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# THE NON-RECTILINEAR SPILLWAY DUG SYMMETRICALLY AND THE RECTILINEAR SPILLWAY (EXPERIMENTAL STUDY)

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## ABSTRACT

It is clear that the role of spillway is ensured the safety of dams. It is characterized by its different geometric configurations such as rectilinear spillway and non-rectilinear spillway.

The present work was interested in the experimental comparison between the non-rectilinear spillways dug symmetrically (by different depths of hollowing of the alveoli) and the rectilinear spillways in thin wall of the same width, in order to compare the evacuation performance between them. This study showed that the performance of non-rectilinear spillways symmetrically excavated, is greater than the discharge capacity of rectilinear spillways in thin wall in all phases of hydraulic loads.

**Keywords:** rectilinear spillway, non-rectilinear spillway, symmetrical digging, evacuation performance.

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## 1. INTRODUCTION

The spillway plays an important role in the safety of dams; it allows the passage of exceptional floods without incident and without the dam being submerged [4].

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The spillway classification shows two types of spillways; rectilinear spillways and non-rectilinear spillways [1].

Many of works are carried out on the rectilinear spillways, in particular the spillways of thin wall. On the other hand, non-rectilinear spillways remain in the experimental and numerical development stage, such as non-rectilinear spillways dug.

The non-rectilinear spillways dug are the origin of the spillways of modified labyrinth, invented by Ouamane [3], but they are characterized by a vertical hollowing of its alveoli [2].

Experimentally research on the yield of non-rectilinear spillways dug excavated has shown that the best performance of digging of the alveoli is that corresponding to a symmetrical digging of the alveoli.

In this same subject, it is recommended to compare the performance of non-rectilinear spillways dug symmetrically (with successive increase in digging depths) with the performance of rectilinear spillways of thin wall. We explain in this work the experimental results obtained on four reduced models.

## 2. DEFINITION OF THE NON-RECTILINEAR SPILLWAYS DUG

The non-rectilinear spillways dug are characterized by a non-rectilinear alignment; they take the name of "dug" by the digging of its alveoli [2].

Its geometric configuration is based on:

- A rectangular disposition in plan.
- Existence of the upstream and downstream alveoli.
- A symmetrical or unique digging of the alveoli.

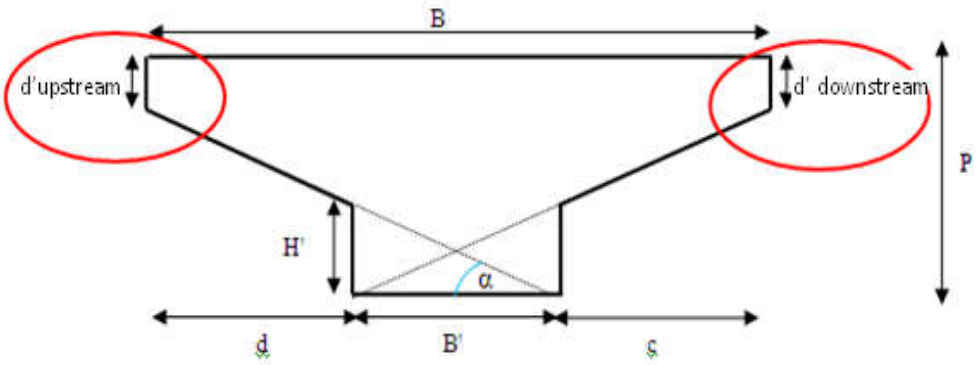


**Fig.1.** View of a non rectilinear spillway dug

With:

B: length of side wall (m)

B ': Width of spillway base (m)

P: Maximum upstream height of spillway (m)

c: length of the upstream overhang (m)

d: length of the downstream overhang (m)

d'a: depth of digging of the upstream alveoli (m)

d'v: depth of digging of the downstream alveoli (m)

H ': Maximum height of the side walls (m)

α : Wall angle (degree)

## 3. MATERIAL AND METHODS

For each experiment, the model of the spillway dug is installed at the exit of the basin of simulation. After verification of the correct installation of the model, a check of the parameters of the flowmeter and the pressure gauges is necessary.

