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OPTIMIZATION OF CIVIL ENGINEERING PROJECTS FROM AN ENVIRONMENTAL POINT OF VIEW

Earth Science

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ABSTRACT

The realization of Civil Engineering projects are always generated impacts on the environment, either they are negatives or positives. The existing options regarding the design and projects allow, in most cases, to combine the construction with the environmental preservation. To illustrate that it is possible to optimize these projects, from an environmental point of view, the examples are given in this paper associated with construction materials, hydraulic developments, surface linear works, underground works, maritime works, bridges and viaducts and natural and excavation slopes.

KEYWORDS

Project optimization, Civil engineering projects, Environment

INTRODUCTION

All Civil Engineering works generate environmental impacts, some positive and some negative.

The Democratic Republic of Congo (DRC), in general, and Grand Katanga in particular, being in the process of development, is particularly concerned by this subject; given that for the economic and social development of the populations Civil Engineering works are really indispensable, in addition these works provide more significant conditions of economic production and social welfare in the most developed countries. In some cases, these works are exclusively aimed at protecting people and property from natural disasters and their impacts, as is the case of stabilization works on natural slopes, dams for flood control and for the retention of solid materials, with a view to protecting downstream areas, especially people and property. In other cases, in order to facilitate the communication and transportation of people and goods, we can cite structures such as roads, tunnels, bridges, viaducts, etc., as well as other structures that are used for the protection of the downstream areas, especially people and goods.

The media focus on the negative impacts of many of these books, setting aside the positive impacts, which in most cases have a much higher value. This importance, which is also nurtured by environmental organizations, conveys to all people the idea that designing and building civil engineering works is always harmful to the environment. However, without these works, it is not possible to create modern living conditions, whose goal is economic development, improved health conditions and communications.

Examples of such infrastructure include water supply dams, irrigation dams, clean and renewable hydroelectric power dams, recreational dams, roads, railways, tunnels, ports, airports, underground cavities, etc.

Given that the construction of these works always generates negative environmental impacts, as mentioned above, it is essential to seek solutions, in the planning and project phases, to reduce and compensate for them. We can thus affirm that well-conducted project studies have always tried to identify and minimize these negative impacts on the environment, while ensuring the technical and economic feasibility of the respective developments.

Nevertheless, it should be recognized that, in the past, in the presence of several technically possible alternatives. The most economical solutions have frequently been chosen, even taking into account that these solutions would have greater impacts on the environmental balance of the area of influence.

Consequently, the establishment of environmental legislation, associated with the elaboration and approval of civil engineering projects and the monitoring of their execution, has been a great step for the compatibility of these works and for the preservation of the environment.

The mining legislation in force in the DRC requires mining operators to produce a RAP (Environmental Mitigation and Rehabilitation Plan). The mining operator will only be able to obtain an operating permit once his RAP has been approved.

In other jurisdictions, legislation that has been published in Portugal requires that the Environmental Impact Assessment of a given development be completed at the same time as the Preliminary Project and that both studies include, where possible, the analysis of alternatives. Only after a favorable Environmental Impact Statement (EIS) has been issued can the project proceed.

In a good number of these developments, the role of Geology and Geotechnics is essential, mainly in the case of structures interacting with rock masses or soils, and also frequently with groundwater. This role is all the more important as the interventions and decisions of competent specialists have consequences in economic, social and environmental terms and in terms of the functionality of the developments.

OPTIMIZATION OF CIVIL ENGINEERING PROJECTS THAT MEET ENVIRONMENTAL REQUIREMENTS.

In this article, we have selected some themes and works; and this in order to show how it is possible to optimize civil engineering projects, while taking into account environmental problems and preserving the economic and social interests of the respective developments.

It should be noted that for most of the projects, the realizations later demonstrated how it is possible to make both sides of the problem compatible.

Here are the themes and works that we have selected :

- Building materials
- Hydraulic installations
- Linear structures (roadways, etc.)
- Underground structures (tunnels, cavities)
- Maritime works (embankments, ports, etc.)
- Bridges and viaducts
- Natural and excavation slopes

1. GEOLOGICAL BUILDING MATERIALS

The extraction of these materials is possible, as a general rule, only by cutting down earth or rock massifs (quarries). These processes cause environmental interference and very frequently require the redevelopment of areas degraded by these operations, after they have been completed.

The need to reduce, as much as possible, the cutting down of geological massifs to obtain construction materials has led, especially in the last two decades, to the development of research in different directions to replace the exploitation of geological materials with alternative materials from the recycling of other products, the use of quarry debris or geosynthetic materials, which is not yet the case in our country.

Other important aspects with consequences for the environment as well as for the economy of the works are also discussed. This is the case in particular of the problems related to the management of construction

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materials during the construction phase and the compensation of excavation volumes and backfill, thus avoiding, as far as possible, the creation of earth deposits, even on a temporary basis.

