WORKSHOP
TECHNICAL COMMITTEE P - CEMENTED MATERIAL DAMS

CEMENTED MATERIALS AND IMPROVED SOILS: OPPORTUNITIES FOR SMALL DAM TECHNOLOGY

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PRESENTATION OUTLINE

1. Background
2. Areas of Improvement using cemented materials and improved soils
3. Improving the storage capacity
4. Improving the resilience against overtopping
5. Improving the resilience against internal erosion
6. Cemented materials and improved soils economic and quick construction solutions
7. Conclusion

1. BACKGROUND

Low and small dams are very important for water storage in the Semi-arid regions of Africa and elsewhere in the world where storage is a basic condition for life and economic activity during the long dry season:

1. IN BURKINA FASO THERE ARE

a) 1100 dams with a total capacity of 5.3 billions m^3 ,

b) 1080 small and low dams with a total capacity of 800 million m^3

2. IN THE WORLD

a) there are millions dams storing less than 3 hm^3 of which possibly 200 000 store over 0, 1 hm^3,

b) The world number of such dams may be 200 000 with possibly an average storage in the range of 500 000 m^3 and a very rough global evaluation of 100 000 hm^3.

THOSE DAMS ARE PLAYING A VITAL ROLE FOR RURAL AND REMOTE COMMUNITIES

2. AREAS OF IMPROVEMENT USING CEMENTED MATERIALS AND IMPROVED SOILS

Using cemented materials dams and Improved soils are:

1. **Offering new possibilities for a better design and construction of small and low dams**

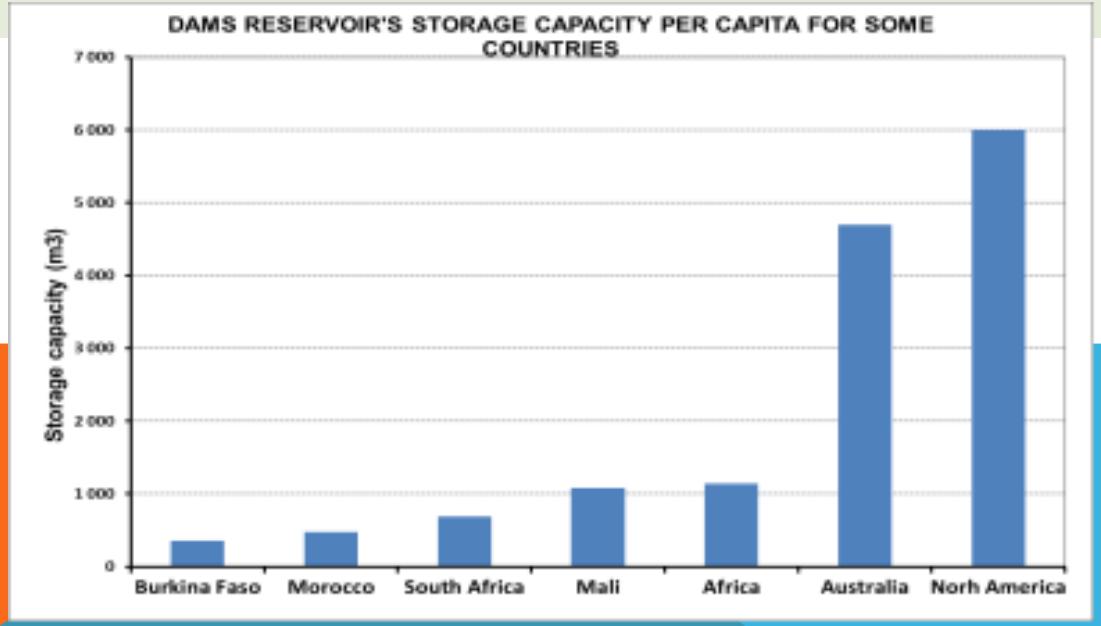
2. **ensuring a better service with more storage capacity**

3. **ensuring a better resistance against overtoping and internal erosion in the Dams fills**

THESE NEW TECHNOLOGIES WILL PROVIDE ECONOMIC DESIGN AND QUICK CONSTRUCTION OF SMALL AND LOW DAMS

3.IMPROVING THE STORAGE CAPACITY (1/2)

In semi-arid regions of developing countries Water storage capacity is weak leading to a low surface water regulation for the needs of the population and for economic growth



For less developed countries, per capita storage capacity is less than 300 m^3:

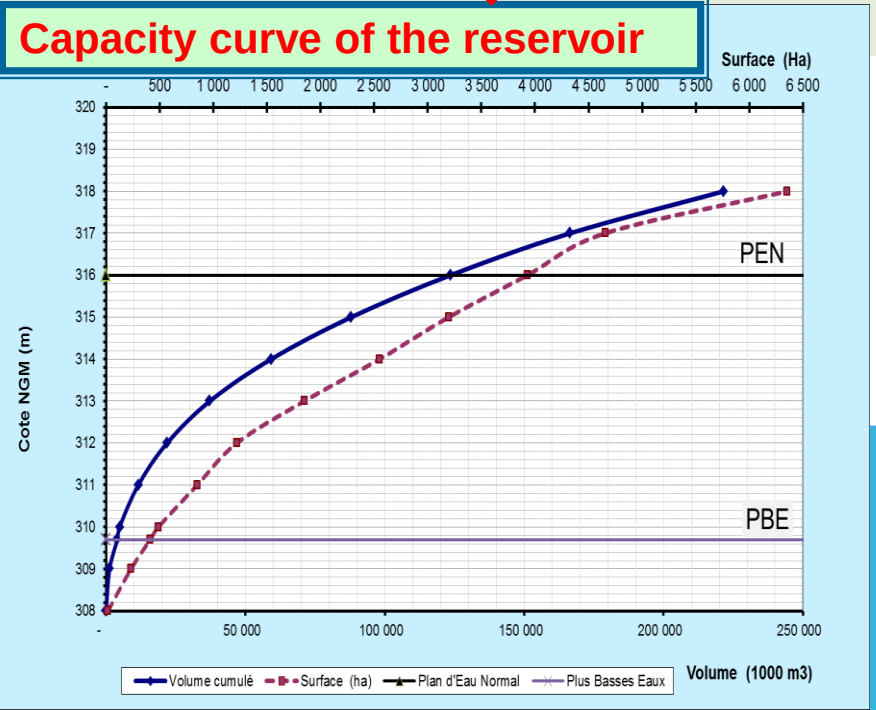
Storage is necessary in developing countries to:

- **ensure water availability during dry season and**
- **store the water in wet years to compensate dry years**

3.IMPROVING THE STORAGE CAPACITY(2/2)

Low or small dams are located on large rivers courses where the floods are generally high and the need to spill important discharge with adequate freeboard lead to the reduction of the available storage capacity: CASE OF SANGHIN DAM IN BURKINA FASO

Capacity curve of the reservoir



CARACTERISTICS OF SANGHIN DAM

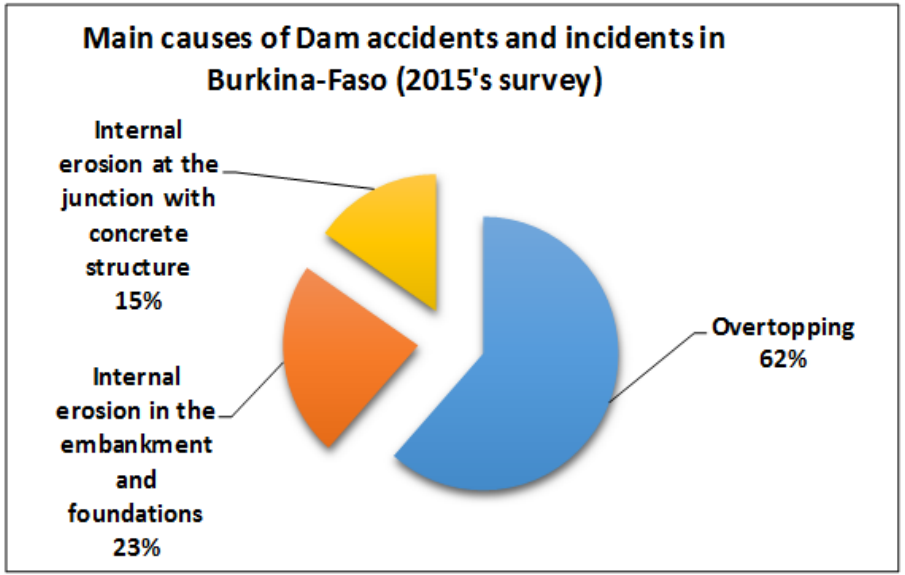
- Total height of the Sanghin dam: 10 m,
- Design floods disharge:1800 m3/s,
- Sanghin dam length: 2000 m.
- The water head necessary to spill the design flood for a spillway of 300 m is 2m.
- The depth of water in the reservoir is 7m

If we spill on one half of the embankment length, the head need to spill 1800 m^3/s will be 1m and the storage capacity will be 167 hm^3 representing an increase in the storage capacity of 36%.

