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STUDY OF FUSEGATE ON WANAKBORI WEIR

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Abstract - *Wanakbori weir is situated on Mahi River near village Wanakbori of Balasinor Taluka, Kheda District in Gujarat State. Wanakbori weir is equipped with 33 independent free standing concrete fusegate units. The 33 fuse gates will remain stable for reservoir level up to 75.25m (242.82') this allowing to control of a flood of about a 50% of the design Flood. For the higher discharges the elements will fuse progressively. Government of Gujarat has implemented this innovative Fusegate technology through Hydroplus International, FRANCE. Hydroplus International experiment this innovative technology of Fusegates on Lussas Dam near Aubenas in South-Central France in the year 1991. In India, this Fusegate System was first implemented in Gujarat state on Wanakbori weir. An agreement was made between the Government of Gujarat and the Hydroplus international France on date 24/2/1994 for study, design, model testing, supply and installation of Hydroplus fusegates on Wanakbori weir. Fusegates are of 20 meter-wide and 2 meter-high comprising each one pressure inlet well in its center. This study gives information about Fusegate on Wanakbori weir. After installation of Fusegates, reservoir storage capacity has been increased, command area has been increased and cropping pattern has been change and thereby increased canal capacity and firming of irrigation. Fusegate system can raise Full Reservoir Level, Storage capacity and Spillway discharge capacity without affecting Maximum Water Level and additional submergence. This system proved best alternative compare to other gate system and it found cheaper in long run.*

Key Words*: *Fusegate, Weir, Discharge, Storage, Spillway

1. INTRODUCTION

Mahi is a river in western India. It rises in Madhya Pradesh and after flowing through the Vagad region of Rajasthan, enters Gujarat and flows into the Arabian Sea. Mahi river rises in the western Vindhya Range, just south of Sardarpur and flows northward through Madhya Pradesh state. Turning northwest, it enters Rajasthan state and then turns southwest to flow through Gujarat state through the north of Vadodara city outskirts and enters the sea by a wide estuary past Khambhat after about a 360 mile (580 km) course. The silt brought down by the Mahi has contributed to the Gulf of Khambhat and the abandonment of its once-prosperous ports. The riverbed lies considerably lower than the land level and is of little use for irrigation.

Fig -1: Wanakbori Weir

Table -1: Basic Features of Wanakbori weir

Location	Village: Wanakbori, Ta: Balasinor Dist.: Kheda
Purpose	Irrigation
River	Mahi
Area of catchment	30665 km^2
Mean annual runoff in the catchment	7950 Mm3
Mean annual rainfall	880 mm
Year of commencement of construction work	1948
Year of completion	1980

The main purposes of installation of gates are irrigation, Hydropower, Storage of surplus water, Flood control and Water supply. Mahi main canal provides irrigation water for 12 months to Kheda, Anand and Mahisagar District. Its irrigation capacity is around 2 lacs hector of above mentioned region. It also provides drinking water to Ahmedabad city.

Government of Gujarat has installed fuse gates on 12 irrigation projects. Out of these 12, one comes under Major irrigation scheme. While other 11 comes under Medium irrigation schemes, which has no control points in upstream.

Table -2: Reservoir Details of Wanakbori weir

Area at full reservoir level	20.86 Km^2
Gross storage capacity	41.91 Mm^3
Effective storage capacity	36.24 Mm^3

Area under submergence		
a) Forest	b) Waste land	c) Culturable
(a) + (b) + (c) = Total 2086 ha		
No. of villages under submergence	24 Nos	

1.1 Fusegate

Francois Lemperiere invented original system of submersible Fuse gates in 1989 in France. Hydro plus International Company established in 1991 to develop and operate the Fuse gate device. HYDROPLUS® Fusegates™ received trademark and patented in 1991. Hydro plus International experiment this innovative technology of Fuse gates on Lussas Dam near Aubenas in South-Central France in the year 1991.

