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CONTROL FLOODING AT LOW AREAS OF MARGINAL EXPRESSWAY TIETÊ RIVER IN THE CITY OF SAO PAULO, BRAZIL

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ABSTRACT: The construction of marginal highway to the Tietê River in São Paulo between the Penha's dam and the Mobile Dam had interference from existing ones and that due to road template; the greide lane under the bridge was lowered. With the lowering these points emerged lows for the Tietê River would become sections restrictions. From the Drainage Master Plan of the Upper Tietê Basin, expanding the flow capacity the Tietê River through a work of enlargement and lowering of the background, identified the lows that caused restrictions even after the expansion work of the underground channel. In these places we adopted the system for protection Polder of the low area as well as in the Netherlands to adopt the same system of protection of their areas situated below sea. In 2010, after the completion of the capacity expansion the Tietê River, there was a flood of sites that did not have the protection system Polder. This study identified and performed the project for implementation of the protection program of the lowland areas of the marginal route the Tietê River in São Paulo, resulting in six protection areas.

Key Words: Control Flooding, Polder System, Tietê River, São Paulo.

1. INTRODUCTION

The basin of the Tietê River is a river of Paraná River unit. The Tietê River is divided into six sub-basins, Low Tietê, Tietê/Batalha, Tietê Jacaré, Medium Tietê/Sorocaba, Piracicaba and Alto Tietê, the latter where the Metropolitan Region of São Paulo is located.
In São Paulo, the river Tietê currently works underwent from rectification your gutter, which currently consists of a channel of the composite section. The main stretch is located between the Penha's and Moible Dam, with a length of 25 km.

Figure 1. Tietê River in São Paulo between Penha's Dam and Mobile's Dam.

The basin of the Alto Tietê in Mobile dam has a catchment area of 4,500 km ². The area has upstream reservoirs supply and level control structures that control the flows in the headwaters of the Alto Tietê basin.

The channel current Tietê, in this part, began to be formed with the execution of an expressway that runs along the river, being called Marginal Tietê. It is an important route of traffic, serving as access to Ayrton Sena, Fernão Dias, Presidente Dutra, Bandeirantes, Anhanguera and Castelo Branco roads, besides being the main access road to the Sao Paulo/Guarulhos International Airport.

Figure 2 - Tietê River before and after Channeling

The existing bridges in this part the Tietê River were a restriction on building the marginal route of the Tietê River, causing the track was downgraded to secure road template in the passage under bridges.
After years of intense urbanization and growth of the city of São Paulo, the flows of the Tietê River reached levels that caused huge damage to the metropolitan region of São Paulo. Thus, the Design of Enlargement and Lowering Channel Tietê River.
In this project, it was identified that the restrictions on time and flow rates were located principally in the vicinity of bridges. With the sites identified, the construction of the protection of these areas through a system of Polder, the Casa Verde Bridge, Bandeira Bridge and Anhanguera Highway Bridge were provided.
In 2010 there was the overflowing of the Tietê River trough in lower situation conditions of project, after studies found that levels considering the movable bottom (sedimentation) result in water levels above the project, but that would not cause overflowing, yet the impact of raising these levels resulted in drowning of the drainage areas adjacent galleries, the emerging need for construction of new polders in the critical regions of the Marginal Tietê river.

2. METHODS

The operation of the Polder is to protect the area adjacent to the river by means of a sealed wall, through direct drainage galleries runoff that exists in the protected area into a reservoir, this will have a defined volume pumping system.
The reservoir should have a pumping system to return this volume to the river, the discharge chamber of the reservoir is protected by a check valve which prevents water entry in the direction the river to the reservoir. The volume of the reservoir will be the difference between the total volume and total volume pumped disposed.
As previously mentioned, the following images show the flooding that occurred in 2010.

Figure 3 – Flooding 2010

Figure 4 – Flooding 2010

Figure 5 – Flooding 2010

Figure 6 – Flooding 2010

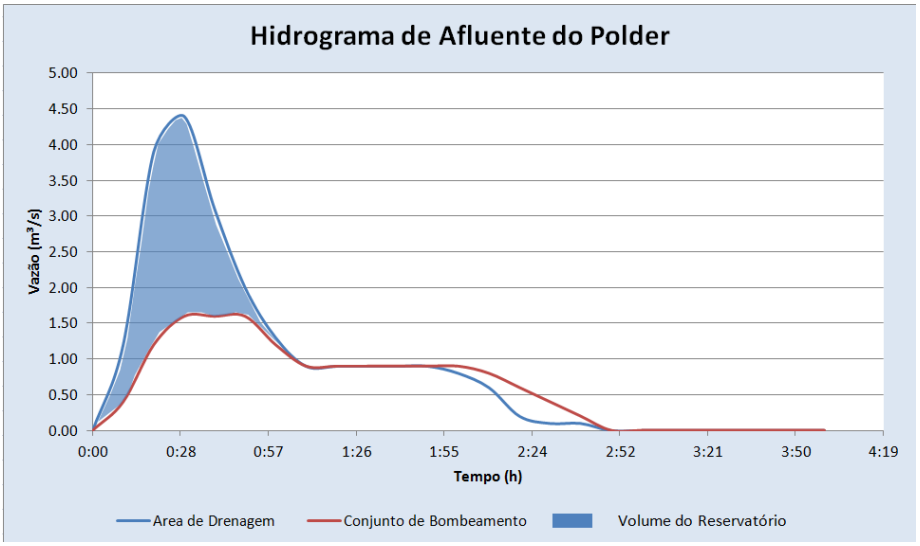
The type of adopted solution for the protection of these lower areas identified by the study, was the polder system, as existing and used worldwide to protect lower areas subject to frequent flooding.
For the design of polders was performed the following studies:

- ✓ Hydrodynamic study of the Tietê River in the passage in question to define the levels of water and subsequent crowning the crest of the levee protection.
- ✓ Hydrological study of the area contribution of the polder subbasin for design the new drainage system and sizing the reservoir.

