

## Watertightness in anti-flotation slabs. MIS-RJ Case

### *Estanqueidade de lajes de subpressão. Caso MIS-RJ*



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#### Abstract

It is common in coastal cities as Rio de Janeiro, that buildings located close to the shoreline have their basements below water table level. In most cases, the engineering solution for these buildings is to design a massive anti-flotation slab to satisfy, principally, the issues related to structural dimensioning and calculation hypothesis. On the other hand, the execution of this solution imply in significant construction problems related to reinforced concrete watertightness and durability. This paper presents a case study about challenges and solutions devised to execute an anti-flotation, 1m thick, 1200m<sup>3</sup> reinforced concrete slab for the new Museu de Imagem e Som (MIS) – Sound and Image Museum, located at 50m from the seashore, at Copacabana in Rio de Janeiro, RJ. The results show that concrete proportions, concreting plan and pouring method adopted were decisive in obtaining a watertight structure, avoiding thus the employment of traditional waterproofing alternatives.

**Keywords:** anti-flotation slab, watertight concrete, watertight concrete structures, concrete at seashore.

#### Resumo

Tem sido comum em cidades litorâneas, como a do Rio de Janeiro, observar a construção de subsolos em edificações localizadas nas proximidades de orlas marítimas. Na maioria dos casos, a solução de engenharia envolvida nesses projetos é o uso de lajes de subpressão com o objetivo de garantir, principalmente, os aspectos relacionados com o dimensionamento estrutural e hipóteses de cálculo. No entanto, há complexidades significativas quanto à execução desse tipo de solução, no que tange aos aspectos de estanqueidade e durabilidade do concreto armado. Este artigo apresenta um estudo de caso sobre os desafios e as engenhosidades envolvidas para concretagem da laje de subpressão em concreto armado da nova sede do Museu de Imagem e do Som (MIS), com 1m de espessura e volume de 1200m<sup>3</sup>, situada a 50m da orla marítima, na região de Copacabana, Rio de Janeiro, RJ. Os resultados demonstraram que a composição do concreto, o plano de concretagem e os procedimentos executivos empregados foram decisivos para promover uma estrutura íntegra e com propriedades estanques, dispensando, nesse caso, alternativas tradicionais e convencionais de impermeabilização.

**Palavras-chave:** laje de subpressão, concreto estanque, estanqueidade estruturas de concreto, concreto em orla marítima.

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## 1. Introduction

To make the new building for the Museu de Imagem e do Som (MIS) one more international architectural landmark for Rio de Janeiro city, known by the creativity of its artistic expressions and by the richness of its musical rhythms, the Secretaria de Estado e Cultura do Rio de Janeiro, together with Fundação Roberto Marinho (FRM), promoted recently an important international architectural contest, to choose a futurist design. The American architectural bureau Diller Scofidio + Renfro won the contest among other seven architectural bureaus selected for the final decision. The design was developed in Brazil by the renowned bureau Índio da Costa Arquitetura, Urbanismo, Design e Transporte (ICA).

Located at Atlântica avenue, at Copacabana, just at 50m from the beach, the new MIS headquarters will substitute the old museum premises. The MIS, opened in 1965, is installed simultaneously in two places, at Praça XV, located in downtown Rio, and at Lapa. The new building will also host the Carmen Miranda Museum, which is now located at Flamengo neighborhood (CORBIOLI, 2011)[1].

It should be noted that the American architects proposed a museum as a vertical boulevard, with seven stories, a continuous external promenade and a display of sequential ramps and floors. The building will have a total area of seven thousand square meters approximately, including foyers, box office, wardrobe, exposition rooms, auditorium, didactical activities room, shop, cafeteria, panoramic restaurant, bar, terrace, piano bar, belvedere, administration areas, storage spaces for collections, parking and load/unload facilities. The new MIS premises, shown in Figure 1, are being built by the construction company Rio Verde. Construction works are being managed by the company Engineering.

The building has 2 basement floors and a technical mezzanine also located below grade, besides the superior floors. As the building is being built very close to the sea shore (50m), very special procedures and engineering techniques were required to design a watertight anti-flotation slab, with considerable volume (1200m<sup>3</sup>) and thickness (1m).

