



VÁCLAV VIMMR

## 1. INTRODUCTION

The structures of pipe racks (Fig. 1) supporting elevated pipelines were mostly based on steel frame structures or cast in situ concrete frames. When pipe racks are erected in seismic regions, the possibilities of applying precast concrete structures seem to be even fewer. It should be noted that an important lesson was learnt from the recent (6<sup>th</sup> April 2009) severe earthquake in the L'Aquila

region. To the surprise of many people, prefabricated frame structures survived very well. Generally, the main problems of prefabricated structures were the failures of joints between external wall panels and internal load bearing structures.

The advantages of precast concrete structures are very well known. These are, for example, the speed of construction, a reduced number of workers at building sites, lower dependence on weather

conditions, and the possibility of dismantling structures under certain circumstances.

The most important issue of precast concrete structures is the solution of joints. This applies to the precast concrete structures of pipe racks as well. Peikko products yet again played an important role in contributing to the effective jointing of precast concrete elements. This project once again demonstrated that the popular Peikko product called the



Figure 1. Overall view of the construction site



Figure 3. Pipe rack structure under construction



column shoe, originally developed for the connections of columns, [1] can be successfully employed for beam connection as well (see [2])

## 2. PIPE RACK FRAME STRUCTURES

### 2.1 General

In particular, the projects for the Spanish company REPSOL have pipe rack frames that consist of bulky multi-storey columns and composite beams.

(Fig. 2 and Fig. 3) For the design and production of columns and beams, European standard [3] applies.

### 2.1 Columns

Columns of cross-section 600 by 600 mm are provided by concrete corbels that in some cases project in all four directions, but usually on different height levels. The extension of corbels is 350 mm and the minimum height is 450 mm. The main function of corbels

is to support beams and transfer the load from beams to columns. Typical columns are shown in Fig. 4.

### 2.2 Beams

Beams are designed as composite concrete structures. The overall height of a composite beam is 800 mm. The bottom part is produced as a precast element with protruding shear reinforcement to create a composite action with the cast in situ upper layer. The upper edges of beams are equipped with a shell lining to avoid the need for formwork when casting the upper part of a beam. In the bottom part of beams, a couple of Peikko column shoes are installed. Usually, four rather large fastening plates are provided on both sides of the beams. Beams are illustrated in Fig. 5.

### 2.3 Frames

The structural concept of frames is based on the full fixing of columns to the foundation and the fully rigid joints between beams and columns. Frame joints are designed in such a way that they can carry both negative and positive bending moments. Thus frames can take transversal and longitudinal forces (e.g. wind, earthquake) without additional stiffening.

Figure 2. View of a precast concrete pipe rack structure





### 3. JOINTS

#### 3.1 Joints of columns to foundation

Columns are fixed to the foundation by means of anchor bolts and special steel foundation plates. The weight of such a foundation plate can be between 660–830 kg. The foundation plates in Fig. 6 were produced by Deltabeam Slovakia.

The designer's argument for such foundation plates is the possibility of easy demounting. However, it is most probable that ordinary column shoes could satisfy all requirements but at a much lower cost.

#### 3.2 Joints of beams to columns

Rigid joints of beams to columns are illustrated in Fig. 7. Beams are placed on column corbels over neoprene bearing pads (see Fig. 8). The detail of a Peikko column shoe functioning as a reinforcement connector is shown in Fig. 9. Peikko column shoes are capable of carrying compression or tension as well. However, column shoes can function in tension only if nuts and washers are used from the external side of columns. Such an arrangement can be seen in Fig. 7. Negative beam reinforcement is placed in the cast in situ layer of composite beams and can be connected to the column

reinforcement by means of threaded sockets (for instance Peikko MODIX) that are located in yellow spots in Fig. 8. Vertical joints between columns and beams are grouted. In addition, the region of the column shoe must be grouted to protect the steel against corrosion.

Figure 6. Special steel foundation plate produced by Deltabeam Slovakia



Figure 4. A multi-storey column equipped with a special steel foundation plate



Figure 5. Typical beams equipped with column shoes



### 4. CONCLUSIONS

It shows It is obvious that precast concrete structures can be competitive and successfully used in projects such as pipe racks (Fig. 1), in which steel structures and cast in situ concrete structures dominated in the past.

It is important to find suitable products for joint solutions. Peikko offers a wide range of products that enables the promoting of precast concrete structures to new fields of application.

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