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# CONSIDERATION ON THE CORRECT EXECUTION OF THE CONCRETE RESERVOIRES

BY

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**Abstract.** In this paper are presented principles and correct execution methods, the elements used for preparing of the execution before and during the concrete's treatment after casting process. The technical solutions are related mainly to the using way of the constituent materials and the reinforcing, frame work, casting, insulation pre and post casting methods and special treatment methods for engineering buildings, such as reservoirs. Also some risk evaluations elements are underlined regarding the conditions imposed by the beneficiary for design and execution stages.

**Keywords:** reservoirs; execution; concrete treatment; technical solution; vibration.

## 1. Introduction

The present paper aims to underline the principles and the correct execution methods of the reinforced and precast concrete reservoirs, the importance of the human factor during the preparing time of the execution, of

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the execution process and concrete's treatment after casting. By this issue the authors wish to identify the elements used for reservoirs realization which are influencing the final performance of the concrete reservoirs, the existing execution errors and their influence in the final quality of the studied objective (in our case the concrete reservoir). The technical solutions are related to the using way of the constituent materials and methods of reinforcing, frame work, casting, insulation pre and post casting, special treatment methods in the case of engineering buildings of reservoirs type, their requirement becoming being in recent times higher, especially for water storage.

## 2. Execution Methods and Materials

To determine a correct technical solution with the lower financial effort the realizing solutions of the concrete reservoirs have to be optimized relating the technical criterions to the cost criterions, following that the financial investment that is required to satisfy the technical criterions to be as low.

However, from practice, optimal models cannot be obtained due to the restrictions imposed by their construction, technological conditions of realization, operation, exploitation, post-use, etc., thus the solving the problems by referring to the knowledge and the correctness the studied execution technologies of special engineering buildings, in the present case of reinforced concrete reservoirs. The prevision from the design stage of the working technologies, the time graph and the allocated resources for execution, materials providers (especially strictly specialized such as additives, ad mixtures, supplies, protection materials for frame work tyrants, pellicles for humidity protection of the concrete, special concretes, materials for treatments of the casting gaps, repairing materials providers etc.) frame work provider even the specialized execution team, leads to highly avoiding of the quality final product's problems, the most times surpassing the influence of the other theoretical factors, such as strength design with all its details, the design of the concrete receipt in the laboratory, the technological design of the frame work with the corresponding casting gaps, computing and directing of the concrete's shrinkage etc.

Nowadays the concrete represents the most appropriate construction material for the underground reservoirs, being predominant in the building where is used, especially for water supply networks, the reinforced concrete utilized for underground water reservoirs have the advantage to present lower shrinkage stresses in comparison with the shrinkage stresses of the other types of buildings. These stresses are half deceasing, even a third when the concrete is maintained in wet state.

One of the first use of the reinforced concrete was for the realization of different types of reservoirs. Now, the reinforced concrete has a widely utilization in this field. The reinforced concrete are used for water supply networks having tens of thousands cubic meters, sewerage works, swimming pools, plants for different technical aims etc. they are used nor only for water storage but for other liquids such as alcohol, wine, oil products diluted acids etc. for the liquids that are presenting aggressive action on the concrete, the reinforced concrete reservoirs are protected. In the last years the reinforced concrete reservoirs with prestressed reinforcement were utilized even for combustible lightweight products as gas, protected with special insulation systems at the interior surfaces. In comparison with the metallic, concrete or masonry reservoirs, the reinforced concrete reservoirs present essential advantages regarding the easy execution and the cost. For reservoirs execution, an important issue represents the necessary impermeable insurance. The most appropriate way to achieve this result is the using of a compact concrete and applying on it of a cement mortar in layers or of a special composition cement plastering and painting of the concrete's surface with different waterproofing solutions. The main conditions to obtain a durable water impermeability of the reservoirs are: the correct execution and an enough stable foundation terrain.

In the case of underground reservoirs, the walls and the floors have to be insulated from the earth filling with asphalt, ruberoid or tarr cartoon; if the groundwater's level is high, a very well realized insulation of the bottom and walls is required. Generally, the reservoirs must be placed in such a manner that the highest level of the groundwater level to be lower than the bottom's base. In all the cases the surface waters evacuation is necessary.

For protection of the reservoirs which are covered with earth against temperature variations, the earth layer has to present an at least 0.7 m width. For exterior reservoirs free dilatation, they must be provided, function of the necessities with dilatation gaps or mobile supports.

The aim is to obtain quality reservoirs, using the appropriate materials, easy to apply technologies, by – where is the case – using of corresponding additives, of the correct realized insulations for the sensible zones, to realize correct engineering works, respecting the deadlines and according to the prize.

### 2.1. Concrete

The concrete, from durability point of view, correct designed for reservoirs (the slab foundation being a massive element) properly placed and maintained, by its specific physical, chemical and mechanical characteristics that is responding to the aggressive agents at is subjected during its exploitation life, represents the most favourable technico – economical solution for many applications from the construction field, especially engineering.