Other problems are, besides ensuring technical parameters related

to watertightness and high concrete strength (characteristic compressive strength was specified at  $f_{ck}$  50MPa at 28 days), weather factors (hot weather, concreting commonly occur at temperatures about 35°C) and logistic (the concrete batch plant is approximately 30km afar from the working site, mixing trucks drive through a tourist route, with heavy traffic. At working days and hours, mixing trucks take at last 1 hour to transport the concrete).

The anti-flotation slab was executed during November 2012 and January 2013, at an elevation about 10m under sea level. Concrete mix proportions, as well as some execution details, mainly those related to watertightness will be described below. A substantial part of procedures employed is included in Brazilian current standards (ABNT NBR 6118:2007 [2]; ABNT NBR 12655:2006 [3]; ABNT NBR 14931:2004 [4]) and in international literature (KOSMATKA; WILSON, 2001 [5]; KENNEDY, 2005 [6]; LAMOND; PIELERT, 2006 [7]). However, most part of procedures was based on directives supported by the reference paper published by Helene, Terzian e Sardinha (1980) [8].

## 2. Watertightness concept

It is important to explain that concrete, as a material, is capable of promoting sufficient conditions for a very low permeability which means that it can be considered watertight. As it can promote an efficient barrier against water penetration, concrete is largely employed to build large reservoirs, pools, dams, water and effluent treatment plants, etc.

Nevertheless, most problems of employing this potentially “watertight” material, arose from the difficulty of obtaining the watertightness of structures, which depends not only on the material, but mainly on proceedings. Thus, besides a material of adequate quality, the procedures related to good engineering practices are needed to avoid honeycombs, defective compaction, unpredicted fissures, construction joints or defective joints through which water may percolate.

The watertightness of a concrete structure may be understood as the capacity of this structure to avoid percolation of liquids through

Figure 1 – Future MIS headquarters, Copacabana, Rio de Janeiro, RJ, Images by Diller Scofidio + Renfro for the international contest. (Courtesy of ICA)



walls, joints or slabs that contain those liquids. It mainly involves issues related to good construction practices and requiring special care during execution.

Thus, it can be understood that to build a successful, watertight anti-flotation slab, at least two aspects shall be carefully and deeply considered:

- The first one is related to the material (concrete) that shall be resistant, sound, of very low permeability and durable;
- The second one is related to special cares and procedures that constitute the set of good construction practices in order to get a final watertight structure.

However, experience has proven that bigger and most frequent failures in liquid retaining structures are related more to execution techniques and procedures (good construction practices) than to material quality.

### 3. Design data, materials and procedures adopted for MIS

#### 3.1 Historical and basic design data

Initially, the solution proposed by the structural design bureau, Escritório Técnico Julio Kassoy e Mario Franco Eng. Civis Ltda. (JKMF), for MIS foundation, consisted in diaphragm walls for lateral retention, cast-in-place piles with steel profiles and structure construction downwards from grade up to reach foundation level, when direct foundations, columns and a 30cm thick anti-flotation slab with tiebacks anchors into earth. Notwithstanding, it was verified that this procedure would be rather slow.

Then it was studied a second alternative, drilling provisional tiebacks anchored to the soil in three lateral faces of the site, where no buildings existed at neighbor land plots. In this way it would be possible to reach the foundation level and build the structure upwards at a much higher speed. Main columns would have direct foundations. This method was adopted and at one of the lateral sides of the plot (where neighbor buildings existed), provisional slabs were built working as horizontal beams, which would enable proceed with excavation as those slabs attained required design strength.

As the site is very close to the sea, and the foundation design was given a prize (Prêmio Milton Vargas 2012), during excavation procedures the well points for water table depressing had several clogging problems and also soil breakouts with the consequent flooding of the excavation. Under these conditions it became more and more unfeasible the execution of direct foundations, as the soil did not remain stable when excavated to execute the foundations. The designed method became a painful procedure.