Wanakbori weir is equipped with 33 independent free standing concrete fusegate units of 20 m wide and 2 m high comprising each one pressure inlet well in its center. The total length of spillover is 673.608 m. the total length of fuse gate is 22 x 33 = 660 m. So 13.608 m remaining length as the weir about 6.80 m long on each extremity, is equipped with fixed concrete element without well. The increase of the weir crest level by 2 m allows an extra storage of 900 Mcft and also an increase of the discharge capacity in the irrigation main canal by increasing driving head. The 33 fuse gates will remain stable for reservoir level up to 75.25 m (242.82') this allowing to control of a flood of about a 50% of the design Flood. For the higher discharges the elements will fuse progressively. Fusegate are so designed that at predetermined spill water level, fusegates will start collapsing and which will allow higher flood to pass. However, moderate flood can pass over crest of fusegates.

There are 33 fusegates and 2 fix end blocks constructed on Wanakbori weir. Now crest of the Wanakbori weir is increased from R.L 220.60 ft to 227.36 ft. Work of installation of Hydroplus fusegates was completed in June 1995.

Table -3: Cost of Fusegate

	Original estimated cost	Revised estimated cost
Fusegate	737.50 lacs	962.00 lacs
Civil work	120.50 lacs	193.59 lacs
TOTAL	858.00 lacs	1155.59 lacs

1.2 Concept of Fusegate system

Freestanding units are set freely side by side on spillway sill to form a watertight barrier.
Each unit bears against hydrostatic pressure from U/S reservoir small abutment blocks located at the downstream edges. Units weighted with ballasts to resist hydrostatic pressure. Drain holes are provided to remove any leakages along the under face.

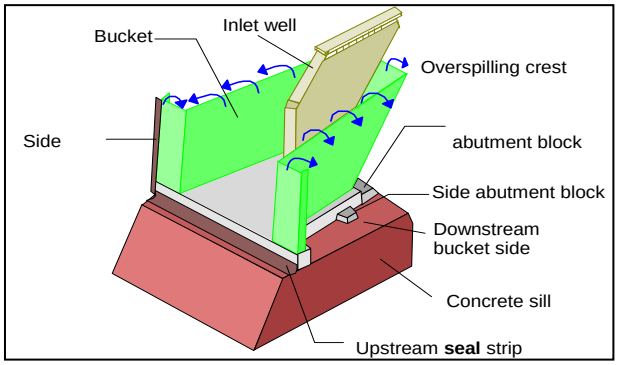

Fig -2: Typical Labyrinth Fusegate

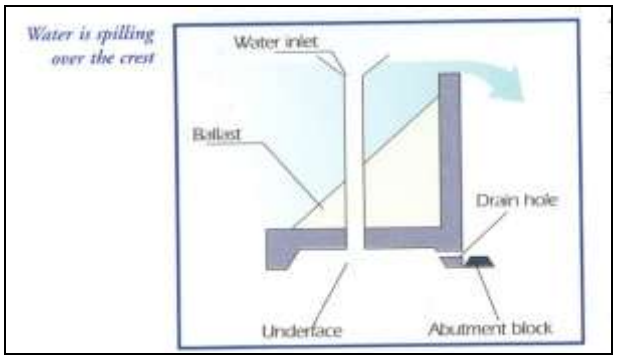

Fig -3: Phase-1 of Fusegate

A water inlet well admits water to the under face when the headwater reaches at specified level which is higher than the crest of each unit.

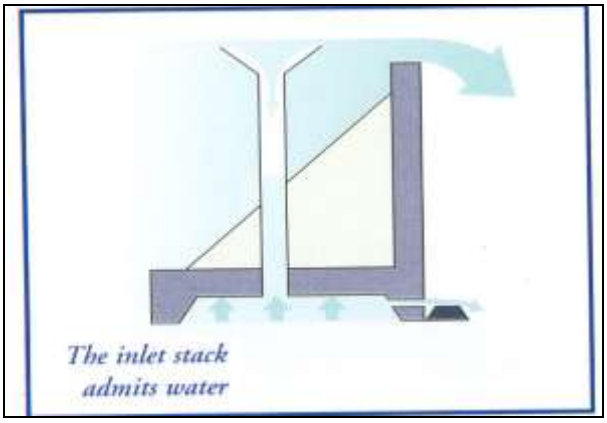

Fig -4: Phase-2 of Fusegate

These together form a Fusegate system. Water is admitted to the under face when the reservoir water level rises above the lip of the inlet stack when the drain holes cannot discharge the whole flow pressure starts building up under the Fusegate and eventually causes it to Fuse off from the sill and roll down stream.

