ASPECTS REGARDING THE CONSOLIDATION – INJECTION WORKS FOR THE OF MIHOIEŞTI DAM

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Abstract

The issues dealt with in this paper consists of the submission the optimal solutions for the consolidation of Mihoiesti dam, taking into account the problems that occurred during the exploitation of this objective, and site conditions. The accumulation Mihoiesti was to ensure, primarily, the water in the area of mines Apuseni Mountains - Rosia Poieni use fall created to produce electricity and other uses of the river basin Aries. Waiving further develop water requirements for the operation of copper Rosia Poieni, imposed, as in the current situation, accumulation conducted to act as temporary accumulation over a period of time greater, with some implications for the function. Currently, the dam does not meet the conditions of safety in operation, with large water waste-way undersized and there is still unfinished work. Dam with a mask made in an interim arrangement, with some areas infiltrations, and the extension version, constituting a threat to downstream areas. To resolve this problem, it is proposed to achieve the work for the operation of accumulation Mihoiesti as permanent accumulation. The use of the lake will flood wave attenuation, with important effects on the probability of occurrence greater than 2%, which states as specialists appear every 50 years. The coffer dam was executed in a first step to achieve an accumulation of a volume of 6.25 million m^3, of which 0.25 million m^3 volume warping. Sealing-consolidation works consist in the execution of the drilling injection to create a veil that extends seal on both slopes.

Keywords: accumulation, dam, injection-consolidation, security, stability.

1. Introduction

"*A dam is unsafe if it provides public goods and materials for a level of protection required for the surrender and dam meets current safety criteria used in engineering*". The basic principle used in safety assumes that all persons must be given the same level of protection against a potential hazard and level of preparation for emergency cases, regardless of size of dam or pond [2], [3], [4]. Big dams are an extremely important event for seismic risk assessment. On the one hand, the dams themselves have a high, having implications for the whole economy, through the production of electricity, water supply systems for irrigation and flood prevention, etc. On the other hand, structural damage of a dam can lead to major disasters, the population exposure to effects caused by sudden floods. The situation in Romania is such a kind that should be given to the future safety of existing dams. The first reason is that these dams were designed and constructed on the basis of technical standards which, in their great majority, are no longer in force, a second reason is the major climate changes in the last period, which led to the volume of water in increasingly large lakes in the accumulation of them. A third reason logically, is the length of existing dams. Accumulation Mihoiesti is located at the foot of Bihor Mountains, Mihoiesti in the village, Alba County, downstream from the confluence with Ariesu Mare river, approx. 4 km upstream of town Câmpeni. Dam has a height of 29 m and volume accumulation is 6.25 million m^3 of water. Planning goal is to adjust the flow of the river Aries throughout the year, so that the pumping station Gârda to achieve an approximately constant flow.

Dam was filling the ballast, sealed to upstream face of the mask with PVC foil of 0.4 mm and 0.5 mm, ballasted with reinforced concrete slabs on a total area of 11,000 hectares, figure 1. Seals in depth were achieved with a veil of injections performed on foot wall of embankment of sealing face dam. Canopy is accessible, being used as access road to the village Vidra, figure 1.

Fig. 1- *The dam and the pond Mihoieşti - overview*

For passage of flood waters, was executed a discharger to the right, a quick channel width of

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20m and a basin easement. On this overflow the past approx. 800 m³/s at high water which took place in spring 1989. Dam is equipped with two sockets: an outlet for emptying the fund, which directs the current flow and the transition to a downstream outlet energy flow, now traps water in the future and will feed a central hydroelectric [6], [7]. Empty bottom is provided with an overflow tower that supplements actually the weir box from the right bank. With the realization dam was built and stop treatment and distribution of drinking water for Câmpeni and Abrud with water intake, in energy gallery, which provided a decanter and a metal supply pipe diameter Ø = 600 mm.