4. IMPROVING THE RESILIENCE AGAINST OVERTOPPING: IMPORTANCE OF OVERTOPPING AND MAIN CAUSES (1/5)

The main causes of earth dams failure or incidents in the world:

- **overtopping,**
- **internal erosion**

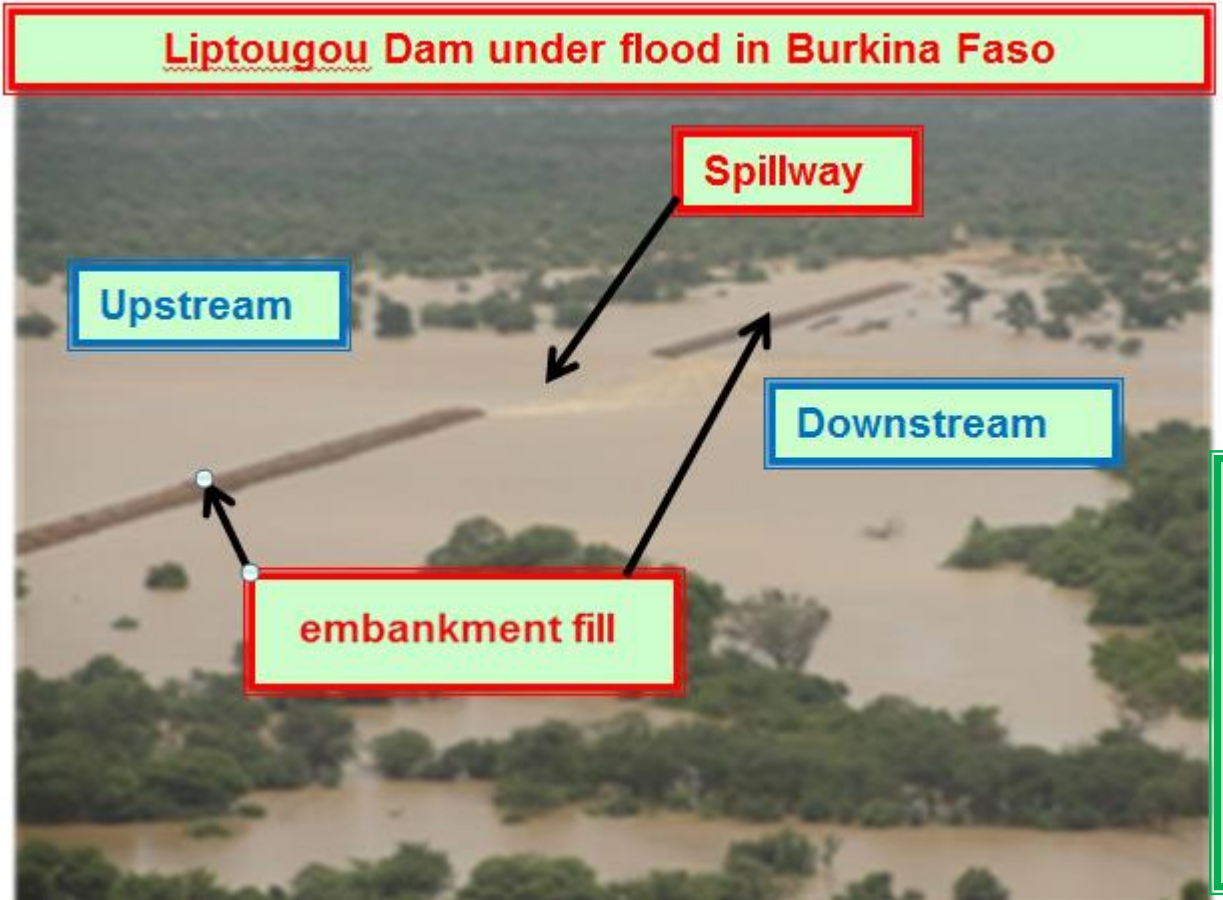


The floods evaluation and the design floods setting are characterized by a high uncertainty which need to be considered during the design, construction and operation of these dams

The main cause leading to overtopping of embankment dams are:

- **the difficulties to evaluate the floods at the dam site due to lack of appropriate hydrological and meteorological data,**
- **the lack of proper sizing of the dam spillways or the obstruction of malfunctioning of the spillway during floods.**

4. IMPROVING THE RESILIENCE AGAINST OVERTOPPING: IMPORTANCE OF OVERTOPPING AND MAIN CAUSES (2/5)



Case of a low dam experiencing a combine floods generated by:

- heavy rainfall in the catchment area and
- from cascade failures of small dams in the upper reach of the catchment.

Due to the low height of the dam and very flat slope of the river, upstream and downstream water level are very close.