To support the theme of geological materials, used during the construction phase and the optimization of their use, we present some examples of dams, linear structures, bridges and maritime embankments in the following list :

- **Dams**
- In the operating area and in the reservoir area

- The Nurek zoned earth embankment dam in Tajikistan (304 m high) see figure 1

Figure 1: The Nurek Dam, located in Tajikistan in 304 m zoned earth fill, built between 1961 and 1980 (source Google Earth)

- The Chicoasén earth embankment dam located in the state of Chiapas, Mexico (261 m high).
- The Hassan I earth embankment dam in Morocco (145 m high)
- The embankment dam with rockfill cladding of Grand'Maison in France (140 m) see figure 2

Figure 2: Poclain at the Grand'Maison dam first part, 140 m high, 10 m wide at the crest but 520 m at the base, 12.4 million m3 of fill had to be implemented (source ec1000.net)

Linear structures (roads, railways, canals)
Earthworks (volume compensation)

- Access road to the sites of the Ruzizi III dam and hydroelectric power plant between Bugurama/Kamanyola and Rukoko in DRC
- Tunnel on the National Road Number 1 at the southern entrance of the city of Lubumbashi in DRC

Marine backfill
Polder and sand backfill

- Palm island in Dubai(figure 3)

During its construction, the challenge was to put sand on the seabed. The dredgers picked up the sand from the sea and dumped it where the breakwater was to be built. All this was done when the sea was at its calmest. Finding the right sand was a huge job in itself. Dubai has a lot of sand, because there are vast areas there. But the sand in the desert was too fine and the sand in the sea was coarser and wave resistant. To keep this sand in place, bare rubble was put on it. The idea was to raise the breakwater to a height of 4 m above sea level. This was the beginning of the maritime defense, without which the island could not exist.

The sloping layers take the force of the waves as they hit it. But sand and rubble are at the base. What really protects them both is another layer of rock. Each piece of rock weighed up to 6 tons. The huge supply of rocks forced the builders to excavate rocks from 16 quarries across the UAE. The 11.5 km breakwater needed 5.5 million cubic meters of rock, enough to build two Egyptian pyramids. Now, when the breakwater had been built for half its length, construction of the island began. Sand dredging collected sand from the Persian Gulf and dumped it to form the extreme island. The 8000 ton dredgers filled in only one hour and dumped at 10m/s, enough to fill the Olympic pool in only 4 minutes.

Figure 3: Construction of the Palm Island, the stage of Polderization; building a massive island, in the shape of a palm tree, until 2006. The island was to have a diameter of 5.5 km, increasing the coastline by 56 km. (Source adoutcivil.org)

Chek lap kok Airport in Hong Kong(Dredging area)

- Filling of the beaches of Haam-Wenduim(Belgium)
- Singapore (Expansion of the industrial zone)
- Rocha Beach, Figueira da Foz Beach(Portugal)
- Embankments/Bridges
- Embankment Bridge over the Meuse River
- Vasco de Gama Bridge (Continuous viaduct that crosses the Tagus estuary in its wide part, north of Lisbon). Portugal (see figure 4)

Figure 4: Vasco de Gama Bridge designed to withstand an earthquake up to 4.5 times stronger than the one that devastated Lisbon in 1755, which had then reached a magnitude of 8.7 on the Richter scale. It can also withstand winds blowing up to 250 km/h.(Source bonjourlisbonne.fr)

- Valla da asseca(700 m viaduct)

2. HYDRAULIC ENGINEERING

Here we have unitary structures of various natures such as dams, diversion works, flow distributor works, control petries, grit chambers, etc. which are interconnected by other linear structures such as open channels, buried collectors, etc.

You will understand that following the catastrophic events of October 3, 1988, the city of Nimes has equipped itself with several hydraulic installations intended to ensure protection against flooding during high water periods (Peyras et al 2006a).

The Valladas slope located east of Nîmes, two upstream and two downstream excretory dams, several open canals and buried collectors allowing the interconnection of the dams and various punctual works (petries, diversion works, sand traps). See figure 5

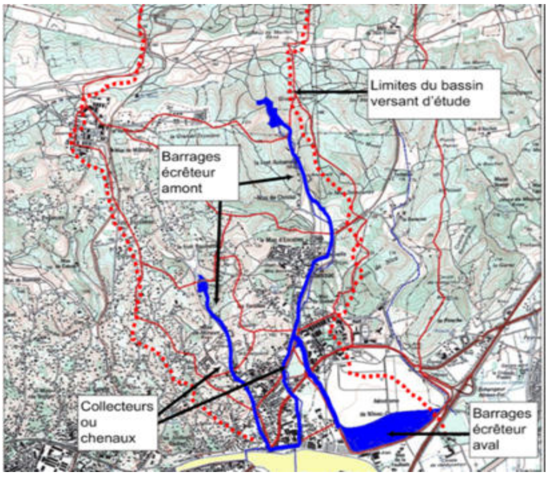

Figure 5: plan of the hydraulic development for the city of Nîmes

3. LINEAR WORKS

With regard to linear surface structures, reference is made to examples of alternative routes, the crossing of karstic areas, the comparison of tunnel and open-air solutions, as well as the economic, social and environmental aspects of land expropriation. Cases related to the Lisbon-Porto highway (Torres Novas - Fátima section) and CREL (Lisbon External Bypass), the IP3 highway (Lamego - Régua) and the Anílio tunnel integrated in the Egnatia Road, in the north of Greece, are presented. As an example, the alternatives for crossing limestone massifs on the A1 Highway, near Fatima, are shown in Figure 6.