2. The opportunity of the workings

Issues treated in this work consists in presenting the best solutions to strengthen the dam Mihoiesti, solutions proposed in the events that took place a few years ago the dam site area and actually led to imposition of work through which stabilize the dam. Environmental incident which took place at the dam Mihoiesti accumulation was a "necessary damage", because otherwise there would be no possibility of carrying out works in the investment in this important area. Then, due to the discharge of large amounts of water, was born a wave of mud that caused the asphyxia of the fish on an area of 25 km. The analyzing the situation at Mihoiesti it was found that the dam that provides water to downstream settlements is the most vulnerable target in the whole basin of Mures [2], [3], [6], [7].

In fact, the Mihoiesti, was not supposed to be an accumulation, because it was an investment in progress made by that time the proportion of 20 %, but reached a compromise to maintain water for 6 -- 8 million m^3 for drinking water downstream localities. And just this water dam kept under pressure. At the dam for temporary accumulation Mihoiesti, figure 2, the work of the targeted investment in dam safety, gave their important role for mitigation in the basin Aries the high water. Mihoiesti dam and provide water to the city and here Câmpeni a hydroelectric works.

To make the work proposed for a proper operation, it was necessary to clear water with a dam about 1 m. Note that, by decision of partial emptying of the water accumulated in the dam, have been trained and quantities of alluvial causing thus lowering the amount of oxygen in water and implicitly, mortality in fish downstream. In 20 years, has accumulated a layer of mud up to 2 m even at 4 m, so that any bleeding, mud is trained in the valley.

The role of existing temporary accumulation of defence against flooding, to mitigate its effect is only sensitive to current the high water, with reduced rates. The use of the pond will flood wave attenuation, with important effects on the probability of occurrence of more than 2 %, which, as mentioned above, occur once every 50 years, through the accumulation of the necessary work in accumulation transformation permanent.

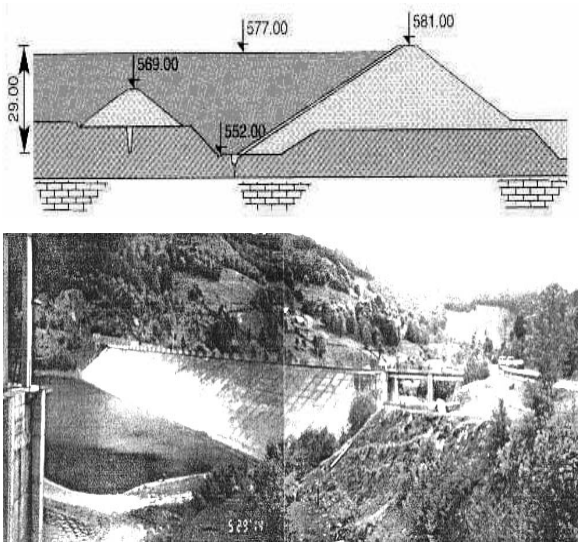


Fig. 2 *Cross section and upstream view of the Mihoieşti dam*

In the first stage of implementation, during 1980 - 1987 were carried out following works: emptying bottom; gallery energy; dam in coffer dam solution consisting essentially of a barrage of ballast, with minimum and sealing elements that made summary and temporary work, energy intake, and hydro mechanical equipment at the intakes of the two galleries and the waste-way for the large water. Designed as a first step as coffer dam in order to execute the final stage of planning, considered at that time to a total volume of 91.0 million m^3.

Dam was built with a mask in an interim arrangement, as there was a risk that by maintaining a permanent volume of water into the pond, be jeopardized stability dam. To solve the deficiencies noted the achievement of the proposed works for the safe operation of accumulation Mihoiesti as permanent accumulation. Gallery energy was performed in a central purpose of hydroelectric power, hydraulic energy required operation, and disposal of part of high water verification, in function of the return.

From geological point of view, most of the basin, and embankment, rock base is represented by different varieties quartz peaks sericitoase chlorites and gneiss feldspar. In the area of dam site in left

hill, in the bottom and the right to appear quartz peaks, chlorites sericitoase crossed by quartz veins and in the right gneiss feldspar. Area altering the basic rocks is an average thickness of 5.00 m on versions of approximately 6.00 m layer. Alluvia major riverbed of the average thickness of 4.00 - 5.00 m, but accidentally reach thicknesses of 8.00 m, are represented primarily by sands with stones and rocks, but sometimes appear discontinuous lenses of clayey sand or sandy clays both the bottom and at the top. Diluvium is composed of a clayey material - sand, with angular fragments of altered rock type such as peaks and gneiss; diluvium dimensions are variable, between 0.5 m - 5.00 m. The thickness diluvium on the left is between 0.50 m - 2.00 m, respectively, 3.00 m - 5.00 m on the right. On the right, there are three levels of terrace, with the average thickness of 2.00 m - 4.00 m. The basin character are virtually impermeable, the base rock consists in the most part, of crystalline peaks. In general, alluvia have characters similar to those of embankment. The peaks are mostly stable.

