ICOLD CONGRESS
P.K. WEIRS WORKSHOP
CONCLUSION AND PERSPECTIVE
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Existing spillways

- 10.000 « Large Dams » have gated spillways; their flow per m is most often between 20 and 100 m^3/s but may reach 150 m^3/s. It is now the main solution for extreme floods over some thousands m^3/s.
- 50 000 « Large Dams » have free flow simple Creager Spillways with flow per m most often between 5 and 20 m^3/s . It is the usual solution for extreme floods under 1.000 m^3/s.
- Some hundreds « Large Dams » use Alternative Solutions: Free Flow Labyrinth Shapes or various Fuse Devices. These alternative solutions could be much more usual for future « Large Dams » .
- Hundreds of thousands Small Dams, lower than 15 m, have usually free flow Creager Spillways with most often a flow per m under 5 m^3/s.

Gated spillways

- A main advantage of a gated spillway is the possibility of managing the reservoir.
- A serious drawback is the risk of a wrong use of gates and especialy of gates remaining closed during a flood and a failure even for a moderate flood.
- This advantage may be kept and this drawback avoided if gates are used only for a part of extreme floods and associated with free flow spillways or fuse devices

Free Flow Spillways

The main use of Large and Small Dams is the water storage and especially the seasonal water storage which is much reduced for many dams by siltation after decades. For most « Large Dams » with free flow spillways, the average useful reservoir depth is about 5 m; for hundreds thousands small dams it is 2 or 3 m.
The rate of failure of small dams by floods is rather high in many countries with much rain along few monthes.
Increasind storage or reducing the rate of failure may be obtained by Labyrinth shapes reducing the nappe depth for a same flow.

Labyrinth and P.K. Weirs

Some dozens labyrinth free flow spillways were built before 1970, most with small capacities and vertical walls. But the UTE dam in U.S with vertical walls had a capacity of 15.000 m^3 /s and two spillways in Algeria had inclined walls, the most important being Beni Bahdel.

Since 20 years many studies and model tests have been devoted to various shapes of labyrinths with inclined walls, then called P.K. Weirs, first in France and Algeria, then in many countries including Belgium, India and Vietnam. The efficiency has been much improved as compared with vertical walls labyrinths and the flow per m^2 of nappe depth reaches easily three-fold the flow of a traditional Creager spillway. P.K. Weirs have been built since 15 years:

- 15 existing dams in France have been improved by P.K. Weirs most from Electricité de France with capacities between 100 and 1.000 m^3 /s,
- 5 new dams have been built in Vietnam with P.K. Weirs and a capacity over 5.000 m^3 /s.

About 20 P.K. Weirs have been built or are under design in other countries.

The figures above do not include some dozens of fusegates with Labyrinth shapes include below, as Fuse Devices.

Fuse Devices

Fuse Devices are opening for exceptional floods by bending, tilting or erosion for exceptional flood; they are lost and replaced within some days or years. At least five solutions have been used.

- About 100 fuse dykes of large capacity have been built in U.S. and China last century. Their failure by overtoping may take much longer time than foreseen and this solution is not much used presently:
- Thousands small spillways in U.S. have used Flash Boards for small flows: usually made by wood boards standing against vertical steel pipes. They are not expensive but limited to small heights and lacck failure precision.
- Fusegates tilting for a precise reservoir level have been used for about 50 dams. Most have labyrinth shapes. The Capacity may be rather low but reaches 15.000 m^3 /s for Canton Dam in U.S and 20.000 m^3 /s for Wanakbori in India.

Two new solutions seem promising:

- Concrete Fuse Plugs tested in Vietnam which may be used for hundreds or thousands m^3 /s.
- Vertical simple steel plates over a Creager Weir for increasing at low cost reservoirs level by 0.5 or 1m (**F**use **S**teel **P**lates: F.S.P.). They could be used instead of Flash Boards and apply to many future or existing spillways for some dozens/or hundreds m^3 /s. Model tests have been made in Algeria (Biskra).

Which Spillways for Future Dams?

For most future dams, traditional solutions should be compared with alternative solutions which will often be more efficient and/or less expensive. As example:

- P.K. Weirs are very promising for spillways capacity between 100 and 10.000 m^3/s and could be there the most usual solution.
- Fuse Steel Plates (FSP) appear very promising for spillways capacity under one or few hundreds m^3/s.
- Concrete Fuse Plugs may replace many traditional Creager Weirs.
- Fuse gates which associate the advantage of Labyrinth shape with the capacity of a fuse device may be used for various capacities and reach over 10.000 m^3/s.

The rôle of Gates for future dams

The huge capacity per m which may be obtained by new Free Flow solutions may much reduce the use of gates for all spilling capacity.
But keeping gates for a minor part of it may be advisable for managing the reservoir when limiting the impact of gates jamming. This may apply for small or large overall spilling capacity.
The need of gates operators will be much reduced.

Associating P.K. Weirs with Concrete Fuse Plugs for new dams

Devoting half of a spillway length to P.K.Weirs and half to Concrete Fuse Plugs tilting for floods of 1% probability appears a very safe and cost effective solution especially for overall capacity over 1.000 m^3 /s.

Criteria of comparizons

Traditional criteria may be unadapted to comparizons between traditional and new solutions.
As example the traditional « Design Flood » criterium may favour the choice of a gated dam when a Labyrinth solution such as P.K Weirs may be safer and less expensive. For most embankment dams the key criterium could be the probability of overtopping.

Improving Existing Dams

P.K. Weirs or various fuse devices presented above may apply to thousands existing « Large Dams » and to dozens thousands Small Dams; many dams data may be specifics.
Ministries or Owners in charge of many dams could first identify by a general study 5 or 10 % of dams which deserve much safety or capacity improvment. The cost of such general study about needs and not about solutions is not much expensive.
The experience of Electricité de France may be usefull and selected about 10% dams to be improved.

Conclusion

Spillways of Future Dams could be very different from the traditional ones.

P.K. Weirs appear one of the most promizing. Their technical data are now well defined.

Their future is mainly linked with solutions in each country for promoting them as well as other innovative solutions.