It was then decided to study a radier type foundation, excavating the whole construction site to a single level, with a 1,0m thick slab that would work as a foundation slab for the columns as well as an anti-flotation slab. It was verified too that 1,0m thickness will be insufficient for all "embedded footings" inside this anti-flotation slab. Even with a concrete strength of 50MPa, stresses inside the slab would be too high for that thickness. To solve this problem, the inferior radier elevation was lowered and the columns with higher loads had their footing height increased up to 47cm. The cross section of some columns was also increased in order to reduce the slab punching shear stresses. As this was the adopted solution, the major challenge consisted in finding a proceeding that could assure concrete integrity, avoiding pathological manifesta-

tions that may jeopardize the stress distribution and the structural performance.

In short, the MIS anti-flotation slab was conceived as a trapeze in plan view, measuring approximately 51m long (parallel to Atlântica Avenue), with sides 25m and 20m, respectively. The four sides are embedded into diaphragm walls with variable thickness depending on direction, neighbor constructions and soil conditions. The characteristic design compressive concrete strength is  $f_{ck}$  50MPa, the slab volume is approximately 1200m<sup>3</sup> and the mean thickness is 1m. The slab was reinforced as a "cage" and at intermediate thirds in height (at 33cm each), a complementing reinforcing mesh was added, having 1  $\varnothing$  12,5mm each 30cm of spacing in both directions. The steel/concrete ratio of the anti-flotation slab excepting footing and complementary reinforcing is 72kg/m<sup>3</sup>. Considering footing and already mentioned complementing reinforcing, this ratio increases to 105kg/m<sup>3</sup>.

#### 3.2 Concrete mix and employed ingredients

The concrete mix for the anti-flotation slab was developed by PhD Engenharia (Concrete technology consultancy company for Fundação Roberto Marinho) from an extensive laboratory program, jointly with Votorantim Cimentos / Engemix S. A. (concrete supplier). Prototypes were tested at construction site in secondary structures, in order to verify fresh concrete conditions and hardened concrete strengths. The standard ABNT NBR 12655:2006 "Concreto de cimento Portland – preparo, controle e recebimento – Procedimento" prescriptions were followed, specially item 5.2.2.2 "Condições especiais de exposição", as well as minimal design specifications:

- $f_{ck} \geq 50\text{MPa}$  (at 28 days), as specified in concrete structural design;
- water/cement ratio  $\leq 0,4$  (linked to aggressiveness class);
- mortar ratio from 52 to 55% (related to pouring height and workability);
- slump from 16 to 25cm (fluid concrete: related to segregation and bleeding issues);
- silica fume addition (at least 5%) (high strength concrete and AAR prevention);
- waterproofing admixture, acting by integral crystallization, promoting self-healing of fissures (dosing ratio depending on concentration/supplier).

It should be observed that the waterproofing admixture, acting by integral crystallization that promotes self-healing of fissures was dosed per manufacturer's technical instructions, including the recommendation of obligatory visits of the their technical representative, who went several times to the concrete batch plant to verify procedures. In this case, it was employed 1,0% by cement weight of XYPEX NF 500 (concentrated), supplied by MC-Bauchemie Brasil. It is also important to stress that the chosen mix proportions were developed having in mind the ingredients that are available at Rio de Janeiro (which are not the most appropriate for a fluid, high strength concrete, with consequently high elasticity modulus, as per design specifications). The worst problem for the ingredients was the high fineness modulus of sands. Grain grade curves submitted by Engemix, normally employed at Caju batching plant, showed lack of fines in both sands (natural and artificial) which corresponds to higher fineness modulus (between 2,3 and 2,9 respectively).

The mix proportions as well as the suppliers of the ingredients for the anti-flotation slab concrete are described in Table 1. It can be observed that no water was employed, besides that existing in sands (to be subtracted from the whole amount of ice). All mixing water was replaced by ice cubes with initial specified temperature of -10°C (delivered by refrigerator trucks with a Thermo King type refrigeration unit). The technical specification to accept concrete at working site asked for a 20°C temperature. In reality, that temperature went up to 25°C in very hot days. As concreting batches had maximum volumes of about 150m<sup>3</sup> and the slab had a high reinforcement ratio with well distributed rebars through the 1m thickness, the temperature difference in hot days did not imply in fissures of thermal origin. The mean time of arrival, acceptance and discharge of mixing trucks was 12 minutes, which is rather quick. In order to not slowing down the concrete production before concreting events, based on a large data obtained from the concrete batch plant about sand humidity, it was admitted the weighted average of 5% as a constant for both sands (natural and artificial) and, consequently, the amount of ice was also constant for each mixing truck. This amount was calculated as 130kg per cubic meter, with the explicit exception written in the technical specification of a corrective procedure in case of rainy days or if very high humidity batches of sand were detected by the control technicians at the concrete mix plant.