Groundwater alluvial deposits occur in the meadow, but also to the deposits on adobe peaks or cracks in the surface area, altered basic rocks. They present leaching out aggression against the concrete.

3. The proposed consolidation solution

In order to solve the problem of strengthening the dam Mihoiesti, given the problems that occurred during the operation of this objective, but the site is proposed variant which consists of:

- Sealing foundation by making injections of seals - and strengthen the foundation for creating a tissue seal. Injections of consolidation will be implemented in sheeting extrados galleries of G1 and G2;
- Mask from sealing geomembrane, including works by running a breaking wave parapet. Mihoiesti accumulation was placed in Class II of the importance which it corresponds to a debit account with the annual probability advance of 1 % and the verification flow of 0.1 %.

The importance of work safety on the accumulation Mihoiesti, according to GD no. 261/1994 and Law no. 10/1995 on quality construction, is B, meaning a category of importance, with an RB $0.5 \geq$ index of risk > 0.25.

4. The works of the foundation seal

Veil sealing dam's foundation is designed accordingly geological conditions of dam site, meaning taking into account that there are rocks encountered type of crystalline rocks, peaks and gneiss feldspar with a degree of alteration and breaking high on the left. Veil sealing will extend both versions, to eliminate the infiltrations that were observed. Geometrical characteristics for the two sides are: l_{margin} = 40 m left and right l_{margin} = 110 m. Veil sealing the foundation will run on concrete wash board perimeter. Reinforced concrete wash board - hearth upstream - is the liaison between the mask and veil sealing, figure 3. It runs from the existing pinch, a width:

- 3.50 m on the central area and the right P1 - P23 and a depth of 0.50 m;
- 5.50 m on the left area peak P24 - P27 and an average depth of about 0.70 m.

Fig. 3 - *View of the breast – achievement of the central wash board*

Between the existing cut-off and the wash board of 5.50 m, a length of approx. 2.00 m will run a simple seal concrete class C 8/10. The numbering of drilling String injection to seal the consolidation of foundation rocks is as follows:

- Downstream thread 1;
- Upstream thread 2;
- Intermediate thread No.3.

In the centre there veil seals made in the initial phase - the initial thread 1. Location of boreholes will be made on the strings, as follows:

- 2 strings of drillings injected in bed and on the right at 1.50 m distance between

strings. He will be in four stages. Depth of boreholes will be 10.00 m - 35.00 m 2 and the thread, for thread to 10.00 m 3;

- 3 strings of drillings on the left injected at 1.50 m distance between strings. The number of drillings will run in 4 stages, depth of boreholes is 10.00 m - 35.00 m for strings 1 and 2, respectively 10.00 m - 20.00 m 3 for the thread.

In the same series, the distance between the drillings in the end will be 1.00 m and the distance between the drillings on the stage will be:

- Stage I drilling located at 8.00 m;
- Stage II, between intercalary drilling drillings performed in stage I, to 4.00 m of drillings in stage I;
- Stage III, drilling drillings intercalary between the stage I and stage II, at 2.00 m distance between the drilling of stage I and one stage II;
- Stage IV, intercalary drilling atϖ 1.00 m distance.

For implementation injections seals - consolidation will take account of the manner of execution of injections seals - consolidation of rocks. Because betonies conditions and complex phenomenon of contraction of the concrete, to appear sheeting extrados spaces or open areas to be filled to achieve an intimate contact between concrete and rock. Finding deficiencies shall be highlighted by clashes with a shield or hammer and pickaxe, depending on the sound, can be qualitatively and quantitatively assess the magnitude of free surface lining. Addressing is done by injecting cement milk or chemical solution that will fill the blanks and will rebuild the connection between the concrete lining, that will make intramural injections, performed at a minimum of 30 days after the injections were performed by Fill the vault gallery, injections which in turn are made at 30 days from betonies lining [3], [4], [5].

