ICOLD 25TH CONGRESS - STAVANGER (NORWAY)

Associating Concrete fuse plugs with PKWeirs increases by 60 % the capacity of the spillway PKWeir and by 300 % the discharge of a Creager sill

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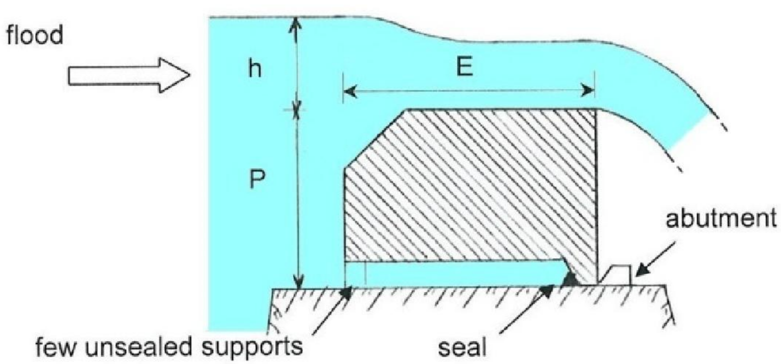
- **PKWeirs and Concrete fuse plugs data are first summarized below.**

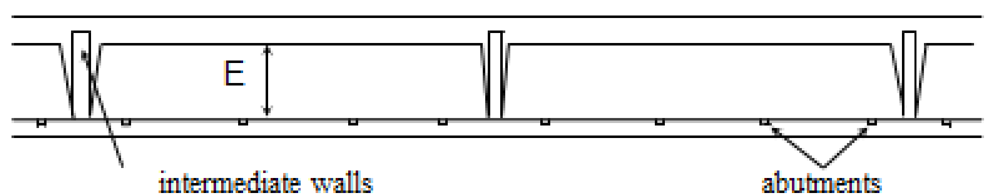
Low cost spillways to increase safety and storage: the Concrete fuse plugs

Concrete fuse plugs are simple massive blocks placed side by side on a spillway sill. They are free standing and stable until the water level in the reservoir reaches a certain elevation and they start tilting when this elevation is exceeded.

To ensure that the magnitude of uplift pressure under each block develops as required, a hollow area is provided under each block which is wide open at the upstream side and completely closed and watertight at the downstream side. Blocks placed on the same sill may have the same height P but different width E, so that they tilt at different water elevations according to increase of floods discharge. A simplified formula "**h= E - 0.4 P**" may be used for a quick rough estimation of the water head "h" for tilting.



Concrete fuse plug overtopped by flood



Plan view of the spillway

Concrete fuse plugs

Concrete Fuse Plugs may be used for new dams. In such case, it is possible, with about the same quantity of concrete and cost as for Creager weirs, to double the flow of the extreme flood discharged through the spillway or to increase the storage for a same safety. They may also be used to improve existing free overflow spillways either by increasing maximum spillage, after lowering the sill, or by increasing reservoir storage or by combining both.

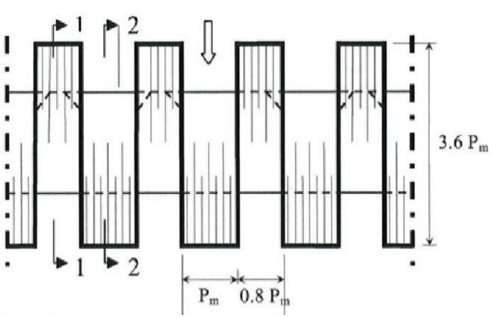
More details are given in Appendix 3 of ICOLD Bulletin n°144 and may help to optimize the designs.

Concrete fuse plugs at Wedbila dam (Burkina Faso**)**

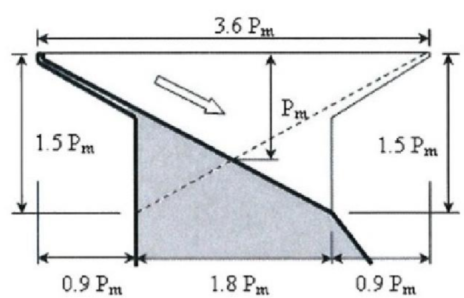
Piano Key Weirs (PKWeirs)
triple the spillways discharge

Tested since 15 years and implemented on many dams in various countries since 10 years, this improved labyrinth design appears very cost efficient, optimizing hydraulic efficiency as well as structural requirements and construction facility.