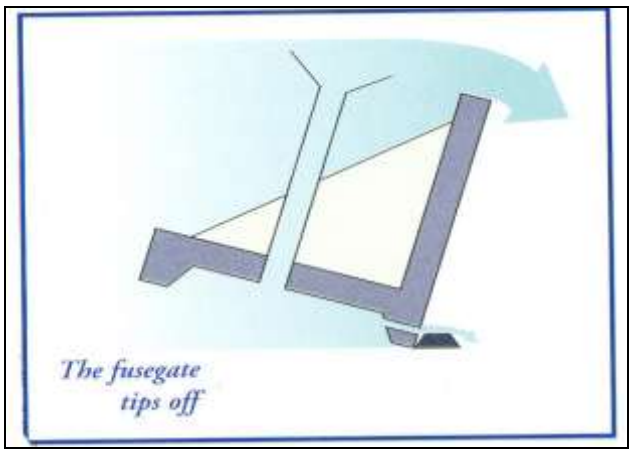

Fig -5: Phase-3 of Fusegate

The Fusegates have the top edges of their inlet stacks at different heights to control the sequence in overturning of units as head water level continues to rise. Therefore, Fusegate concept ensures increase in storage, all types of flood discharge of spillway and small and moderate flood discharge over the watertight barrier of it. Large flood discharges through an ever-increasing opening as the required number of units gradually fuse from the spillway sill.

1.3 Special Advantages of Fusegates

- In traditional ungated system, loss of live storage capacity with respect to dam height remains high which can be as much as 1/3rd of the potential full capacity.
- While in gated system, frequency of gate failure remains high due to structural defaults, power supply interruption and/or general mal-operation.
- Fusegate receives the advantages of both gated and ungated system and avoids their disadvantages.
- Moreover, this Fusegate System is self-operating, ensures dam safety, high reliability and cost effective. Its maintenance cost is nearly minimum and supervision requires nearly less. This system can be applicable to all types of irrigation projects (Minor, Medium & Major).
- It can be applicable to existing as well as new dams.
- It optimizes spillway capacity, increases reservoir storage capacity and Dam safety without raising MWL.
- It can design according to safety margin for all types of weir.
- Fusegates can be capitalized and cheaper in longer run.
- It can also have utilized in river retentions basin and flood risk management.

2. ANALYSIS

2.1 Discharge of Wanakbori Weir

Table -4: Discharge of Wanakbori Weir

Discharge Before Fusegate	
Year	**Discharge In Cusecs**
1959	735930
1960	240140
1961	454470
1962	670790
1963	207300
1964	45530
1965	36950
1966	64090
1967	369070
1968	676260
1969	300560
1970	392570
1971	250830
1972	201726
1973	1436000
1974	286412
1975	577910
1976	937040
1977	468470
1978	596000
1979	259000
1980	232824
1981	759645
1982	107915
1983	143620
1984	582700
1985	1770
1986	385375
1987	503917
1988	409430
1989	40270
1990	1034536
1991	543687
1992	1027
1993	520061
1994	750808

Discharge After Fusegate	
Year	**Discharge In Cusecs**
1995	37460
1996	353600
1997	507000
1998	339172
1999	0
2000	0
2001	0
2002	0
2003	79145
2004	444526
2005	75606
2006	1150000
2007	519600
2008	0
2009	21767
2010	2598
2011	358216
2012	588575
2013	336101
2014	220000
2015	193019
2016	479624