Once the entire experimental system is verified, the pump is primed to fill the retention simulation basin to the spill along the crest of the spillway to be tested. After deactivation of the pump and stopping the flow on the crest of the weir, the threshold level is determined.

After this first step, the first pump is operated at a flow rate of about 30 l / s by manipulation of the first flow control valve. Once the flow is completely stabilized, measurements of the depth of water upstream of the weir tested are carried out by means of the readings on the manometric table, the flow being recorded directly on the computer (PC) by the flow Via the

COMMUWIN II software.

This operation is repeated each time the flow rate is varied up to the maximum flow rate of the order of 170 l / s. A series of values (Q and h) is thus obtained [5].

Experimentation of the reduced models of the spillways is carried out in this experimental device.

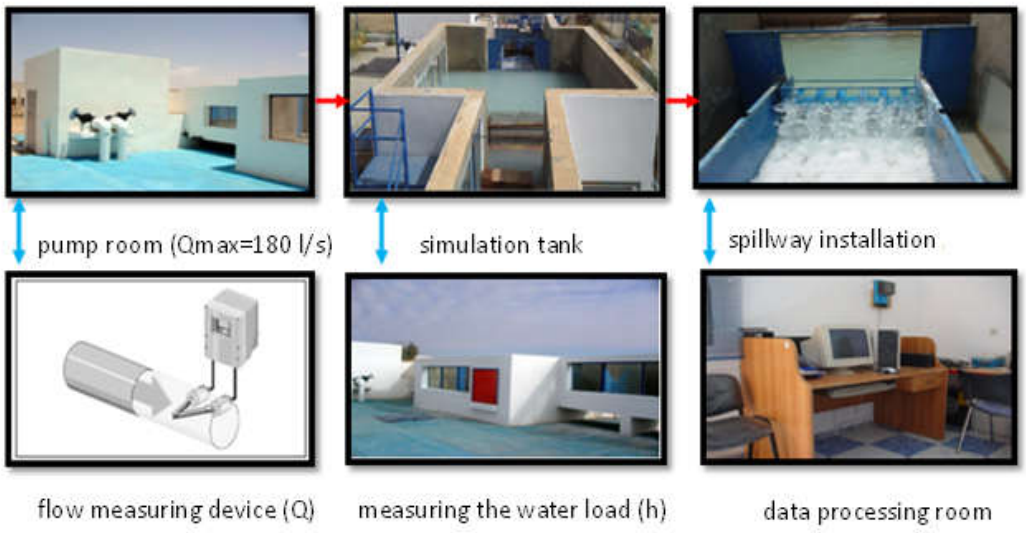


**Fig.2.** Experimental protocol (LAHE Laboratory – University of Biskra)

## 4. RESULTS AND DISCUSSION

The graphic representation will be based on the torque of the measured values, the flow (Q) and the total load on the spillway (H*).

Therefore, in order to compare the yield of the non-rectilinear spillways dug and the yield of the thin-walled rectilinear spillways of the same width, four (4) models were tested (Table 1).

**Table 1.** Geometric characteristics of experienced models

| Model | L (cm) | $W_t$ (cm) | a (cm) | b (cm) | c=d (cm) | d'a (cm) | d'v (cm) | P (cm) | d'/P |
|---|---|---|---|---|---|---|---|---|---|
| D1 | 100 | 100 | 0 | 0 | 0 | 0 | 0 | 15 | 0 |
| D2 | 600 | 100 | 9 | 7.5 | 10.25 | 2 | 2 | 15 | 0.13 |
| D3 | 600 | 100 | 9 | 7.5 | 10.25 | 4 | 4 | 15 | 0.27 |
| D4 | 600 | 100 | 9 | 7.5 | 10.25 | 6 | 6 | 15 | 0.4 |