There are a series of particularities of design and execution of massive concrete works, very special works when the environment temperature is high. For a cement with great initial strength “R” for a 300 and 600 $Kg/m^3$ dosage for each 100 $Kg/m^3$ hydrated cement the temperature is increasing with 12°C, where is added the initial temperature (at delivery) of the concrete. So, for a +20°C delivery temperature, a concrete composition having a 350 $Kg/m^3$ cement dosage will lead in the interior of the massive element to a temperature of about +62°C.

So, the choosing of a cement type having a normal hardening speed and a reduced hydration heat (N+LH) is recommended and not of o great initial strength (R) for massive concrete elements.

According to NE 012/1:2007 the massive concrete elements are considered the elements having the width greater than 80 cm using a fix cement dosage of 300 $Kg/m^3$.

This fix dosage is according to SR EN 206-1:2002, where it cannot intervene in the National Annex (SR 13510:2006) in NE 012/1:2007 and in CP 012/1:2007. From practically aspect of the concrete compositions design, the required fix cement dosage is not possible to be respected for all the exposure classes “X” and all the concrete classes.

NE 012/2:2010 provides that the massive elements have the lowest dimension greater than 1,50 m. for them are required some particular requirements from technological point of view (at casting) and to establish the concrete’s composition, such as the exclusive use of a cement having a reduced hydration heat (LH). A series of technological details are established as well for the elements/structures having the width of 0.80,…,1.50 m if their volume doesn’t exceed 100 $m^3$.

Unfortunately, exists a small number of (new) foundation and structures which their general condition is practically precarious just before realization and for which the respecting of the life duration of minim 100 years can be a performance. On these structures can intervene with different maintenance works, but their periodicity and the cumulated costs can become so great, so a RK decision can be taken earlier than 100 years, only from structural insurance point of view.

### 2.2. Frame Works

The use of the metallic or TEGO type frame works can influence the aspect of the concrete after demoulding. An example of demoulded wall from a reservoir realized in Codlea shows (Fig. 1) that in the zone with metallic frame works the imperfections of the cast surface are presenting greater dimensions than in the joint zone, where TEGO type frame works were used.

Fig. 1 – ”PROTAN” - Codlea reservoir.

The TEGO plating is especially realized for frame works and have a great moulding demoulding strength, in standard using conditions. The product is made of poplar wood. The bond is based on phenolic resin with a good strength at humidity, cold or boiled water, heat or microorganisms. The sides are covered with phenolic film and the edges are dark coloured to ensure the protection. The amount of phenolic film is about 120 g/m$^2$. The construction of the plating (multi-layered) and the type of bond confers a good behaviour to exterior agents (humidity, heat, alkali agents) so, a greater durability. An attentive manipulation and the applying before each utilization of oils or other oil substances ensures the expand of the life span. The cleaning of the plates and preparation for the next use is done with a soft napkin soaked with oil or oil substances. The edges have to be protected, as well. Another advantage is that due to the smooth surfaces, these don’t need finishing. Some examples of demoulded concretes are presented in Figs. 2,...,4.

The metallic frame work systems are increasing the productivity of the constructers work and are considerable reducing the costs due to the modular integrated systems and the reduced number of joints. Are compatible with other systems and present a large, varied and complete range of accessories. As in any field, the problems of the correct utilization of the modern technology and the workers comprehension for the importance of producer's receipt utilization are encountered, to realize quality works. If the special PVC tubes doppers through the joints of the metallic frame work sides are passing, can lead to water leakages in these zones, as is shown in Fig. 5.

Fig. 2 – Demolded concrete of the reservoir wall – TEGO frame work – left; metallic frame work – wright.

Fig. 3 – Demolded concrete of the reservoir wall – zone of passing for joint elements.

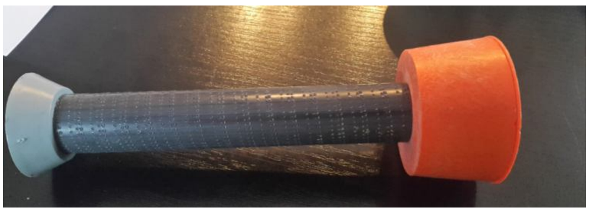

Fig. 4 – Special dopper tube for sealing in the joint zone of the frame work.

Fig. 5 – Incorrect use of the tubes doppers for sealing realization in the joint zones.

**2.3. Cracking Mechanism**

The repair works are becoming until without a clear comprehension of the cracks appearing mechanism. The massive reinforced concrete elements cracked almost instantly or after couple of hours after demoulding. (NE 012/2:2010, Part 2).

The Fig. 6 presents the specific cracking mode and propagation sequences for a plan concrete element having a hindered shrinkage at the base. The fist crack (crack 1) appears almost at the middle of the edge of the supported side and is propagating to the superior part. If $L/H > 2.0$ (where $L_0 = = L$) and the crack is extending at (0.20–0.30)H, the crack becomes instable and will propagate on the entire height of the element. Due to the new redistribution of the initial constraining stresses at the supported side, a new pair of cracks (crack 2) is appearing at the middle of the uncracked zones beginning from the base, adjacent to the first crack and is developing up in the same condition as the first crack if $L_1/H \geq 2.0$, where $L_1 = L_0/2$. The maxim opening for each crack is reached close to the superior part of the cracks that are initiated in the last step.

