principle, with low setting heat cement.

Post treatment consisted of water flooding.

- *The middle part of the structure is a spatial reinforced concrete frame connected to the foundation.* This is located between the site level and +23.00 m level with its two upper levels closed by 80 cm thick reinforced concrete plates of at the +18.00 m level and of 175 cm thick plates at the +23.00 m level. There are two openings of Ø2.1 m on the mentioned plate at +18.00 m level and two openings of Ø6.1 m on the plate at +23.00 m level.
- *The third part of the structure is a steel structure* situated between +23.00 m and +88.11 m levels.

Up to the +48.00 m level it coincides with the plan view dimensions of the reinforced concrete frame, while the upper section follows a narrowing shape.

In the following we provide information with regard to the special reinforced concrete frame structure forming the middle part.

2. THE LOADS AND EFFECTS

The values of loads and effects on structures are determined by the Hungarian standard MSZ 15021/1.

In addition to the usual wind load and temperature effect, loads originating from the process and dynamic effects caused by the operation of the equipment influence the structure comprising the coking plant.

A considerable part of Hungarian territory does not lie above potential earthquake fields and thus generally the maximal load originating from the wind load comprises sufficient reserve, even for the case of earthquakes of the 4-5 MKS intensity.

In the case of this particular structure, taking in account the very high value of the equipment, it was expedient to consider earthquakes of 7 MKS intensity. This fact considerably affected the choice of dimensions and reinforcement system of the structure.

3. THE ANALYSIS OF THE REINFORCED CONCRETE STAND STRUCTURE

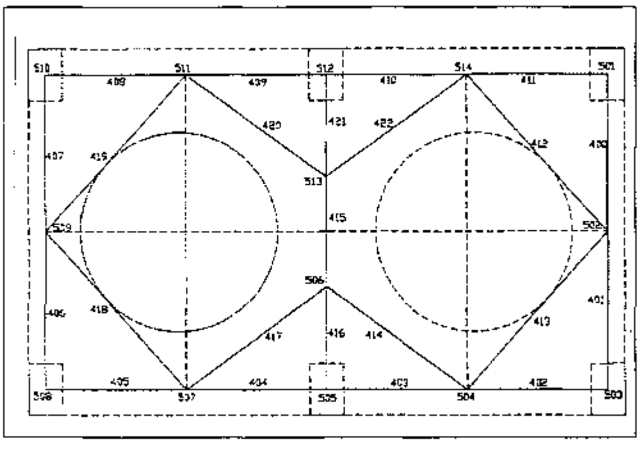
The main elements of the stand leaning on the diaphragm wall system and receiving the loads of the steel structure supporting the equipment are: the frame structure consisting of vertical and horizontal bars and the plates of high thickness situated on the upper two levels.

On these levels the horizontal beams are omitted. Rigid connections of vertical columns' corners and the frame effect are achieved by means of the mentioned 80 cm and respectively 175 cm thick plates.

For the "global" analysis model of the structure in question the substitution with beams is natural. Because of the large openings in the floor plates, it is more useful to substitute "bars" placed in the centres of mass of the remaining "plate bands". *Fig. 2* shows the example of a model used for one of the plate fields.

It is worth mentioning that because of local effects in the area of corner and rend columns, e.g. torsion caused by eccentric connections of beam axes, the problem of introducing reaction forces of the columns into the slab (piercing) required special examination. These models examined the actual design of the structural elements and their compatibility with the armature arrangement.