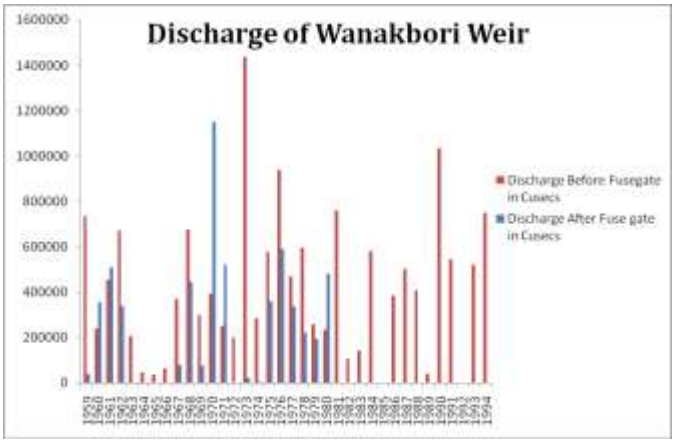

Chart -1: Discharge of Wanakbori weir

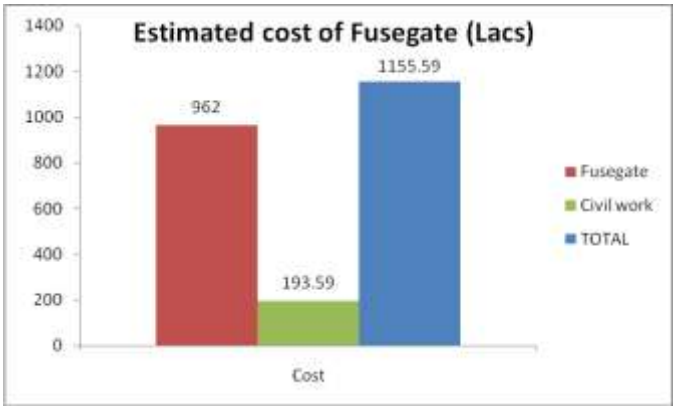

Chart -2: Estimated Cost of fusegate

Table -5: Falling Sequence and RL of Fusegate

Falling Sequence	US Level For Tilting R.L IN M	Nos of Fusegates Tilting	Serial No Of Fusegates Tilting
1	75.25	1	30
2	75.38	1	26
3	75.51	1	21
4	75.64	3	27,28,29
5	75.77	3	4,5,6
6	75.9	4	19,20,24,25
7	76.03	4	1,2,3,33
8	76.16	4	7,8,9,10
9	76.29	4	15,16,17,18
10	76.42	4	22,23,31,32
11	76.55	4	11,12,13,14

2.2 Fusing of Fusegate

Fusing of Fusegate is common phenomenon related with Fusegate Technology.

Risk of simultaneous fusing of Several Fusegate

A specific water level can define leading to simultaneous overturning of several Fusegates as a group (one Main Fusegate + 2 Side Fusegates). The calculation of relative flow increase at the overturning period done. Verification needs to done that this relative flow increase is inferior or equal to 30 % for each Fusegate group.

In order not to create an unexpected additional flow the difference between reservoirs level provoking the overturning of different Fusegate group must not be inferior to the this different will be superior or equal to 5cm. group overturning.

Carried away Fusegate

After fusing of Fusegate phenomenon, Fusegate must size according to possible obstacles. They could meet downstream after overturning and carried away. Then, Fusegate blockage on construction situated downstream of the dam will not occur.

Overturned Fusegate

Damage on overturned Fusegate risk is important for their mending to be profitable compared because of bucket deformation and possible base degradation.

For a new dam project, it will be judicious to arrange a caring for Fusegate handling used for the first setting of fusing of Fusegate. Fused Fusegate can replace for next crop season. Fused Fusegates creates loss of water storage for that season. Eventually the reservoir will fill again up to full supply level original before Fusegate install level but any when the missing Fusegate has been replaced. These drawbacks of loss of water and loss of Fusegate are very limited. In addition, the use of cofferdam device enables FSL to maintain in the reservoir until Fusegate replacement.

Reinstallation of Fusegate

Major flood would lead to the fuse off one or several Fusegates. Installed Fusegates were designed in such a way that one or several would tip off at some percent (40 to 60%) of designed flood or an inflow of respective Cumecs within the range height. After first fuse off, remaining Fusegates fuses one by one as flood increases.

