Bulletin of the *Transilvania* University of Braşov • Vol. 5 (54) - 2012
Series 1: Special Issue No. 1

STUDY ON DURABILITY OF RESISTANCE HALL STRUCTURE CET GOVORA

O. DEACONU[1]

Abstract: *The object of this study is the durability behavior of a r.c. structure in CET Govora. Investigation was made on: foundations, columns, beam and slabs component of turbo-unit servicing TA 4 between levels - 0.04 m and -3.50 m and axes 18 ... 23.*

Key words: *durability of the r.c. structures, inspection, diagnosis, rehabilitation.*

1. Introduction

C.E.T. Govora hale has started to build in 1967, so it is 45 years old. Large volume of work required a gradual progress of the construction.

C.E.T. Govora hale has dimensions of 39.00 x 132.00 m in plans. In length the hall was separated by three expansion joints and to ends is also provided with joints on the neighbouring halls.

For the turbine unit support, professional designer has adopted 16 similar foundations that had a proper operational behaviour.

Resistance structure is monolithic and is composed of a general maintenance service floor, at the rate - 0.04 m, consists of reinforced concrete slabs and beams that download on concrete pylons.

The foundations for currents columns were made of concrete blocks with geometric dimensions: 125x135 cm and 145 x 145 cm, with one or two steps and reinforced concrete shells with geometrical dimensions of 55 x 65 cm.

The foundation of turbo unit TA 4 has an isolation against horizontal vibration.

Columns are arranged in a grid of 3.00 x 3.00 m, with some local variations on both directions due to location of specific equipment or disposition of goals of crossing.

Sections columns are:

- 40 x 40 cm (45 x 45 cm) with longitudinal reinforcement 4 ϕ 20 OB38 (4 ϕ 20 OB38 + 4 ϕ 16 OB38) and transverse reinforcement ϕ 6/25 in the field and ϕ 6/15 OB38 at the base;
- 30 x 35 cm, 35 x 35 cm, 30 x 40 cm longitudinal reinforcement 4 ϕ 16 OB38 and transverse reinforcement ϕ 6/25 in the field and ϕ 6/15 OB38 at the base;

The beams were sections: 25 x 40 cm and 40 x 65 cm, with percentages of reinforcement in the tense zone between 0.26% and 1.75%.

Slabs have a thickness of 12 cm and was made generally reinforcing steel bar PC52, resulting in the following combinations of reinforcement for field and support areas: $6\phi10/6\phi10$; $6\phi10/(3\phi8+6\phi10)$; $6\phi10/9\phi10$; $6\phi12/(6\phi12+6\phi8)$; $(3\phi10+3\phi8)/6\phi10$; $(3\phi10+3\phi12)/(3\phi10+3\phi12)$.

[1] Department of Civil Engineering, Faculty of Constructions, University *Transilvania* of Braşov.

Foundation soil is composed of sandy gravel and clay generally wet stuff with a thickness of 10 to 20 m.

The stiffness of columns and beams are relatively close in value. There are very few exceptions. Dimensions of the concrete sections of the beams complies the basic requirements for dimensioning (h / L> 1/12 and h / b <3) specified in NP 007-97: Code for design of reinforced concrete frame structures [5] and Eurocode 2: Design of concrete structures [6].

Also, the main provisions relating to geometric dimensioning sections and reinforcement elements are met.

The slab has a thickness of 12 cm and it was designed as a rigid diaphragm providing a uniform movement for the vertical structural elements.

On the slab occur concentrated known loads. The main loads considered are: evaporator 4 x 140 ft, high pressure preheaters 3 x 32 ft, 7 ft evaporator cooler, high pressure pipelines, water supply etc.

2. Assessment and diagnosis

Specific technological equipment for '60s and '70s, were damaged in their operation. Thus, it is worth mentioning: on extended portions of the hall, especially in the evaporators area, there is a very high humidity accompanied by significant temperature. The causes are primarily related to massive emissions only in part controlled by the hot steam of pipelines and facilities in operation (fig. 1).

The local damage in various stages of the thermal agent pipeline resulted in massive and uncontrolled leakage of hot water (fig. 2, 3, 8). Over time, this led to significant infiltration of hot water in various areas, and to maintain structural elements completely wet. [4]

Fig. 1. *Damaged floor due to the presence of water vapour*

Fig. 2. *Persistence of humidity*

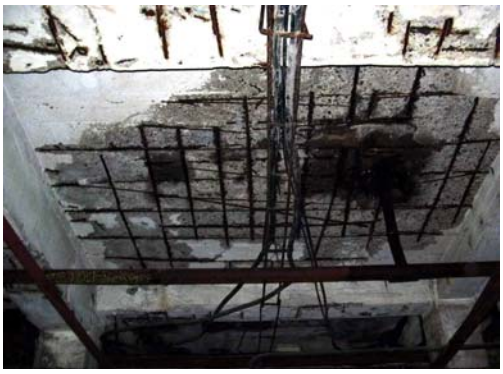

Fig. 3. *Heavily corroded plate*

Fig. 4. *Water pooling in the basement*

Fig. 5. *The column base strongly corroded due to permanent water from the basement*

Fig. 6. *Extremely damaged plate*

near an empty

Maintaining the microclimate poorly, presented above, was favoured by the inadequacy and inefficiency of the current system of natural and artificial ventilation.