Fig. 2 Plate model at +23.00 m level



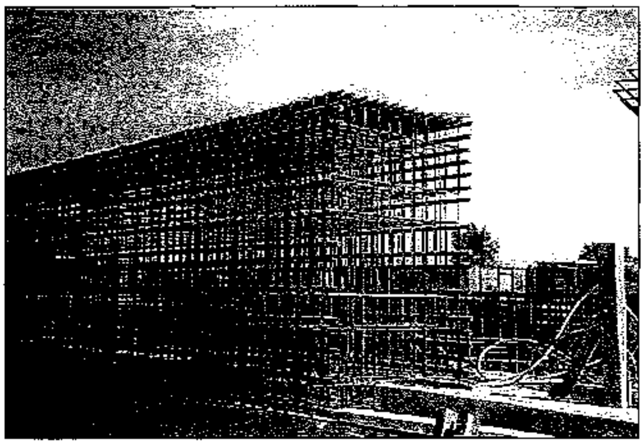


Fig. 3 Reinforcement at the columns

4. METHOD OF CONSTRUCTION

Because of the exceptional large loads and large cross-section dimensions, it became evident that only the in-situ construction method would be cost-effective to meet the structural requirements.

The placing large amounts of reinforcement corresponding to the loads in the beam cross-sections and co-ordinating the concreting units represented a special task (*Fig. 3*).

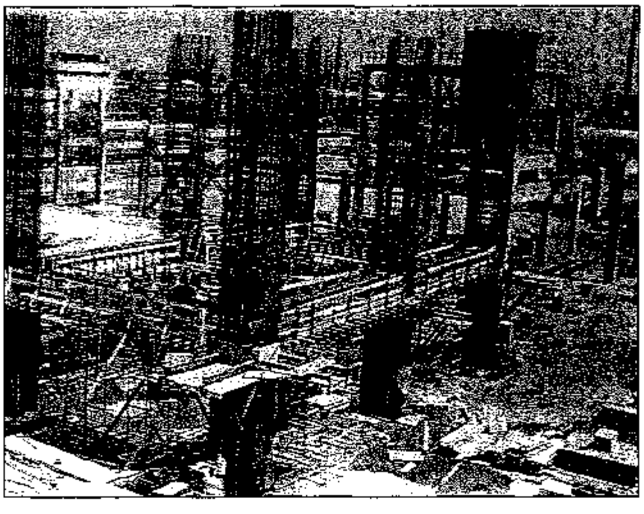
Furthermore, accurate assembly of the armature at the connecting corners and crossings was required.

Accurate forming of the supports and formwork sufficiently rigid to withstand construction together with the selection of the correct camber of the floor formwork was also a distinct task (*Fig. 4*).

The concreting of a thick floor slab with plastic fibre-reinforced concrete according to a specific technology is also noteworthy. Additionally, the precision positioning of fittings in accordance with the plan was difficult task also. E.g. in the 1.75 m thick top slab (+23.00), fittings had to be positioned within ±3 mm of plan view and vertically that required special fixation systems from the building contractor.

It is also remarkable that the 1.75 m thick plate at 23.00 m was performed in a single step of layered concreting. For the