If any tip off incidence occurs at that time extra, Fusegate should constructed according to H.I specification. H.I. should contact before initiating any action prior to reinstallation of Fusegate.

The spillway must clean properly before installation. The Fusegate should set exactly at the same position, as the original was.

Attentions for reinstallation of Fusegate

Particular care should be taken in earth dam regard to the vertical gape (between the base of the Fusegate and the spillway sill) to be maintained & kept minimum. This gape kept at a 3 mm average on the side or downstream of the chamber can reduced below 3mm average by nailing galvanized plates to fill gaps. Hot deep galvanized plates 4 mm thick, 100 mm high, nailed against base of the Fusegate to reduce the gap between the spillway sill& the under face of the Fusegate in case of Fusegate fusing, it is necessary to nail new M.S. plates if the gap exceed an average height of 4.5 mm.

3. CONCLUSIONS

Fusegate increases Full Reservoir Level, Live Storage Capacity and annual irrigation without affecting MWL on Wanakbori weir. Due to installation of fusegates dependable storage increases which can be used for assured irrigation supply, which earlier was nil or erratic. Whole region will benefit due to installation of Fusegates, without expenses on major civil works, except minor maintenance and modification in canals. This will result in overall economical and time saving solution.

Although there may be some possibilities of submergence due to installation of Fusegate however it will not be appreciable compared to increase in annual irrigation and its dependability. Reinstallation of Fusegate will recover the storage capacity of dams hence loss of storage due to fusing of fusegates and silting can recovered to greater extent without much expense on desilting etc. Reinstallation of fusegates will benefit not only Kheda district but also other part of the Mahi irrigation command during scarcity year. Rainfall is erratic and unevenly distributed in Gujarat. Sometimes maximum daily rainfall is as high as half of the total rainfall in such situation this maximum rainfall can be possible to store after installation of Fusegates by avoiding wastage of water.

From analysis it is found that reinstallation of Fusegate justifies the cost effectiveness of the system. Fusegate does not require replacement of seals and anticorrosive paint thereby proved economical long-term maintenance. Fusegates installation is easy and rapid hence it proved the fast and effective solution in water scares condition, which becomes acutely sever in period before monsoon, in most of the dams. Fusegates are flexible structures and no effect noticed regarding deformation, displacement of gates on weir from earthquake on dated 26/1/2001, hence its reinstallation can considered as safe by the aspects of earthquake forces.

Fusegate fuses during heavy flashy flood to save earthen dams, downstream lives, properties, cattle and farming. Fusing of fusegates one after another planned to avoid sudden rise in out flow. In 2006 Fusegate fused exactly as per predetermined water level and fusing flood keeping earthen dam safe during/after flashy flood, hence their reliability and safety of operation during high spillage proved. B/C ratio for after installation of fusegate is more than before installation of fusegate indicating increased in overall benefit.

REFERENCES

[1] P. Garec, H.I. France, "FUSEGATE INCREASE STORAGE CAPACITY AT FOUR DAMS IN GUJARAT".

[2] Henry T Falvcy, "Hydraulics and Design of Fuse gates ", Journal of Hydraulic Engineering, ASCE, July 1995, pp.512-518.

[3] Q.H.W. Shaw, D.G. Cameron -Ellis and W.D. Hakin, "Fuse gates enhance safety and increase capacity at Eikenhof", hydro power& Dams Issue Six, 1999, pp.46.

[4] Sebastien Lacroix, "Use of Fuse gates for improving dam safety", Chinese journal of geotechnical engineering, November 2008, pp.1699-1706.

[5] Gaurang i. joshi, N J. Shrimali, Dr. A C. Patel, "performance of fusegates on weir", international journal of civil engineering, 2003.

[6] Mr. Pratik N. Solanki, Dr. N. J. Shrimali, Prof. H. M. Gandhi, " Study Of Fusegate System On Dhatarwadi Dam In Amreli, Gujarat", Journal Of International Academic Research For Multidisciplinary, 2nd March 2014.

[7] http://www.hydroplus.com