Before the works themselves, will inventory all the holes in the armour and will be numbered. Generally, a hole should correspond to 3 – 4 m^2 armour and has a diameter of 50 mm. If the areas marked free space there is no holes in armour, then they will be visible materialized as planned placement of the holes shown in figure 4.

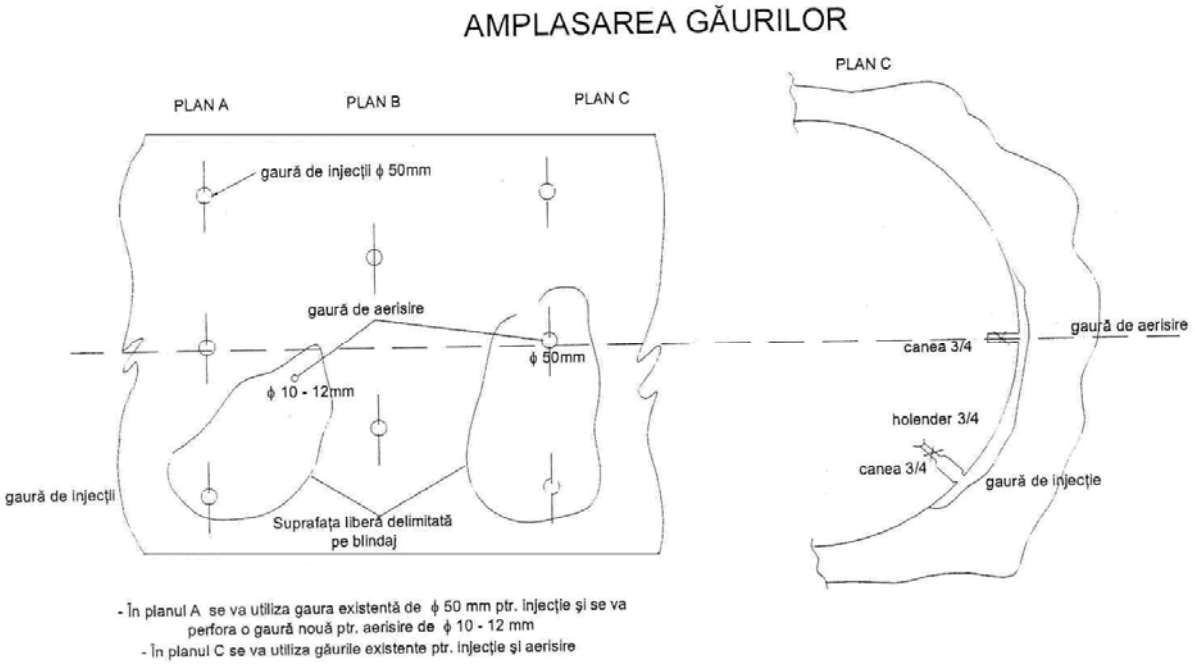


Fig. 4 - *Diagram to place the hole in armour*

The areas where have been identified the void will be marked with chalk on the armour. The free surfaces marked on the armour must be at least two holes, of which the lower hole for injection, hole top for ventilation. There can be injected a surface with a single hole injection, because the suspension would not penetrate into the free space and the water can not be evacuated it is considered that the extrados is a waterproof concrete. The ventilation holes will have maximum diameters of 10 mm to 12 mm and they would be welded spout 3/4 to tap. Link to tole hole is: by welding the pipe tap nozzles and 3/4 holender for connection to pressure hose. This is considered the safest and reliable method, with special mechanical packer adapted to consolidation – prestressing injection introduced into a hole drilled to a length of 15 cm to 20 cm in concrete.