For the calculations the following criteria were used:

- ✓ Risk of 1% to calculate the water depth of the Tietê river and getting flood map - rains of 24 hours duration and total precipitation of 150 mm;
- ✓ Free board of 0.50 meters in the share of crowning the wall dike;
- ✓ Risk of 4% for the design of new drainage galleries - rains of 2 hours duration and total precipitation of 85 mm;
- ✓ Reservoir volume with the difference the drained volume (depending on the drainage area) and the volume of the pumping system defined by a set of four motor pumps with a capacity of 1.60 m^3/s.

In the following, the hydrograph of the polder Bridge Vila Maria on the left bank as an example for the design of the reservoir.



Graph 1. - Hydrograph of the drainage area of the polder and flow of the pump set.

The hydrodynamic study of the Tietê river to the Return Period 100 years (1% risk) identified areas subject to flooding as the criteria adopted. The following images show the areas of flooding identified by this study.

LEGENDA DOS NÍVEIS D'ÁGUA NO RIO TIETÊ E NO CORREDOR DA VIA MARGINAL

Faixa	Profundidade (m)	Cor
1	0.00 a 0.25	
2	0.25 a 0.50	
3	0.50 a 1.00	
4	1.00 a 1.50	
5	1.50 a 2.00	
6	2.00 a 2.50	
7	acima de 2.50	

OBS.: LINHA D'ÁGUA PARA T.R. 100 ANOS

Figure 7 – Flooding Map study

Figure 8 – Flooding Map Study

Figure 9 – Flooding Map Study

In addition to the sizing calculations of the protection system by Polder, there was a need for research the register the underground networks that connect to the Tietê River that can be drowned with the rising water level in the river. These networks are disconnected from the river, the river no communication with the protected area.

When the level of the Tietê River rises, the flap valve does not allow the waters of the Tietê River enter the reservoir, from this moment, if the reservoir level raise, starts operating the pumping system.

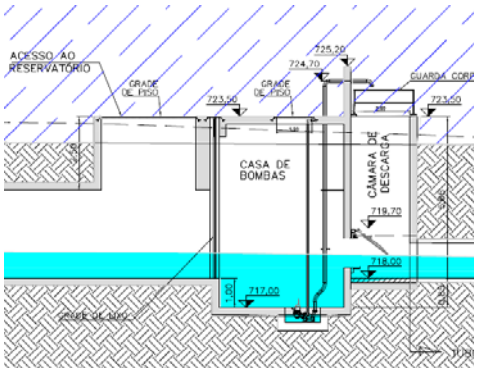


Figure 10 - protection system return water Tietê river

Figure 11 – output gallery

Reservoirs are designed to be landed, causing minimal impact, the following images illustrate the time of construction and after completion of the work.

Figure 12 - Construction of Reservoir

Figure 13 – Landed Reservoir

2.1 Results and Discussion

A program to protect lower areas of the marginal route of the Tietê River includes the execution of six (6) polders identified by hydraulic study of the Tietê River, and shall ensure that the design flow in these spaces without the occurrence of undesirable flooding, safely the wet periods when water levels are high on Tietê and detract maintenance services (dredging).
The definitions of site of the reservoir present difficulties because of the high number of interferences, such as:

- ✓ the reservoir Aricanduva bridge on your right bank had its irregular geometry due to the presence of large trees that could not be removed;
- ✓ the reservoir Aricanduva bridge on your left bank had to be positioned between two networks of gas supply and built under the street, which in turn, will have interference in traffic during their execution for later restoration of the street.
- ✓ the reservoir from Vila Guilherme bridge on its left bank, can be executed in an area that does a collection point for recyclable waste, this in turn was demolished to run the tank and will be reassembled on the reservoir after the construction.

Even with the high number of interference was possible to meet the need of design calculations for new storage volumes and surface drainage networks.

The following table shows the technical data for design calculations.

Local	Basin Area (m^2)	Volume of Reservoir (m^3)	Length the Wall Dique (m)	
			Downstream of the bridge	Upstream of the bridge
Limão Rigth Bank	146,000	1,550	93	117
Vila Guilherme Left Bank	180,000	3,260	67	355
Vila Maria Rigth Bank	30,000	2,187	60	120
Vila Maria Left Bank.	195,000	4,577	120	525
Aricanduva Rigth Bank	92,300	2,420	705	38
Aricanduva Left Bank	160,000	4,349	63	668

Table 1 – Technical data of polders designed

3. CONCLUSIONS

The protection system of low areas subject to flooding by implementing the Polder system is commonly used, especially in the Netherlands, which uses this system of protection for much of its territory which is situated below sea level.
For full utilization of the Polder design, the Tietê river should be in your situation flow return period of 100 years and a rain occurring simultaneously in the Polder sub-basin with a return period of 25 years, this scenario features a high degree of safety of the low area protected by Polder.The protection program by means of Polder system in Tietê river between the Móvel's Dam and the Penha's Dam will secure the traffic on this important highway and of fundamental importance for the circulation of commodities, travel, and other services in the Metropolitan Region of São Paulo.

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