Under these conditions, the reinforced concrete structural elements obviously investigated shown the advanced damage and deterioration in terms of durability. Damages are illustrated by the attached photos (fig. 4, 5).

They are affected both the strength of concrete and reinforcement in varying degrees, in many cases reaching up to complete destruction elements (fig.1, 6, 7).

Fig. 7. *Floor with corroded reinforcement*

It is noted the following main types of deteriorations and damages:

a. intense corrosion in various stages of development of resistance reinforcements, up to increasing the volume of armatures by corrosion products, disintegration and breaking the resistant reinforcements;

b. cracks of the concrete cover at the soffit of elements due to the onset and spread of expansive corrosion of metal;

c. expulsion and dislocation in large areas of concrete layer covering the soffit of structural elements;

Some structural deficiencies were found in structural elements due to execution technologies.

At columns were found: local segregation of concrete from casting, discontinuities on the column height result like the appearance of small cavities in concrete, but reduced as size.

At the beams were found: irregular distances between longitudinal resistance reinforcement (to close or too distanced), uneven distances between transverse reinforcements, incorrect position of transverse armature, the damage due to interventions on structural elements.

Water samples taken directly from pipes or floor surface established that the aggression mainly at metals and leaching from concrete (fig. 8, 9).

Fig. 8. *Damaged pipe*

After analysing the geometric dimensions of the foundation and the upper layers of the subsoil was found that the concrete condition is good.

A calculation was performed to assess the efforts in structural elements (columns, beams) for two representative frames in terms of load scenarios.

Fig. 9. *Damaged pipes*

Both transverse frames, given the initial dimensioning and load frame elements considered, their capacity is adequate.

The main reason to advanced damage found is the corrosion armature and partly concrete, in high humidity and aggressive water, present in pipes.

Damage to structural elements is in an advanced stage of development, maintenance involves adding armature bearing capacity, continuity and cooperation with these armature, restoring deteriorated concrete and sufficient coverage high adhesion.

The most damaged elements are those near by the evaporator and preheater, especially columns, to which is necessary to increase the resilience against the initial project. This area presents a danger even for a limited period in terms of resilience, structural integrity and stability falling within the risk classes I and requiring immediate intervention.

3. Intervention solutions

Intervention solutions for plates, beams and columns mainly concern on the one side to restore fully or partially damaged reinforcement and on the other hand adding concrete section to ensure an embedding and the reinforcements cooperation.

It is recommended that the areas where damage is extensive intervention measures to be applied along the entire item.

Before installing the additional reinforcement will be clean the damaged concrete to healthy concrete.

Bottom reinforcement beams will be increased, with the bottom half of the reinforcement as beam field project and will raise support and shall be anchor over the support and will work with these armature as a beam drift switch.

The reinforcement of the bottom plate will be increased with 5 ... 7 Φ / m on the centre of the plate, in each direction, with the equivalent section of the lower half of the reinforcement provided by the project for the area field and anchoring beyond support. Before applying shotcret the visible reinforcement will be protect with an adhesive.

At the bottom of the plate and concrete beams shall apply dry-process shotcrete, after applying a primer layer with an adhesive.

Local repairs, mainly at the edges of columns and beams with cover plates shall be made of diameter equal to the diameter affected reinforcement and the application of concrete repair materials with epoxy grout or mortar with adhesive. [2]

Near by the evaporators zone, is necessary to supplement the resilience of columns and beams. Given the limited space for building, capacity to resist is supplemented by up to 40% with a profiled steel structure [3].

To remove aggressive water leakage is necessary to replace or repair installations that lose water and eliminate the existing puddles on the floor.

The main cause of damage was and continues to reinforcement corrosion in high humidity in the environment and aggressive water action, including significant temperatures, sometimes very high. [1]

4. Conclusions

Was remarked, in a negative sense, inefficient natural and artificial ventilation system, which over time could not prevent the formation and maintenance of microclimate remembered.

Appreciated that plate and beam elements that lower reinforcement is reduced by 50%, presents a real danger even for a limited period in terms of resistance and stability, falling within risk classes I and requiring immediate intervention.

For the current case of damage, the solution of intervention is to restore the integral destroyed or partially armature by adding concrete with the use of modern materials must be ensured cooperation between the reinforcements old and new. [7]

As an additional intervention it is recommended eliminate or to reduce the emission of liquid and steam in the space of basement.

References

1. Deaconu O. "*Study concerning the behaviour to durability of the structures from reinforced concrete subdued of natural conditions of exploitation*", PhD thesis, University of Transilvania Brasov, Romania, 2009.
2. ACI Committee 314 *Guide for evaluation of concrete structures prior to rehabilitation*. ACI-Materials Journal, nr. 5, 1993;
3. CEB Bulletin No. 243 – *Strategies for Testing and Assessment of Concrete Structures* – Popăescu A. (co-author) Lausanne, 1998;
4. CEB Bulletin Nr. 183 – *Durable Concrete Structures. Design Guide*, 1989;
5. Eurocode 2: *Design of concrete structures*;
6. NP 007-97: *Code for design of reinforced concrete frame structures*;
7. Prof. Dr. Ing. Augustin Popaescu, Ing. George Croitoru – *Technical Expertise: Concrete slab and beams (share -0.04 m and + 8.00 m) for TA4 turbine hall of the turbo-aggregate axis 18-23, C.E.T. GOVORA*, ROMTAM Construct SRL, 2004.