The injection operation will be carried on planes, ordered in a direction (downstream to upstream and vice versa), always starting from the radier surfaces holes, and then going updome. The armour of the wells or pipelines forced will attack injection the lower planes, running an injection upward, plan after plan. If the free surface, respectively the void is greater than 1 m^2 and has an irregular shape, the injection need may arise through several successive holes. The injection itself, depending on the thickness of steel plate armour and its consolidation system, the maximum pressure of injection is 2 to 3 atm. Generally, the suspensions used for injection will consist of cement water mixtures, in proportions of 1:10 – 1:0.5. Usually, the report will use the cement water mixtures, like 1:3, 1:2 and 1:1. Additionally, bentonite is used by approximately 2 to 3 % by weight of cement, in order to provide the suspension stability.

Previously, bentonite will hydrate with water. After a period of 16 to 24 hours, will return to the area injected with a control injection, consisting of a dilute suspension in a water cement ratio 1:5 or 1:10, after another 3 days, would again control the tola by hammering, to check the effect of consolidation. Where the suspension doesn't enter properly because the free space was too narrow micron there is the possibility occurrence of low areas. If to a water sample of these areas, the loss is 1 to 5 l in 5 minutes and under a pressure of 2 - 3 atm, then we can run an additional injection with a mixture of concentrated sodium silicate and chloride calcium. This solution will be verified in the laboratory, in relation to time of freezing, to avoid damage to the mixer, pump and hose. Each hole injection, respectively free surface of the armour will have a diagram of absorption of injection. After the execution of the injections the contact leaf – concrete, if the consolidation injections or intramural injections were made already, will fill the holes punched by extrados armour and the armoured section will be taught to weld caps and anticorrosive protection.

5. Mask seals

To achieve the seal was proposed that the mask must be constructed of a material geocomposite, type geomembrane. The sealing dam Mihoiesti proposed to consist of a geomembrane liner of PVC, mechanically fixed to the body dam, with the main characteristic elasticity and high performing and drainage function. The purpose of the upstream seal is to provide an effective impermeability and long slabs and joints for the fence on this area, figures 5 and 6.

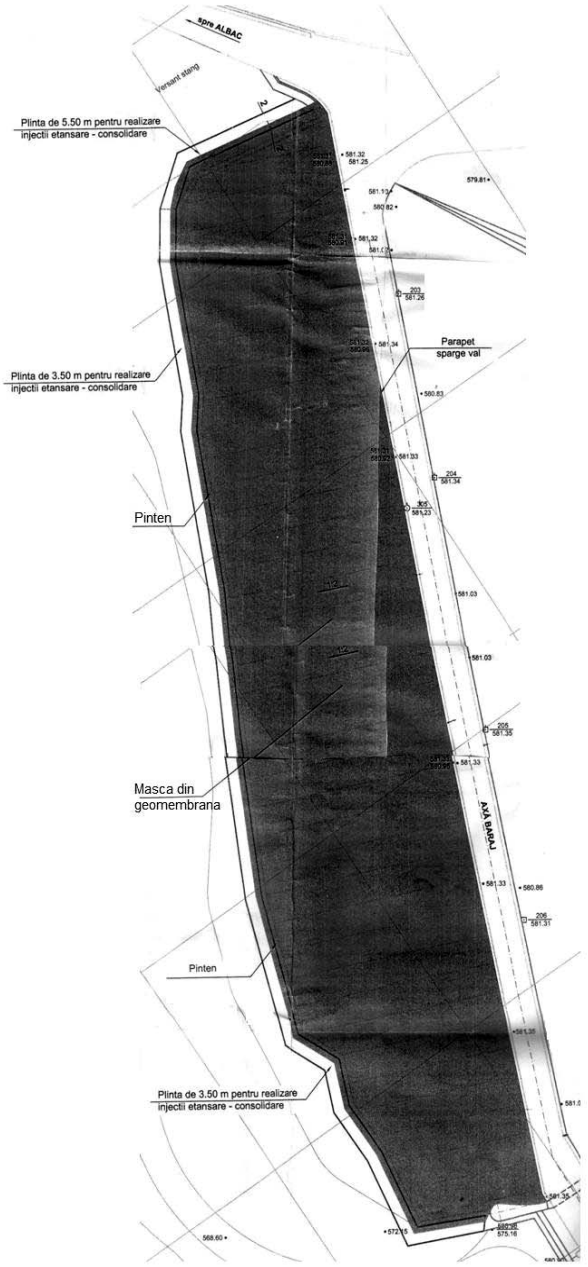
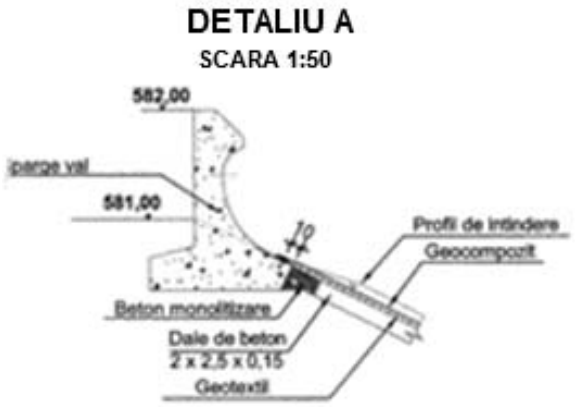


