Water in Africa:
Hydro-Pessimism or Hydro-Optimism?

Água em África:
Hidro-pessimismo ou Hidro-optimismo

Centro de Estudos Africanos da Universidade do Porto
Porto, Portugal, 2-3 October 2008
« WATER IN AFRICA »
HYDRO-PESSIMISM OR HYDRO-OPTIMISM

ALGERIA

M.A.O. PROJECT
- KERRADA DAM -

TEIXEIRA DUARTE

" WATER IN AFRICA ". HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008
CLIMATIC AND HYDROGEOGRAPHIC ENVIRONMENT:

**Algeria**, second biggest African country
- Total area 2,381,740 km²;
- Population density above 34 million inhabitants, almost half live on coastal areas.

The argelian climate shows a huge geographical variation which from year to year changes the average annual precipitation as followed:

- North of the country – 350mm for the West area to 1000mm for the East area;
- Atlas mountains – up to 2000mm
- Sahara Desert – less than 100mm per year.

The raining seasons are becoming shorter along the years. Recently there is a huge variation of the highest precipitations values. These climate changes have a strong impact on the available hydrical resources.
Studies made upon the annual precipitation evolution over the past 25 years identified an intense and persistent “Dry Period” which affects the Algerian territory.

Precipitation is has been identified as 30% below normal values characteristic to each period. This “Dry Period” has an impact on:

- The rivers disposals;
- The underground aquifers are not fed;
- The reservoirs which stored the water are below maximum levels.
During the last ten years, this situation deteriorated due to a constant reduction of the water quantity which affects the supply of drinkable water to the population and of water to irrigate the agricultural soils.

This situation obliged the country to make drinkable water network a priority and defining a strategy in order to minimize the problem of water provisioning until 2020.
HYDRO-OPTIMISTIC ENVIRONMENT:

Until the years 70-80 the plan to supply water in Algeria was concentrated in dams development, water line, reservoirs, etc.

In the 90s those projects declined when the water quality and quantity sustained in those dams started to decrease.

With the new century, a great research for new solutions was started. Requalificatcon projects and some new inovating solutions to fight the hydro-pessimism line which embraces Algeria has begun.
HYDRO-OPTIMISTIC REACTIONS:

- Desalination units:
  The construction of more than 20 desalination units all along the 1,300km Algerian coast. The production capacity of all those units may exceed 2,500,000 m³/day and supply around 12.5 million inhabitants.

- Existing dam requalification:
  The requalification of 12 dams and of all of their hydraulic line, with a fully functioning and a maximum water retention capacity of 1025 hm³.

- The implementation of new dams:
  It is planned until 2020 the constructions of 30 new dams with a maximum water retention capacity of 1555 hm³.

- New hydraulic systems:
  A total of 7 new projects which link cities such as the M.A.O. Project (Mostaganem – Arzew – Oran). This projects will allow to supply 155 million de m³/year in water.
STUDY AND REALISATION OF THE M.A.O. PROJECT:

"WATER IN AFRICA". HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008
M.A.O. Project – Lot 1.0:

Chéliff dam and the « Chéliff dam/ Treatment plant » pipeline

Company : M.A.P.A.
Goal : Main dam of all the M.A.O. system
Water retention capacity : 85 million m³
M.A.O. Project – Lot 2.0:

Kerrada dam and « Chéliff dam / Kerrada dam» pipeline

Company : ASTALDI,Spa / COSIDER,TP  
Foundations outsourcing : TEIXCO Spa  
Goal: reservoir dam of the M.A.O. system  
Water retention capacity : 70 million m³
M.A.O. Project – Lot 3.1:

Pipeline « Pumping Plant– Mostaganem Reservoir– Oran Reservoir »

Company: Teixeira Duarte, S.A. / ETRHB

Goal: Fabrication and installation of a 90km pipeline; Construction of the Mostaganem and Oran reservoirs.

"WATER IN AFRICA". HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008
M.A.O. Project – Lot 3.1:

Fornaka – Tubes Production Plant
Contraction of BPAT tubes with diameters from DN2200mm to DN1400mm

"Water in Africa". Hydro-Pessimism or Hydro-Optimism
Porto, 2008
M.A.O. Project – Lot 3.1:

MOSTAGANEM RESERVOIR
Water retention capacity = 120,000 m³
M.A.O. Project – Lot 3.1:

ORAN RESERVOIR
Water retention capacity = 300,000 m³
M.A.O. Project – Lot 3.1:

PUMPING PLANT
Power 3.6 MW / Output 4.0 m3/s

"WATER IN AFRICA". HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008
M.A.O. Project – Lot 3.2:

Treatment plant

Company: M.A.P.A. / DEGREMONT
Goal: To ensure the quality of the stored water in the dams before its entry in the pipeline system.
Production capacity: 560,000 m³ water / day
M.A.O. Project Lot 2.0 – Kerrada dam

Foundation treatment works
- Injections curtain -
The dam will have a 85m height embankment, a 70 million m³ water retention capacity and several concrete structures:

- A grouting gallery;
- A drainage gallery;
- A water intake linked to the Derivation gallery.

The pumping plant will ensure the transfer of the retained water in the Kerrada Dam to the treatment plant.
M.A.O. Project Lot 2.0 – Kerrada dam

Realization of the treatment of the foundation
Injections curtain

- Project phase -
The project of the Kerrada dam foundation treatment planned 2 different Types of intervention:

Consolidation injections:

The main goal of this type of treatment is to improve the geotechnical characteristics of the rocky massive in the most superficial area of the foundation. This intervention not only increases the resistance, reducing the soil’s deformation, as it improves the waterproofing, reducing also the cement grout’s circulation in the most superficial area.