Fig. 4 State during construction



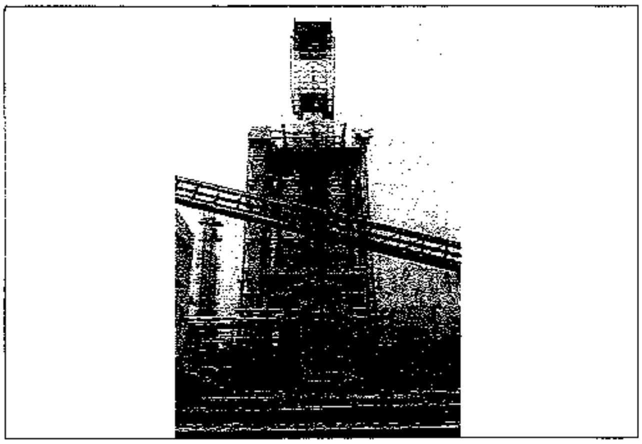


Fig. 5 The completed structures

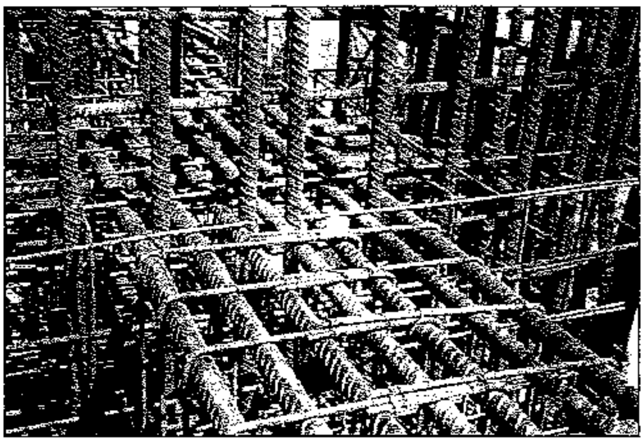


Fig. 6 Connection of the column and the beam

cost-effective construction of the stands required for supporting this large mass, the reinforced concrete frame structure already built was also used for carrying vertical forces *(Fig. 5)*.

5. STRUCTURAL DETAILS

Some structural details of the reinforced concrete stand and some of the solutions are also noteworthy:

- The prefabricated reinforcement of the reinforced concrete columns had to be manufactured on special production benches with steel structure accuracy. This reinforcement also had to meet the requirements of transportation and lifting.
- The lengthwise bars of high columns could not be spliced because of geometric reasons, thus steel bars of exceptional length were ordered, which in turn required special vehicles for their transportation.
- The lifting and fixing of the ready-made column reinforcement required special design considerations in order to avoid deformation. The lifting and positioning was performed under instrumental control.
- Because of the dense reinforcement, the necessary and sufficient concrete coverage required special attention.
- In the given corrosive medium, concrete coverage short of the designed value could not be permitted. At the same time, thicker concrete cover of the reinforcement could lead to cracks and "musseling"-off. Because of this reason, formwork of exceptional accuracy and rigid support were required. In the case of freshly concreted columns tension effects caused by wind and movements had to be restricted.
- Introduction and processing the concrete in high, ready-made column reinforcement without segregation required concrete mixtures with chemical additives. Also the operation of high frequency vibrators in a curtain-like manner were performed for the first time here.
- For protection against thermal damage because of unusual concrete dimensions, low setting heat cement was used to reduce the heat losses of surfaces at night and multi-layer blankets (geotextile, foil) were used.
- The order of assembly of dense columns in the nodes of reinforced concrete pillars, beams and plates was determined in a "sequence instruction" that greatly facilitated methodical material handling and assembly*(Fig. 6)*.

Dr. József Almási (1940) graduated the Civil Engineering Faculty, Technical University of Budapest in 1964, he started his professional activity earlier at Láng Machine Factory, then as an engineer at Mélyépítő Co (1964-66),1967-95 had been teaching concrete structures at the Technical University of Budapest as senior Assist. Professor meanwhile he carried out various design, expert and scientific work. Since 1995 he has been manager of Cronauer-Almási Engineering Consulting (CAEC) Ltd. Member of Hungarian *fib* Group. Palotás Award holder (2002).

János Nagy (1938) graduated the Civil Engineering Faculty, Technical University of Budapest in 1964, in 1992 had a post-graduate education in management (OMEGAGLEN). Honorary Associate Professor at the Technical University of Budapest, from 1964 to 68 design engineer at the Surveying and Geotechnical Engineering Bureau (FTI), since 1968 has been working at Hydraulic Construction Co., presently as general manager of the VÍZÉP Engineering Construction Ltd. Major construction works: Danube port at Baja, Tisza port at Szeged, Port and riverside retaining wall at Óbuda, Tisza Hydraulic Plant Kisköre, Danube Hydraulic Plant Dunakiliti. Member of Hungarian Group of ISSMFE and that of the Hungarian Chamber of Engineers.

Csaba Bancsik (1944) finished his studies as hydraulic engineer at the Baja College of TUB in 1974, has been working mainly as site engineer, major construction works: Sió-canal mouth plant, dwelling estate of Paks nuclear plant, several 3000 cu. m. water towers, Hydraulic plant Dunakiliti, Danube ports at Nagymaros, Gönyű etc. Presently he is active as technical manager of VÍZÉP Engineering Construction Ltd.