Fig. 5 *Mask seals of geomembrane – phase I + II*



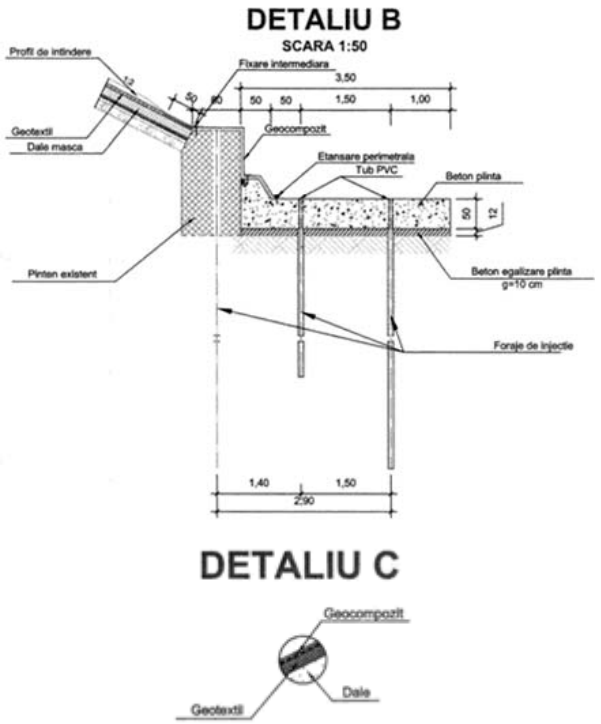


Fig. 6 *Details for the mask seals*

Surface covered with this material geocomposite is approximately 11,100 m^2. Lining used in the variant proposed, is a prefab made from a composite membrane - geocomposite - made from a waterproof PVC geomembrane of 2.5 mm and a lining of anti-perforation geotextil / drained, which has a mass of 500 g/m^2/suprafață. Geocomposite shows the flexibility to be welded and blended into the ground [1]. Geocomposite expressing strength to breakdown and breaks during handling and installation of. The geocomposite in the flexible sheet, width is 2.10m and length of each sheet will be equal to the height of the section where each sheet is positioned so that there will not be necessary overlaps and horizontal welding. Sheets can be prefabricated into large panels to reduce their installation. Proposed lining elastic properties that allow the use and positioning them in demanding, is difficult. This includes more specifically, a foundation with a rough surface, provided that stability is ensured, that the foundation is stable.

To regularize the surface here because deviations of vertical and horizontal joints between slabs, cavity, joints of parameter will be installed on all the upstream geotextile with a weight of 1000 g/m^2, the coating having the role of support or even anti-puncture layer. The geocomposite will be drainage to the bottom a drainage system, which will consist in: parament drainage layer, created by the gap between the geocomposite and the dam body and respectively by geotextiles – anti-breakdown geotextile and the geotextile which is a part of geocomposite; the vertical lines created by the system of extension of the geocomposite, drainage pipe longitudinal of collecting, created by a band of 50 cm height, with a diameter of 80 mm, which mainly will drain the dam body. A stainless steel drain plate, located outside of each pipe, the pipe will prevent the geocomposite to entry under the column water from drainage tiles, geotextile network will be doubled. Foils will be dropped from the canopy dam; adjacent sheets are joined vertically by hot welding. All welds exposed to water will be 100% checked and verified to meet the condition of impermeability to water. Before anchorage parament sheets or panels used will be provided against wind, with some bags of ballast, or by fitting them with a temporary profile to the fringes. Geocomposite sealing PVC should be kept taut and in close contact with stream dam to prevent the formation of which could prejudice the cute lining durability. To this end, geocomposite will be anchored by vertical parallel lines stretching systems. Space between these lines will be fixing the 5.75 cm.