With:

a: width of the upstream alveoli (m)

b: width of the downstream alveoli (m)

d'/ P: ratio of the digging depth of the alveoli to the height

L: developed length of spillway (m)

W : spillway width (m)

**Fig.3.** Spillway of thin wall tested (Model D1)

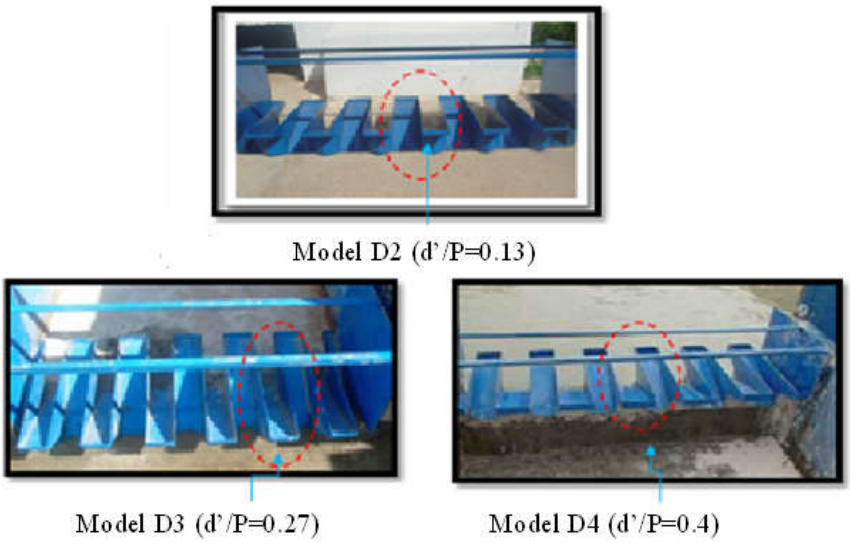


**Fig.4.** The tested models of spillways dug symmetrically

## 5. EXPERIMENTAL

### 5.1 Comparison between the yield of the spillway dug (d'/P=0.13) and the yield of rectilinear spillway

The figure which represents a comparison between a non-rectilinear spillway dug symmetrically (d'/P = 0.13) with respect to a spillway in thin wall of the same width indicates

that:

- The difference between the two flow curves is of the order of 32% for the low hydraulic loads (H*/P<0.5).

- Variation of the discharge range from 48% to 59% for medium and heavy hydraulic loads (H*>2P/3).

-The mean performance of the non-rectilinear weir with symmetrical digging (d'/P= 0.13) with respect to the rectilinear weir in thin wall of the same width is of the order of 2.15 times.