### 3.3 Execution recommendations

The whole technical specification was elaborated based on reference paper “Considerações sobre estanqueidade de estruturas de concreto” published by Helene, Terzian and Sardinha (1980) [8]. Besides basic guidelines exposed in the paper about lean concrete/structural concrete interface treatment, assurance of rebar recover and placing, other procedures were essential to assure the watertightness of the structure, the main

one was related to concreting joints and the other with proceedings. Besides general recommendations, the Contractor Rio Verde team, which was responsible for project execution, was given specific technical guidelines about proceedings for anti-flotation slab by PhD consultants.

#### 3.3.1 Concreting joints

Principally, due to time limits for mixing trucks circulation at Copacabana coastal avenue, as well as existing legislation related to noise produced by construction sites, it was not possible to program slab concreting in a single, continuous event, what would be ideal (and feasible) by the use of special additives and procedures. Concreting, thus, was divided into 10 different phases (determined by the structural designer).

When casting a concrete watertight structure, construction joints or concreting joints are one of the most sensible points which ask for more attention. Execution shall be planned in a way to minimize nonconformities at these points.

At all concreting joints, it was recommended to use poultry wire mesh as an incorporated formwork, structured by the steel reinforcement existing at the joint, together with hydro swelling tapes. Reinforcement design included an “C” clamp shaped bar each 25cm, designed to work as a support to tie the mesh, all the way up every joint (at one of the sides). Thus, a vertical joint was obtained, allowing concrete to be duly vibrated through the whole slab and principally next to concreting joints, which are the most critical places. The typical detail of the poultry wire mesh used as an incorporated formwork and of the hydro swelling tape at the slab, can be seen in the perspective of Figure 2.

It should be noted that the ideal location for the hydro swelling tape should be as close to the wire mesh bottom as possible. However, when the reinforcement for the next concreting phase is already completed, this place is almost inaccessible. The tape was then placed at a higher region, approximately 30cm below the slab up-

**Table 1 – Concrete mix proportions for the anti-flotation slab by weight, dry materials for 1m<sup>3</sup> of concrete. Designed for a characteristic compressive strength  $f_{ck}$  of 50MPa at 28 days.**

Mix proportions	Designed for $f_{ck}=50\text{MPa}$
Cement per m <sup>3</sup> (CP III-40 RS – Votoran Moagem Santa Cruz)	448kg
Silica fume addition (Silmix)	30kg
Water/cement+additions (cementing materials) ratio	0,35
Water (from sand humidity only, mean value fixed at 5%) + ice	168kg
Medium sand, natural (Areal D. Lucia)	650kg
Artificial sand, crushed sand type II (A 21 Mineração)	73kg
Crushed stone 0 (A 21 Mineração)	162kg
Crushed stone 1 (A 21 Mineração)	921kg
Waterproofing admixture, acting by integral crystallization (XYPEX NF 500 concentrado, MC-Bauchemie)	4,5kg
Polyfunctional plasticizer admixture (MIRA RT 75, Grace)	4,0kg
Superplasticizer admixture (Tecflow 9040, Rheoset/Grace)	2,9kg
100% of ice replacing free mixing water (humid aggregates, sand humidity weighted average is 5%)	130kg (ice)

per face, as can be seen in Figure 2. The same procedure (tapes) was implemented at reinforcing slabs intersection with diaphragm walls. Figure 3 exemplifies actual situation at worksite before, during and after concreting a generic phase.