The purpose consists of an internal profile U-shaped, anchored at stream dam and a profile in the outer, stretching and fixing of PVC geocomposite over profile. Assembly is sealed with a cover sheet of PVC with thickness of 2.5mm used for lining the main, but not geotextile waterproof and welded to geocomposite. The entire assembly is sealed with a table of PVC coating, welded to it to ensure there are no infiltrations of water to anchor bolts that rupture membranes.

The anchor is designed so as to maintain the lining in a stable upstream stream to be resistant to weight, wind, wave and ice action, namely lifting. The anchor is designed to stretch lining to prevent slow zones and cute and be able to maintain the lining of independent stream dam, enabling and facilitating the drainage water between dam and geocomposite by creating air spaces flexible between surface structure and lining of geocomposite. This space allows air drainage. Stretching profiles will be placed on the upstream tilted rather wash board. Given that there might exist places where the vertical wash boards is quite high, it is necessary the backing geomembrane. After sealing the lining was installed to avoid, if an exhauster that could unbalance the water pressure and that could break the composer, then it will ballast area wash boards Geocomposite seals will be anchored at the bottom of a sealing perimetral to avoid water infiltration under geocomposite. Perimeter sealing will be proof against water pressure. Geotextile extends horizontally from

wash board to make a perfect connection between the seals and seal upstream foundation. This sealing will be placed right at the edge of the sealing on the sides and the top prize. Under the contour sealing is done by the comprehension of the geocomposite, with plates of stainless steel plate, with 80 x 8 mm bolts and concrete anchors with chemicals will be placed at a distance of 0.15 m. compressible gaskets and jointing plates are used between geocomposite and flat plates, distribution effort. Resin mortar is placed next to the concrete wash boards, to equalize the roughness and to achieve a good seal. Perimetral sealing surface will be placed in the basis of dam at a quota of approximately 580.75m and will be insulated against rain and waves.

Sealing surface is made of thick, flat steel with section 50 x 3 mm, set in the concrete with anchors with a distance between 0.25 m. The sealing surface is covered by water once the 1000 years, when an undesired event can occur; its configuration allows it to with stand a limited water level, estimated for an event. To ensure the level of 0.1 %, and protection against the waves, was provided using prefabrication parapet wave breaks, the clear height of 1.00 m dimensions parapet breaks – wave, figure 7, are 1.21 x 3.70 m and height of 1.65 m being executed on the site and monolithic with the upper sealing mask. Utilization parapet breaks - wave runs monolith concrete of C18/22, 5 H II / AS 32.5 - T2 (L2) - P4 - G150. The length of a prefabricated item will be 3.70 m and weight of an element is 7.40 tons.