This situation creates lot of threat on the embankment fill with wetting of an important part of the downstream shell

4. IMPROVING THE RESILIENCE AGAINST OVERTOPPING:
PRESENT TECHNOLOGY AVAILABLE TO REDUCE OVERTOPPING AND CONSEQUENCES (3/5)

Protecting the embankment in the spilling zone with conventional concrete of RCC

Spillway for the Yakouta Dam in Burkina Faso

Using new high performance spillway

PK Weir of the Dam in Vietnam

4. IMPROVING THE RESILIENCE AGAINST OVERTOPPING:
PRESENT TECHNOLOGY AVAILABLE TO REDUCE OVERTOPPING AND CONSEQUENCES (4/5)

Combining concrete free overflow spillway with emergency spillway_Lumbila Dam case study

➢ Materials and their technical specifications

- **Laterite**
  IP <15;
  % fines < 25;
  % gravel > 50%

- **Cement**
  The cement used is CPJ class 45

- **Water**
  From the dam reservoir

➢ Implementation of cement material on the embankment for emergency spillway

- **execution of the laterite backfill**
- **supply on a thickness of 20 cm of the laterites soils**
- **supply of CPJ class 45 cement; the cement dosage being 100 kg per cubic meter of laterite soil**
- **dry mixing of cement and laterite with the grader;**
- **moistening of the soil-cement mixture with the tanker truck;**
- **Mixing of the moistened mixture with the grader;**
- **spreading of the homogenized mixture in water content (thickness 0.20 meters);**
- **compaction of the soil - cement with a smooth vibrating roller**

4. IMPROVING THE RESILIENCE AGAINST OVERTOPPING:
PRESENT TECHNOLOGY AVAILABLE TO REDUCE OVERTOPPING AND CONSEQUENCES (4/5)

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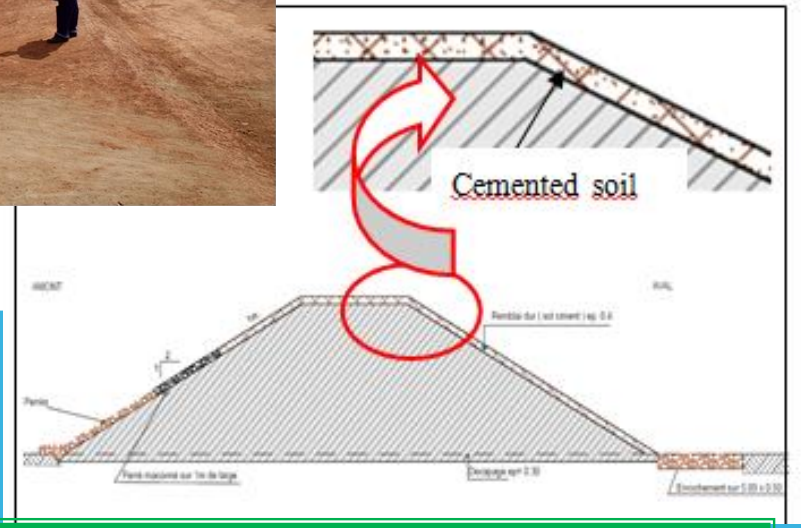
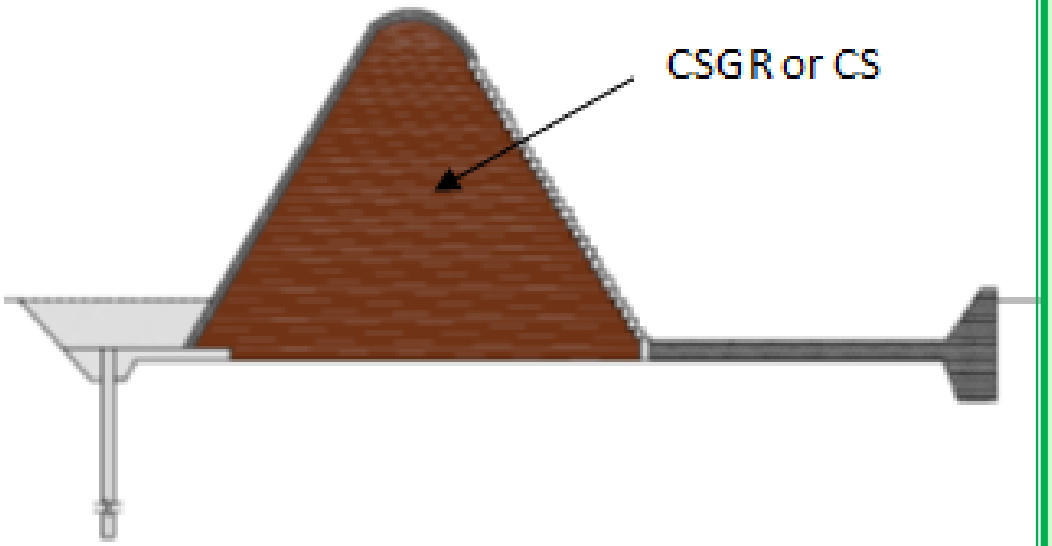