The hydro swelling tape was put in place only a few minutes before concreting the phase juxtaposed to the already concreted phase. As these phases were not concreted in sequence with previous phases, the time interval was at least 7 days. A wooden barrier was also placed at the bottom of the poultry wire mesh to prevent cement slurry leakage. Obviously, there was a normal controlled leakage of cement slurry through the wire mesh (a very small amount), because the employed concrete was of the fluid type, but nothing that could jeopardize the objective of having a rough surface with the incorporated wire mesh. The ideal condition for the next phase concreting would be a dry, saturated and quite rough surface. Thus, the joint vertical face was saturated before concreting the juxtaposed phase. As the hydro swelling tape has a controlled, slow initial action, there were no problems in this procedure that could damage the tape, which activates in contact with water.

At the concreting joint region an hexagonal galvanized mesh,  $\varnothing$  0,56mm,  $\frac{1}{2}$ " opening with three twists, poultry wire was utilized, supplied by Fábrica de Telas São Jorge. Two superimposed and dislocated meshes were employed at each joint in order to reduce the mesh opening. The utilized hydro expansive tape has more

flexibility to fit the concrete substrate contours and not needing a groove to be placed. It is of PENEBAR SW 55 type (controlled swelling water-stop) made by PENETRON Brasil, and installed as per manufacturer specifications. The supplier also supervised this procedure in loco, as the tape could not touch the rebars and its installation asked for a special care.

### 3.3.2 Concreting procedures

#### 3.3.2.1 CONCRETING PLAN

The anti-flotation slab concreting plan was in accordance with detailed design specification, which divided it in 10 different phases and with concreting joints layout as already indicated. Related to this, it can be observed that the designed layout, due to time-schedule reasons and reinforcement characteristics, did not obey the ideal shrinking joints procedure, in other words, all slabs vertical faces (corresponding to each phase) remain "free" to move and dilate, including in regions where slabs intersect with reinforcing walls built above diaphragm walls.

Thus, it was planned that no juxtaposed concreting phases were held together, which provided the maximum possible number of free slab sides. Besides this, it was recommended a minimal time interval of one week between juxtaposed concreting phases, which did not mean cast two phases simultaneously, if not

**Figure 2 – Typical detail at concreting joint region, showing the poultry wire mesh as an incorporated formwork and hydro swelling tape**