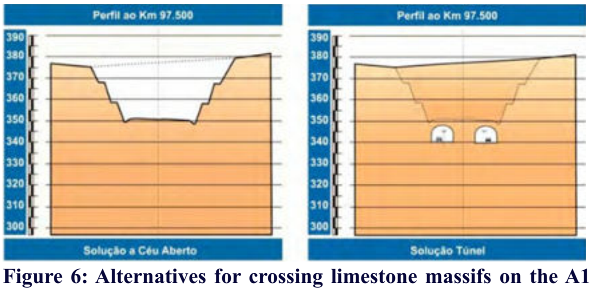

Figure 6: Alternatives for crossing limestone massifs on the A1 Highway (Portugal)

Reference is made to the main environmental impacts generated by the construction of tunnels, in particular their effect on the hydrogeological regime of the geological massifs they cross and the destination to be given to the materials resulting from their excavation.

4. UNDERGROUND WORKS

In the field of underground cavern excavation, particularly for metro stations, hydroelectric plants, fluid reservoirs and hazardous waste storage, reference is made to the impacts relating to the hydrogeological regimes of geological massifs, pollution of the surrounding land, subsidence and settlement phenomena affecting surface land, the deposition of excavated materials and the treatment, shaping and landscaping of the areas where these materials are deposited.

Examples include

- The Kipushi Corporation (KICO) underground mine is shown in Figure 7.

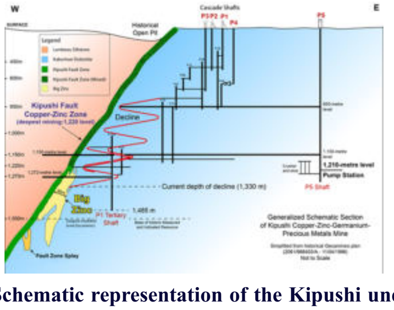

Figure 7: Schematic representation of the Kipushi underground mine infrastructures

Three tailings dams, located southeast of the former concentrator in the Kipushi River valley, are observed on this site. To our knowledge, stability and contribution to environmental degradation have not been measured in previous studies.

- The Venda Nova II hydroelectric plant, located in northern Portugal, whose construction involved the excavation of more than half a million cubic meters of rock and, as these materials cannot be used in the region, their disposal and the development of the corresponding areas.

5. MARINE WORKS

For this theme, let us quote some works essentially made up of the embankments :

- The palm island in Dubai forming three artificial islands in the shape of palm trees (figure 8).
- The world off the coast of Dubai forming nearly 300 artificial islands, seen from the sky form a planisphere.
- On the Meuse where at least 41500 m3 of earthworks were carried out as fill

Figure 8: The Palm Island of Dubai

6. NATURAL AND EXCAVATION SLOPES

For this theme, let us approach it by pointing out the risks that result from the instability of natural slopes and that generate impacts on people and property in inhabited areas. Consequently, interventions are needed to ensure stability, while interfering as little as possible with the environment and the landscape (as is the case of the Setúbal-Arrábida - Portugal road, in the Arrábida Natural Park (Figure 9) and the reliefs along the Douro River, in Porto). With regard to excavation slopes, stability analyses for the project that take into account the geological, hydrogeological and geotechnical conditions of the land involved are necessary, while ensuring that the choice of solutions causes the least possible conflict with the environment. This situation can be illustrated, in particular, by referring to a support structure built on an excavation slope, with a high height in a highly fractured limestone massif, on a section of the CREL Highway, in the Lisbon area, where there was a concern for adequate landscaping treatment in relation to the solution adopted.

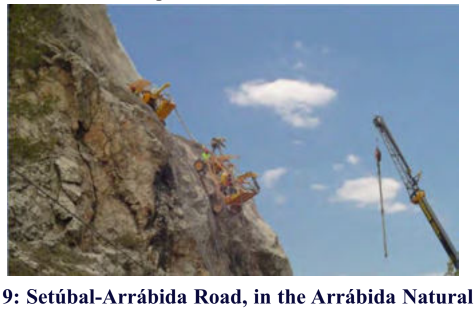

Figure 9: Setúbal-Arrábida Road, in the Arrábida Natural Park (Portugal)

CONCLUSION

The sudden growth of the world's population, which has been estimated at 7.8 billion inhabitants and its concentration in urban areas (50% of the current population) and, to a large extent, in megacities, requires the construction of new infrastructures of all types to accompany economic and social development, while demanding, as far as possible, the preservation of the environment.

However, for most African countries that are either developing or still poor countries, these works are almost non-existent, hence the need to

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obtain them while taking care of the cost and environmental protection.

The objective pursued by giving all these examples that we have selected from different countries of the world is to demonstrate that it is indeed possible to reconcile the development of a city, a region or a province and consequently of a given country with the preservation of the environment, through a significant, qualified and decisive intervention of Engineering Geology and Geotechnics, which implies that the professionals are well prepared and competent.

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