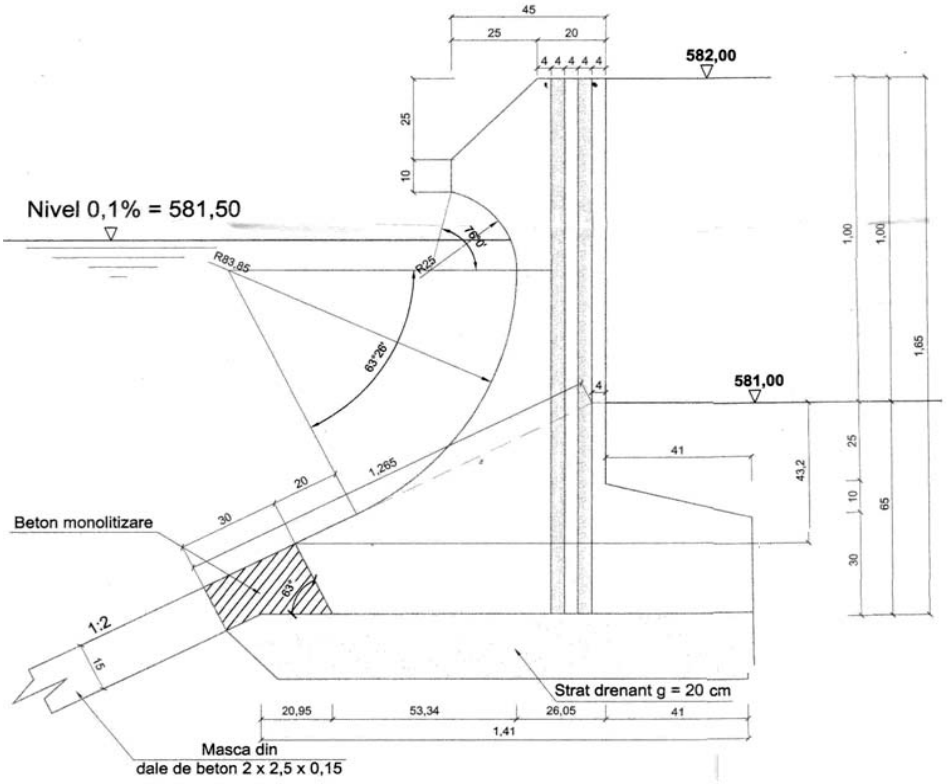


Fig. 7 *Parapet wave breaks*

For changes in slope – the bottom of parament upstream the bottom of the vertical side of the wash board – the waterproof geocomposite will be kept adherent to the foundation by the thickbands of stainless flat, flat with section of 50 x 3 mm, set in the concrete with the anchors placed at a distance of 0.25 m, using the methodology described in the sealing surface and a waterproof geomembranes band of PVC. Prefabricated elements are monolith between them and the mask seals on the upstream dam slope of 1:2, leaving the joints of dilatation of 20.00 m 20.00 m. assembly elements parapet breaks - wave is performed only by workers trained specifically for this operation. Assembly will begin after all the prefabricated elements were transported to the site for the work after their preliminary centering. Mounting is done with breakdown lorry 10 tonnes. After final centering elements prefabricated mounting casings and fittings on the premises monolith, will be checking and mounting works for hidden monolith.

6. Conclusions

To solve the problem of safety in the operation of the dam Mihoiesti to achieve the proposed work on the operation of accumulation Mihoiesti as permanent accumulation. The use of the lake will flood wave attenuation, with important effects on the probability of occurrence greater than 2 %, which states as specialists appear every 50 years.

In order to solve the problem of strengthening the dam Mihoiesti, and having regard to undesirable events that occurred during the operation of this objective, but the site was proposed works to strengthen the dam, consisting of: sealing the foundation, by injection seals - consolidation the sheeting extrados galleries G1 and G2 and a tissue sealing, sealing of the mask geomembrane, including works by running a breaking wave parapet.

For sealing works - not strengthening the dam is removed from agricultural production areas. Making this work does not endanger the environment and not harm the environment because the proposed work does not involve any kind of pollution, either air or water, whether surface or groundwater. Rather, through these works, a greening favourable for coastal towns and the lifting of the tourist area of interest by a sheen of water permanently.

References

1. **Manea, S., Găzdaru, A., Feodorov, V., Batali, L.** *Geosyntetics in constructions – Properties, utility, calculations*, Editura Academiei Române, Bucureşti, 1999, Vol. I
2. **Manea S.**, s.a. *Earth mechanics*. Editura Conspress Bucuresti, 2003.
3. **Stanciu A., Lungu I**. *Fundations*, Editura Tehnica Bucuresti, 2006.
4. **Toderaş M.** *Geotechnics and fundations*. Editura Universitas, 2005.
5. **Toderaş M.** *Geomechanics. Earth mechanics and fundations exercises.* Editura Universitas, 2005.
6. *Mihoieşti dam – protection against flood and other use*, 1990.
7. *Technical and geological documentation – Mihoieşti dam and pond,* 2002.

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