Soil cement placement for Loumbila Dam in Burkina Faso

Cross section of the emergency spillway

4. IMPROVING THE RESILIENCE AGAINST OVERTOPPING:
PRESENT TECHNOLOGY AVAILABLE TO REDUCE OVERTOPPING AND CONSEQUENCES (5/5)

Innovative design using cemented materials dams to address overtopping



CSGR Dam cross section for dam resistant to overtopping (spilling section)

- **The CSGR or CS dams offer the possibility to make the overall fill resistant against water and overtopping.**
- **The cross section of the dam is trapezoidal and even during construction the dam can be overtopped without destruction**
- **With these materials, the overall dam is design to sustain overtopping.**
- **The head necessary to spill the floods is reduced and the concentration of energy to be dissipated at the downstream toe of the dam is reduced.**

5. IMPROVING THE RESILIENCE AGAINST INTERNAL EROSION: IMPORTANCE OF INTERNAL EROSION AND CAUSES FOR SMALL EARTH FILL DAMS

Case of internal erosion hole in a small embankment dam in Burkina Faso

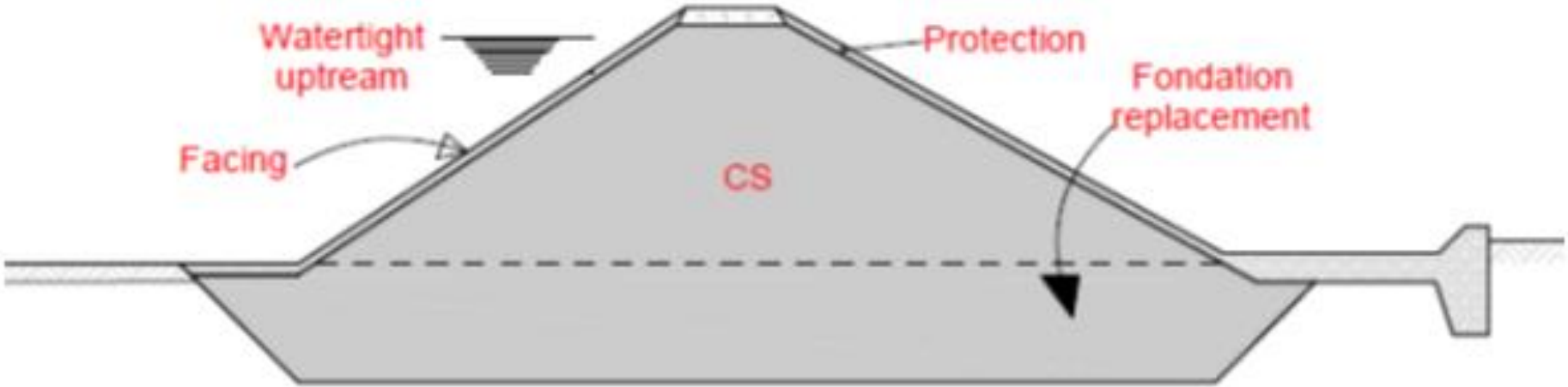
The internal erosion as the second causes of small and low dam's failures occur in the dam body due to:

- **lack of proper design and construction of the fill,**
- **the quality of the work,**
- **the nature of earth materials used for the construction of the dam.**

5. IMPROVING THE RESILIENCE AGAINST INTERNAL EROSION:

SOLUTIONS AGAINST INTERNAL EROSION USING CEMENTED MATERIALS AND IMPROVED SOILS

Cross section for a CS dam resistant to internal erosion and resistant to overtopping



6. CEMENTED MATERIALS AND IMPROVED SOILS ECONOMIC AND QUICK CONSTRUCTION

Due to the fact that available materials near dam site can be used for the construction and also considering the construction method using compaction like soils materials conditions to have cost reduction and gain on schedule are high and interesting to reduce the cost of investment and also in maintenance.

7. CONCLUSIONS

Cemented materials and improved soils technology are gaining more attention and leading to important innovation in the dam technology

which offer opportunity for a better design and construction of small dam resilient to:

- **Overtopping,**
- **internal erosion**
- **providing quick construction and certainly less maintenance cost.**

THANK YOU FOR YOUR ATTENTION