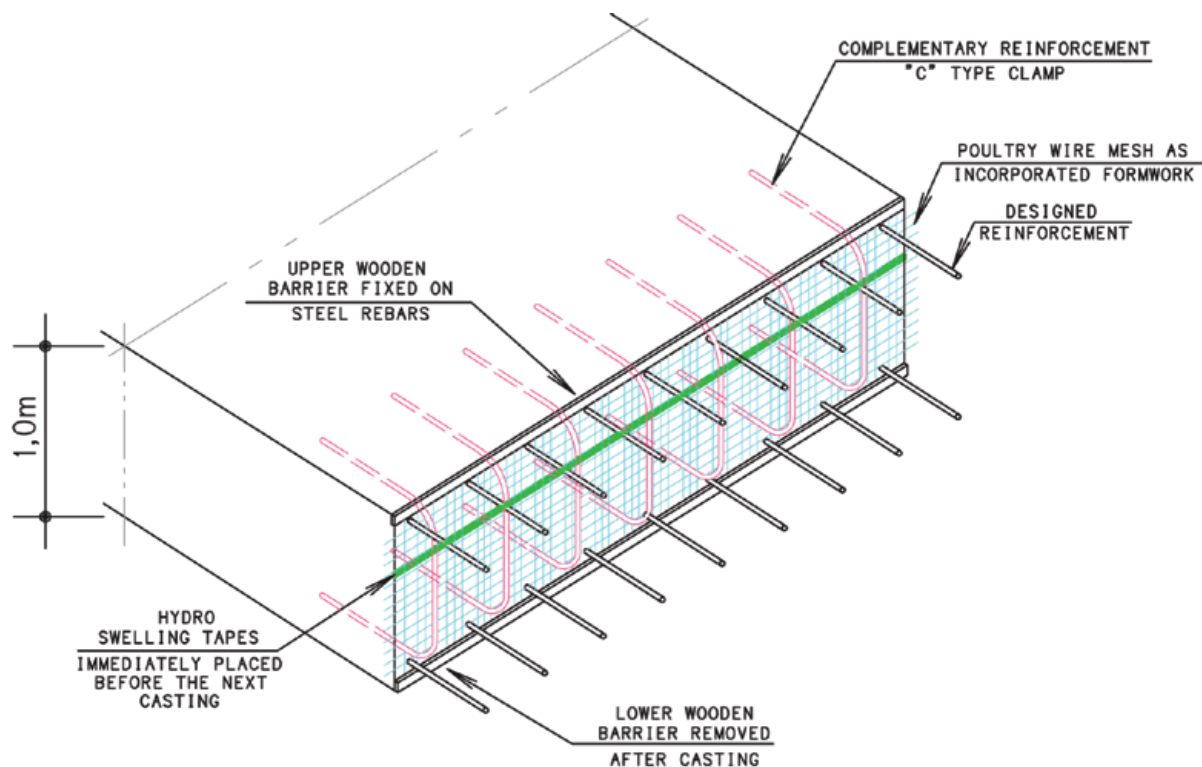
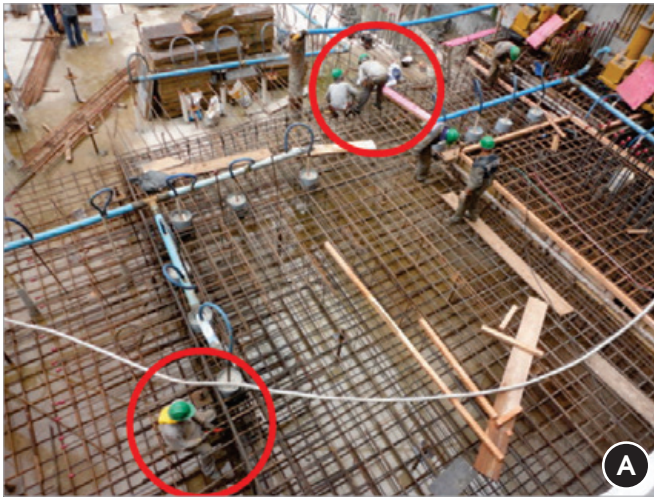


Figure 3 – Typical details of anti-flotation slab concreting joints along the 10 concrete placing phases



Detail of preplacement step: poultry wire mesh adjustment at designed joint



Detail of concreting joint with poultry wire mesh and external reinforcement support



Detail of poultry wire mesh performance during concrete placing: minimal cement slurry leakage



Detail of concreting joint before hydro swelling tape placing: vertical and rough surface, the next slab reinforcement not yet finished

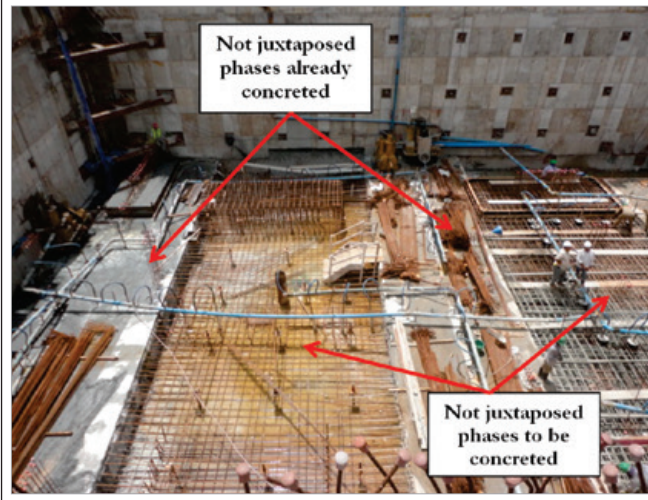


Detail of hydro swelling flexible tape already placed for next concreting procedure: reinforcement for next concreting phase is totally completed



Detail of finishing obtained by upper wooden support barrier, wire mesh just underneath, will yet be cut

**Figure 4 – Not juxtaposed (intercalated) concreting phases**



juxtaposed. In this way, the temperatures originated by cement hydration exothermal reactions should be decreasing and, consequently, deformations associated to this phenomenon will be minimized. These measures, notwithstanding, had no impact on project time-schedule, enabling an effective production of approximately 20m<sup>3</sup>/h, which means that 1200m<sup>3</sup> of concrete were placed in 60 hours divided into 10 different concreting events. This concreting plan, in not juxtaposed (intercalated) phases, can be observed in Figure 4.