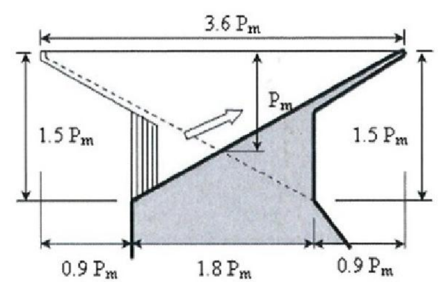
The layout of walls has a rectangular shape, part of the walls is overhanging and those walls along the flow are inclined. This is hydraulically favourable and allows the base width of the structure to be reduced, thus allowing its utilization upon most spillways or gravity dams. The here below figures show a typical design of symmetrical PKWeir with proportions based on “Pm” which is the maximum height of the labyrinth walls.



Plan view



Cross section 1-1 (outlet)



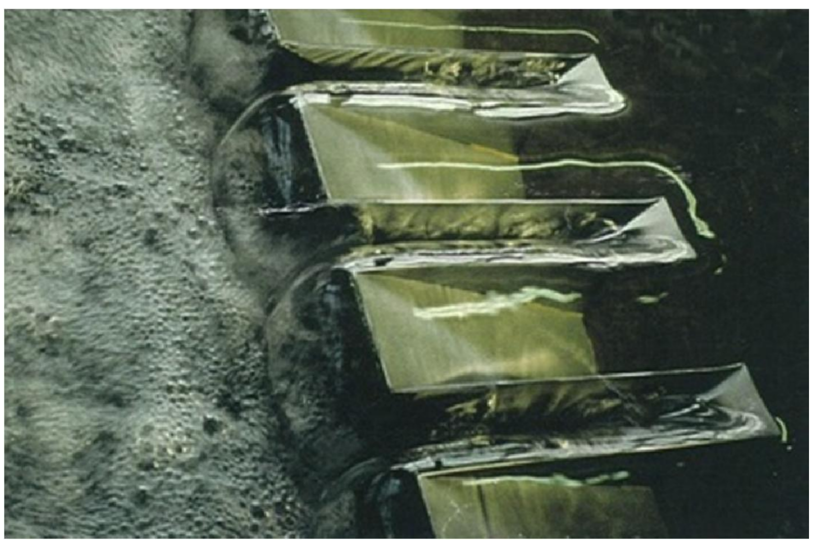
Cross section 2-2 (in let)

Pianos Key Weirs

Other configurations may be used case by case according to the local conditions (For instance, only one upstream overhang, or only one downstream overhang, or no overhangs, etc..).

For a water upstream head over the weir crest"h"between 0.4 Pm and 2 Pm and a ratio between the developed plan length of wall and the overall spillway length close to 5, the discharge (in m3/sec) per metre of spillway is close for the model above to
4.3 h√Pm as compared to **2.15 h√h** for a Creager Weir.

More details are given in Appendix 2 of ICOLD Bulletin n° 144.



Flow discharge on model

Van Phong dam (Vietnam)

PKWeirs and Concrete fuse plugs

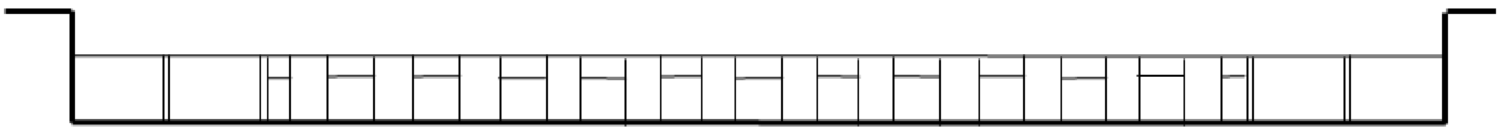
1. Associating PKWeirs and fuse plugs allows benefiting from the specific advantages of the two devices: those of the PKWeirs for the usual floods and those of the fuse plugs for the exceptional floods.