Injections curtain:

The main goal of this type of treatment is to reduce the water seepage through the dam foundation, reducing the infiltration loss and reducing the internal erosion risks of the foundation.
M.A.O. Project Lot 2.0 – Kerrada dam

Realization of the treatment of the foundation
Injections curtain

- Phase study -
Execution of the Exploration drills
Complementary geological-geotechnical campaign:

In order to complete the study and to get a better geological-geotechnical and also hydro geologically knowledge of the soils foundations, a complementary geotechnical recognition campaign have been done.

Along the axis of the dam, 8 drills have been made, vertical, sampled and with Lugeon tests until a depth that penetrated the waterproof substrate.

In a geological point of view, the soils of the dam foundation are represented as followed:
Grey sandstone and red marls at the surface

Alternation from sandstone to marls

Grey marls in depth

"WATER IN AFRICA". HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008
High permeability area:
Superficial levels made of a friables sandstone and decompressed marls, where we can notice permeability values between UL=20 and UL > 100
Medium permeability area:
Transition area between the intercalations of marls and sandstone and the marls unit, with values $5 < U_L < 15$
Low permeability area:
This is an area made by levels of very strong marls and some very compact sandstone and a little fractured, with permeability values $UL < 1$. 
Test drills execution:

In order to get a better definition of the injection curtain, 3 tests zones have been made (1 at the right bank and 2 at the left bank) which allow to study some variables and parameters about the drilling and injection methodology:

- Drilling methodology (compressed air / circulating water);
- Configuration of the injection curtain:
  - Distance between each drill:
    - primary drills at 12m
    - secondary drills at 6m
    - tertiary drills at 3m
    - quaternary drills at 1.5m
  - Number of lines to be executed for the injection curtain:
    - Monolinear Injection Curtain to be made upon the dam axis
    - Bilinear Injection Curtain with a line at the upstream and one at the downstream of the dam axis, with a 2.10m separation between the lines
- Cement grout types
M.A.O. Project Lot 2.0 – Kerrada dam

Realization of the treatment of the foundation
Injections curtain

- Construction phase -

"WATER IN AFRICA " . HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008
Works quantities

At the beginning, the project have described the execution of a monolinear injection curtain with a total of 30 000 ml and 21 000 ml for the consolidating injections.

After having realised 8 “exploring drills” and 3 test zones, a bilinear injection curtain has been chosen – with an upstream and one downstream alignment upon the dam axis, eventually completed with the realisation of a third central alignment, which totalizes 100.000 ml drilling for the Injection Curtain, to be made within 15 months.
4ème Séminaire sur les technologies du béton.

Le béton: Durabilité, Solutions et Innovation

"WATER IN AFRICA". HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008
4ème Séminaire sur les technologies du béton.

Le béton: Durabilité, Solutions et Innovation

"WATER IN AFRICA". HYDRO-PессИSМ OR HYDRO-ОPTИSM

Porto, 2008
Injection methodology:

In the particular case of Kerrada dam, the foundation treatment will be mainly made with ascending injections in some 5m length sections.

But, in case of water losses detected during the drilling, instability of the drill walls or problems related to the drilling it will be necessary to apply the descending injection technique.

« Stop injection » criteria:

The refusal criteria shall be bimodal:

- The calculated manometric injection pressure;

- Injection volume;
Drilling equipments

Consolidating Injections:
Drilling equipments

Injection curtain:

Right bank
Drilling equipments

Injection curtain:

Left bank
Drilling equipments

Injection curtain:

Inside the Gallery
Injection equipments

Automatic injection plants

"WATER IN AFRICA". HYDRO-PESSIMISM OR HYDRO-OPTIMISM
Porto, 2008
Injection equipments

Self-powered injection plants – Open area
Injection equipments

Self-powered injection plants – Inside the gallery
M.A.O. Project Lot 2.0 – Kerrada dam
Conclusions

- Algeria is a country where it has been verified an intensive and persistent “Dry Period” for more than 25 years. This phenomenon has an obvious impact on:
  - The river disposals;
  - The underground aquifers are not fed;
  - The reservoirs which stored the water are below maximum levels.

- The deterioration of this situation in the last decade, where average annual precipitation values already show a 50-60% deficit in comparison to the normal values for each season, has contributed to the existence of a HYDRO-PESSIMISTIC script.

- This persistent phenomenon forced the country to make of the drinkable water network its priority and to define a strategy to minimize the consequences of the “Dry Period”, inverting this hydro-pessimistic tendency until 2020.
Conclusions

- Consequently, several HYDRO-OPTIMISTICS solutions have been studied, giving a strategical direction which planned the execution of a group of large and medium size projects to minimise the present problems related to the water supply, mainly:
  - Construction of 23 new desalination plants;
  - Requalification of 12 dams;
  - Construction of 30 new dams;
  - Construction of 7 huge regional hydraulic systems to transfer water between cities, such as the M.A.O. Project and its Kerrada reservoir dam.

- The implementation of the M.A.O. Project is one example of the HYDRO-OPTIMISTICS reactions/solutions for a country going through an almost extreme HYDRO-PESSIMISM phase.

- In fact, the construction of this huge project will allow drinkable water to be provided to the 3 largest cities of West Algeria (Mostaganem – Arzew – Oran), id est, for 2.5 million inhabitants with a 155 million m3/year total.
"WATER IN AFRICA". HYDRO-PESSIMISM OR HYDRO-OPTIMISM

Porto, 2008