The constraining degree of the axial strain is defined as the ratio between the secondary stress resulted from the concrete's shrinkage and the stress resulted if the shrinkage is entirely hindered. Numerically, the tensile specific strain due to the constraining is equal with the product between the constraining degree from a section and the specific strain from the free shrinkage. (Ionescu & Ispas, 1997).

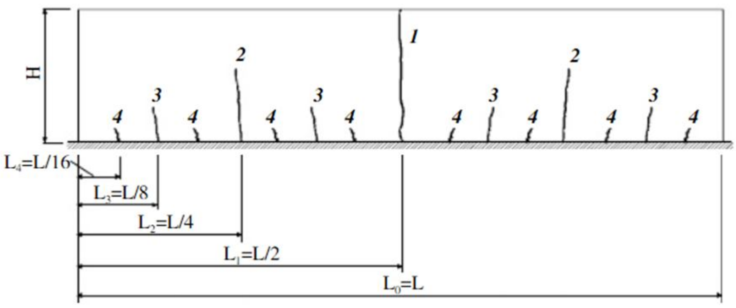


Fig. 6 – Specific shrinkage cracking mode for a concrete element fixed at the base (GP 115/2011).

The redistribution scheme of the base constraining degree is a pure shear mechanism see Fig. 7. The constraining degree is more reduced for each successive cracking sequence, as can be observed from Fig. 8.

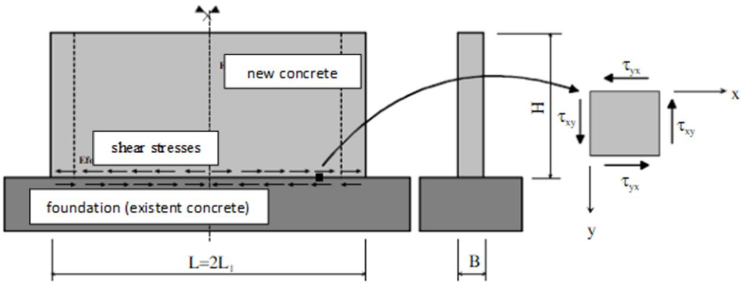


Fig. 7 – The constraining of the axial strain at the base of the structural wall by shear mechanism appeared at the base – element contact interface (GP 115/2011).

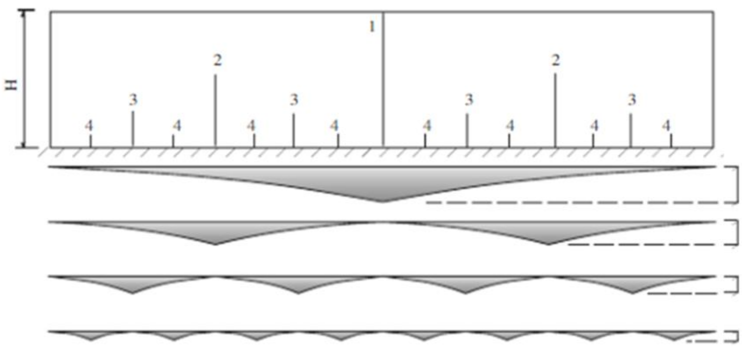


Fig. 8 – Distribution scheme of the constraining degree of the axial strain with the cracking sequence (GP 115/2011).

The concrete's shrinkage is producing a type of characteristic strain for this material. The phenomenon, known from the start of the studies and experimental research regarding the conte's behaviour still represents an issue with important influences in safety and durability of the reinforced concrete buildings.

If it is preserved in air (relative humidity of 100%) the concrete a volume decrease (shrinkage); in saturated state again, it suffers the opposite phenomenon – swelling. Because the concrete during hardening is losing a part of the water and shrinks, the interesting factor for practice it represents the shrinkage.

The drying shrinkage represents a long-lasting phenomenon, at the beginning more rapid and which progressively is attenuating in time. Neville tests (NEVILLE A.M.,1979) shows that at 28 days the shrinkage is almost 40% from the 20 years shrinkage, at 1-year age 80%. The main cause of shrinkage represents the loss of the water from pores having as consequence the reducing of the distances between the solid parts. The phenomenon is not reversible only partial reversible is due to the consolidation of the hydrated calcium silicate. (INFOTECHNIK, 5/2017).

## 3. Conclusions

The technical criterions represent all the conditions that have to take into account when a design – concepting – correct execution process is conducted in conditions of maxim security.

The exaggerated economical efficiency imposed by the beneficiaries, in the most of the cases is surpassed by a series of exigencies, such as: strength, stability, application, functionality etc. the necessity of obtaining of an economical solution with a lower cost, lower materials consume and a conformity degree specific of the actual Norms.

A good advice and a correct solution can bring money and time economy and in particular a quality warranty of the work. A real design in which all the input data are known, a correct execution unforced by the exaggerated economic conditions imposed by the beneficiary, the correct modern materials choosing for advanced technologies can lead to achieve performant, strength and stable buildings works.

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(Rezumat)

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