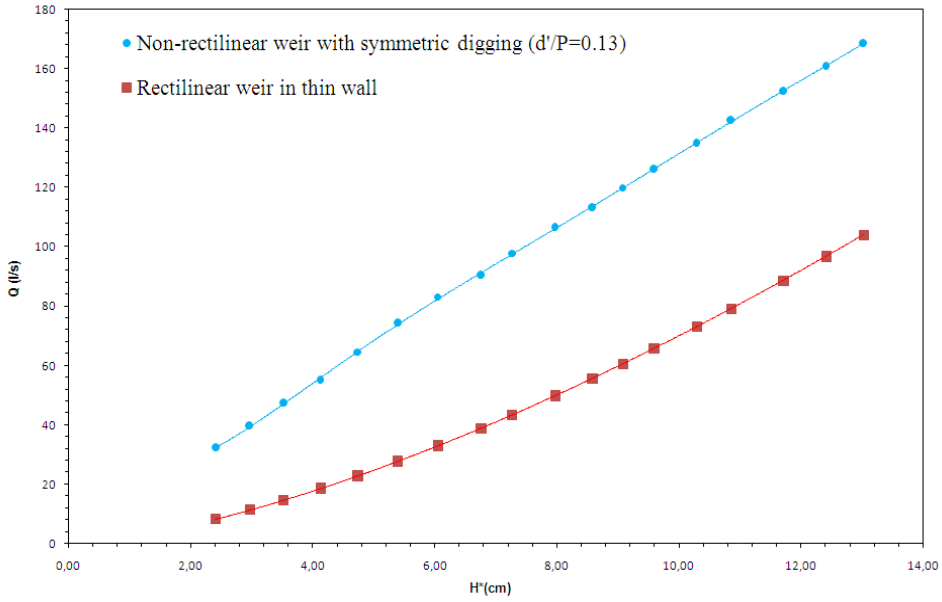


**Fig.5.** Flow curve of the spillway with symmetrical digging (d'/P = 0.13) compared to that of the rectilinear spillway in thin wall

**5.2 Comparison between the yield of the spillway dug (d'/P=0.27) and the yield of rectilinear spillway**

This figure indicates that:

- The difference between the two flow curves is of the order of 37% for the low hydraulic loads (H*/P<0.5).

- Variation of the discharge range from 46% to 58% for medium and heavy hydraulic loads (H*>2P/3).

- The mean performance of the non-rectilinear spillway with symmetric digging (d'/P= 0.27) with respect to the rectilinear spillway in thin wall is of the order of 2.12 times.

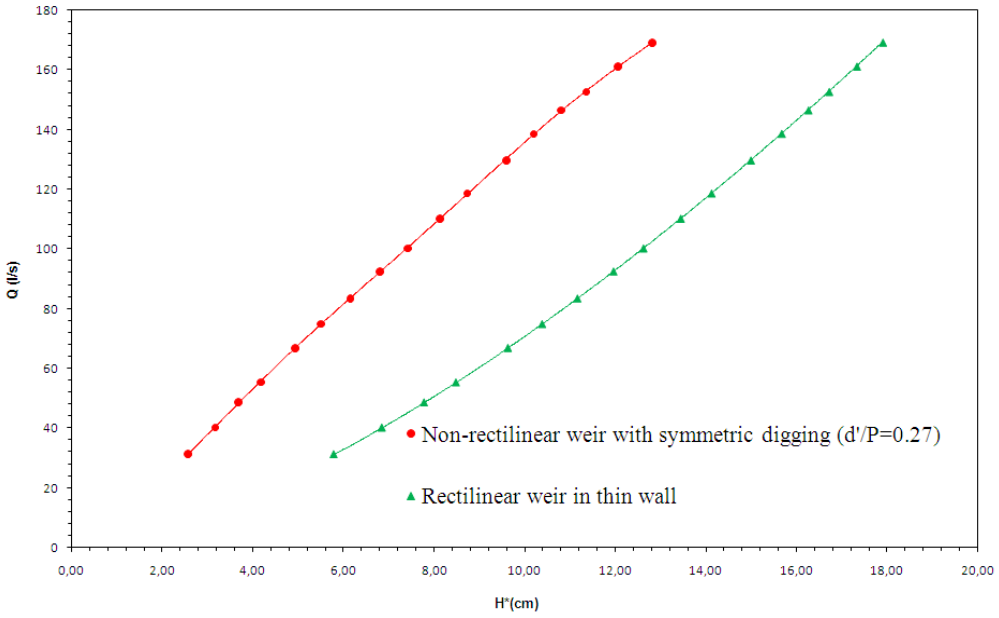


**Fig.6.** Flow curve of the spillway with symmetrical digging (d'/P = 0.27) compared to that of the rectilinear spillway in thin wall

**5.3 Comparison between the yield of the spillway dug (d'/P=0.4) and the yield of rectilinear spillway**

The figure which represents a comparison between a non-rectilinear spillway dug symmetrically (d'/P = 0.4) with respect to a spillway in thin wall of the same width indicates that:

- The difference between the two flow curves is of the order of 37% for the low hydraulic loads (H*/P<0.5).