#### 3.3.2.2 CONCRETING PROCEDURES AND TECHNOLOGICAL CONTROL

It was recommended that the first layer be carefully poured to ensure that concrete could pass through the inferior reinforcing mesh. For this case it was also recommended the consolidation by vibration with lesser diameter heads (2”), and instructions for special cares to be taken were given (for instance, not to lean the vibrator

head on rebars, specially at edges, where a higher concentration of reinforcing bars is found). Once poured the first layer, covering bottom rebars, subsequent layers were vibrated from sub-layer previously vibrated (this limitation was also defined by the vibrator head length).

Basically, concrete was placed in three horizontal sub-layers of approximately 0,33m (33cm) high all the way in each phase, without caring of construction joints, in order to get an uniform layer. Concrete was continually placed in a preferred direction from the poultry wire mesh to the opposite side, foreseeing that hardening would be quicker at mesh region, in order to avoid higher pressures at these more fragile points, and returning to the initial point (not yet concreted) to pour the next sub-layer, and so on. In exceptional cases of an accidental interruption due to mixing trucks flux or to intense traffic from batch plant to working site, it was recommended to re-consolidate (re-vibrate) the concrete before beginning new pouring, and that interruption could not be greater than 1h.

During all concreting phases, at least two vibrator operators for concreting events were predicted, with a minimum of three extra vibrators, as one of them could fail during operation, what could impair concrete quality. It was also recommended to employ vibrators with 2” and 3” diameter heads, the lesser diameter ones being the most appropriate to be used at regions where higher steel ratios were concentrated (bottom and edges).

All concrete batches were carefully consolidated and cured. Detailed consolidation procedures can be consulted in well-established literature (KOSMATKA; WILSON, 2001 [5]; KENNEDY, 2005 [6]; LAMOND; PIELERT, 2006 [7]) and also in the standard ABNT NBR 14931:2004 “Execução de Estruturas de Concreto. Procedimento” [4]. Some relevant points to be remarked, employed in concreting this MIS anti-flotation slab, were:

- Concrete was consolidated (vibrated) always vertically (never in tilted or horizontal directions);
- Concrete was consolidated (vibrated) at the most possible points of each slab in every concreting phase;
- Extra care was taken to avoid excess or lack of consolidation;
- Vibrator head was introduced quickly and drawn slowly (to avoid possible air packs);
- The head length was always greater than the thickness of the layer to be concreted;

**Figure 5 – Detail of concreted phase, joint to the reinforcing wall, with a curing mat over the surface and of curing procedure (mat being soaked)**



**Figure 6 – Anti-flotation slab already finished and beginning of formwork erection of 2nd basement columns (some of them already concreted)**



- Extra care was taken to avoid vibrating the rebars;
- A minimum distance, related to the depth penetrated by the vibrator head, was maintained to define the points to be consolidated (the depth penetrated by the head was the same as the distance for next point to be vibrated).

Regarding curing, it is possible to asset that this was one of the most important steps in concreting procedure. If curing would not be efficient and correct, it could make the concrete inadequate, even if all previous steps had been well executed. For the anti-flotation slab, a high pressure cleaner, the WAP type was utilized, with its nozzle regulated to obtain a water spray, as a nebulizer mist, in order to cover the already concreted part and also the phase being concreted. It shall be remarked that there is no problem in having this mist during concreting.