   In comparison with a spillway including only PKWeirs, it is possible

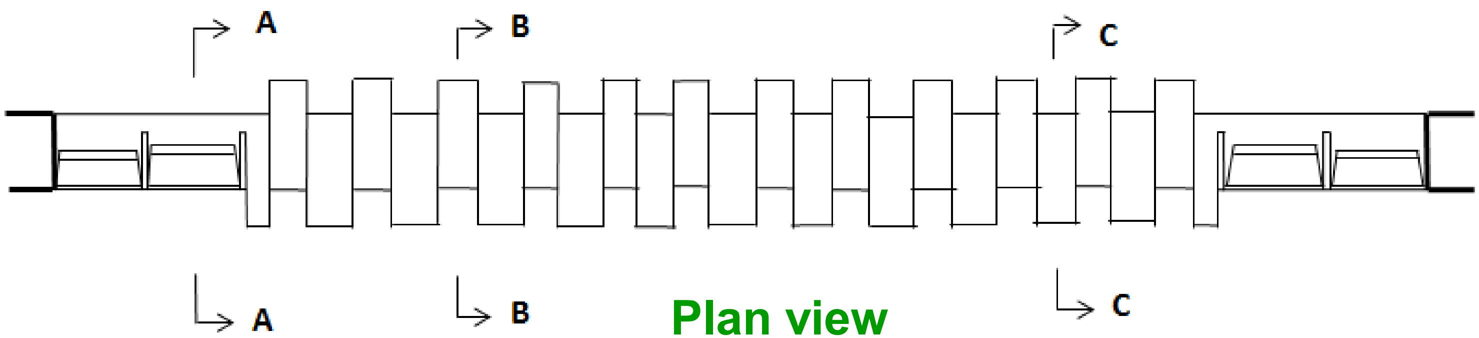
   - **either to increase by 60% the maximum discharge without modifying the spillway length or the nappe depth,**
   - **or to reduce by 40% the spillway length without modifying the discharge or the nappe depth,**
   - **or to reduce by 1/3 the nappe depth without changing the spillway length or the discharge.**

PKWeirs and Concrete fuse plugs

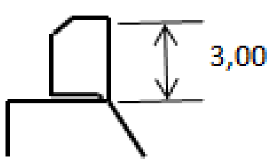
2. The here-below drawings present the general arrangement of the spillway. The figures are for examples below.



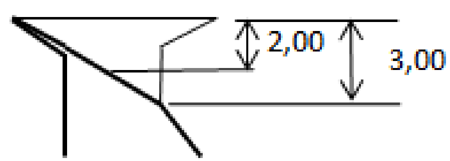
Vertical section from downstream



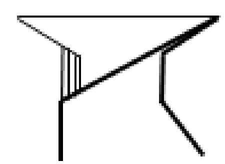
Plan view



Cross section AA



Cross section BB



Cross section CC

PKWeirs and Concrete fuse plugs

3. Two examples are here below presented for a spillway **50 m** long associating concrete fuse plugs 3 m high with PKWeirs elements 3 m high with maximum walls height Pm = 2 m.

The first one includes 2/3 of the length of PKWeirs for 1/3 for fuse plugs which have all tilted for a nappe depth lower than 1 m. The table here below shows the order of magnitude of the corresponding maximum discharges to be compared with those of a spillway of same characteristics but including either 100 % of PKWeir or a Creager wear.

Before tilting of the first plug, a nappe 0.85 m depth allows to discharge about 200 m3/sec, i.e. 40 % of the maximum discharge, percentage which represent for instance the 100 years flood.

2/3 PKW and 1/3 Plugs	490 m^3/sec
100% PKW	300 m^3/sec
Creager	110 m^3/sec

Discharge for a 50 m length and 1 m nappe depth

PKWeirs and Concrete fuse plugs

The second example includes 1/3 of the length of PKWeirs for 2/3 for fuse plugs which have all tilted for a nappe depth h = 2 m. The corresponding discharges are indicated in the table here below.

Before tilting of the first plug, a nappe 1.70 m depth allows to discharge about 330 m3/sec., i.e. 1/3 of the maximum discharge.

1/3 PKW and 2/3 Plugs	1 000 m^3/sec
100% PKW	610 m^3/sec
Creager	300 m^3/sec

Discharge for a 50 m length and 2 m nappe depth

It appears that the increase versus a solution 100% PKWeir is about 60%.

PKWeirs and Concrete fuse plugs

4. Similar results could be obtained using Fusegates or flap gates instead of fuseplugs.