- Variation of the discharge range from 49% to 59% for medium and heavy hydraulic loads (H*>2P/3).

-The mean performance of the non-rectilinear weir with symmetrical digging (d'/P = 0.4) with respect to the rectilinear weir in thin wall of the same width is of the order of 2.06 times.

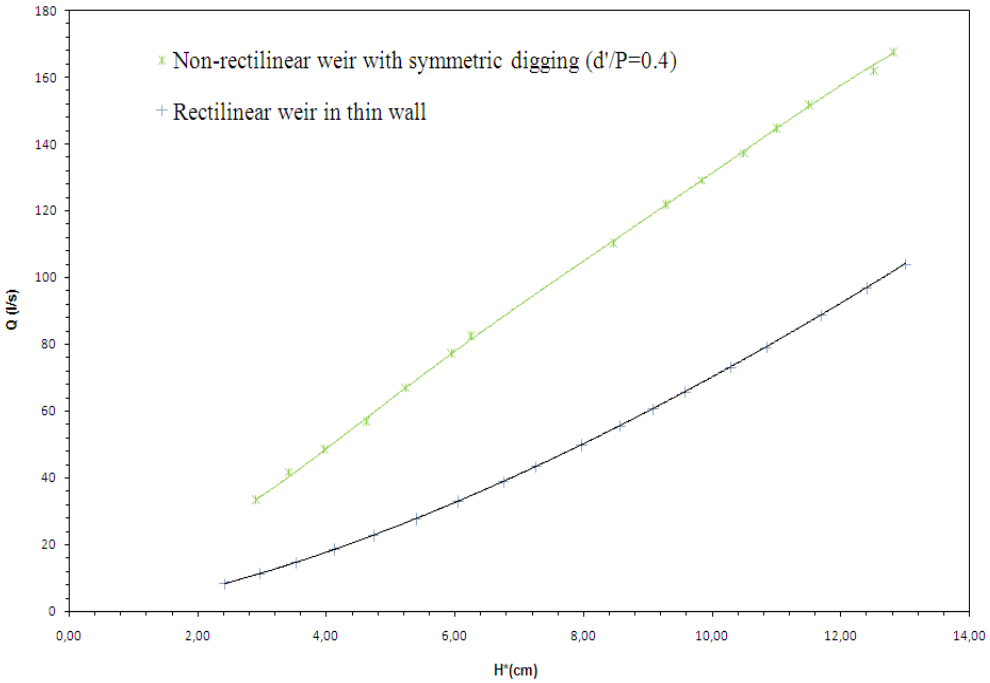


**Fig.7.** Flow curve of the spillway with symmetrical digging (d'/P = 0.4) compared to that of the rectilinear spillway in thin wall

### 5.4 Results interpretation

The very remarkable deviation of the evacuation capacity between the four models of the symmetrically dug spillways and the thin-walled spillway of the same width is reflected by the influence of;

- The slope generated by the symmetrical dug of non-rectilinear spillway.
- The developed length "L" of the not rectilinear spillway dug which favors the evacuation of the high flows in the same hydraulic load on the rectilinear spillways in thin wall.
- Increasing the digging slope increases the performance of the non - rectilinear spillway to a ratio doesn't exceed (1/3).

## 6. CONCLUSION

The results of the experimental tests on four models of symmetrically excavated non-rectilinear spillways and another model of the rectilinear spillway in thin wall of the same width showed that:

- Non rectilinear spillways dug are characterized by their geometrical configurations which favor superior performance compared to thin rectilinear spillways.
- The performance of the non-rectilinear spillways dug symmetrically is of the order 2 times the performance of the spillway in thin wall of the same width, and that in all the ranges of the hydraulic load.
- For better performance of symmetrically excavated non-rectilinear spillways, the slope of hollowing of the alveoli must not exceed (1/3).

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