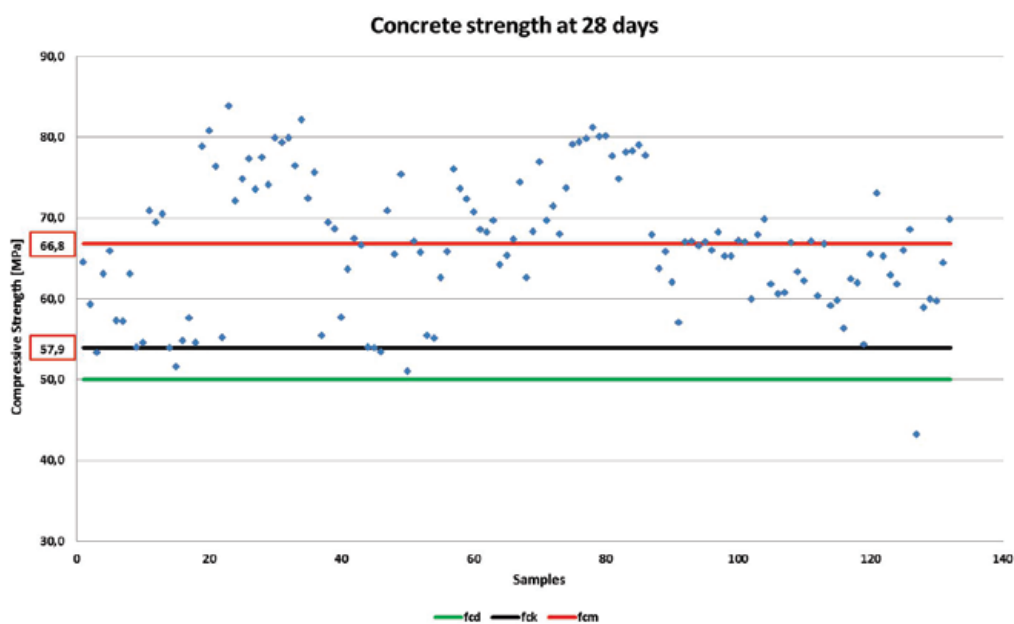
After some hardening of concrete (by touch), the whole surface was covered with a mat soaked with water, which was maintained pressed against the surface of the concreted phase, sprayed with drinking water each 2h at most. This mat was always saturated at the end of the working time to ensure that it would remain humid during night and again early in the following morning, at beginning of work. This careful curing procedure was maintained at least for 7 days (up to the probable next phase concreting date). The curing procedure (a mat being soaked) can be seen in Figure 5. The curing mat employed was 100% polyester with an adhered perforated polyethylene film, manufactured by BIDIM, line Bidim CC-10 type.

## 4. Results

### 4.1 Watertightness

With the recommendations met described in previous chapter, technicians from the Contractor (Rio Verde), Project management firm (Engineering Co.) and from Concrete consultant firm (PhD Engenharia) were responsible for visually verifying possible fissures originated by shrinking or by thermal stress in each concreted phase. In

**Figure 7 – Results of concrete compressive strength at 28 days**





this context, it shall be remarked that during and after finishing the ten phases, no fissures of any kind were detected through which water could percolate. The already finished anti-flotation slab can be seen in Figure 6, with formwork for 2nd basement columns already erected.

#### 4.2 Concrete technological control

An exhaustive concrete technological control was established for the slab –total sampling (100%) – as mentioned above. Of all mixing trucks, only one was identified as having compressive strength below design specification, with a value of 43,2MPa. This value was submitted to the structural engineer, who approved it, by new calculation, not being needed any additional structural reinforcement. Graph at Figure 7 presents the results of concrete compressive strength at 28 days old. It can be seen that there was an excessive dispersion, which probably was associated to errors when pouring cylinders or during compressive rupture test, in short, related to technological control procedures. Later on, by means of a more refined statistical analysis, the anomalous results were abandoned.

### 5. Final considerations

1. It can be considered that an adequate design, the study and development of an appropriated concrete mix, as well as rigorous procedures utilized for concreting the MIS anti-flotation slab described here, were determinant to obtain a watertight, seamless structural element in spite of adverse soil, weather and logistic conditions. It can also be understood that the propositions presented in this paper may be considered as a good alternative for similar cases, as a quicker and less costly option, which in specific cases, may replace the use of traditional waterproofing solutions;
2. It can be also considered that this paper enabled to stress the fact that the appropriate employment of simple and less costly procedures, described in Brazilian standards and in well-established literature, associated to good engineering and building practices, are favorable to get a final, satisfactory result. Many of the procedures described in this paper are in agreement with the prescriptions of our national standards.

### 6. Acknowledgements

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