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US EXPERIENCE WITH FUSEGATES FOR SPILLWAY INADEQUACY REMEDIATION (*)

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1. INTRODUCTION:

With more than fifty applications around the world ranging from 0.9 m to 9 m in height, the Fusegate System has gained significant international recognition over the past few years as a reliable spillway control system. It consists of free standing blocks, which are set on the spillway sill and designed to tip off automatically and consecutively in case of extreme flood events. The system is typically used to increase spillway discharge capacity and/or reservoir storage capacity. Upon successful performance at Terminus dam in California, the US Army Corps of Engineers (USACE) has been considering the system for more projects. The Otter Brook and Canton dams are other examples of different ways this system can be applied to bring dams with undersized spillways to up to date safety standards.

- The first scenario (implemented at Otter Brook dam) involves the modification of the existing spillway; the sill is lowered in order to increase its discharge potential and the storage capacity is recovered with Fusegates.

Otter Brook dam is owned and operated by the USACE, New England district. The reassessment of hydrology has increased the Probable Maximum Flood (PMF) peak from 1076 m3/sec to 1835 m3/sec. The USACE has selected the alternative which involves removing the ogee weir and recovering the storage capacity with the installation of six 2.7 m high 7.3 m wide Fusegates on the lowered sill. The project was completed in 2005.

- The second scenario (implemented at Canton dam) involves the addition of an emergency spillway equipped with Fusegates in addition to the existing service spillway with Tainter gates; the combined spillways allow for the safe discharge of the design flood.

Canton dam is owned and operated by the USACE, Tulsa district. An extra 7787 m3/sec of discharge capacity was required to ensure a safe evacuation of the PMF. The USACE has adopted a solution which involves construction of a new emergency spillway equipped with Fusegates. Excavation works for the 146.3 m wide and 609.6 m long spillway channel are expected to start late 2008. Once completed, the 9.1 m high Fusegates will set the new record for the tallest in the world.

2. THE FUSEGATE SYSTEM:

The Fusegate System is a non-mechanical spillway control technology to increase reservoir storage capacity and/or to increase spillway discharge capacity.

Fusegates are free standing blocks placed side by side on a spillway sill to form a watertight barrier. The Fusegate System operates as a straight or labyrinth crested weir divided into segments or individual “Fusegates”, each forming one component of the weir. Each gate consists of three components; a bucket made of metal or reinforced concrete, a base, and an intake well that is connected to a chamber in the base. Each Fusegate sits on the modified spillway sill and remains in place only by gravity. Toe abutments (lugs) anchored into the sill prevent them from sliding in a downstream direction. Accumulation of seepage water in the bottom chamber is prevented by providing each chamber with two drains. The joint between adjacent Fusegates is sealed with a flat rubber gasket. Fusegates can increase both spillway capacity and reservoir storage. For a retrofit on an existing spillway, a portion of the ogee crest is removed and provided with a flat surface. If the goal of the retrofit is only to increase spillway capacity, the crest of the Fusegates is set near the original ogee crest elevation. If the purpose is to increase storage, then the crest of the Fusegates is set above the original ogee crest elevation. For discharges up to the design flood, the Fusegate functions like an aerated labyrinth weir. Typically, the design flow is chosen to be the discharge with a return period of about 100 years or above. For discharges greater than the design flow, water begins to flow through the well and into the chamber located in the base of the gate. When the overtopping flow reaches the selected design pool elevation, the designated Fusegate(s) will tip downstream, thus increasing the discharge capacity of the spillway. The tipping is initiated by water entering into the base chamber of the Fusegate via an intake well set at tipping design elevation. Once water enters into the base chamber, the uplift pressure rapidly increases, causing the Fusegate to rotate about the toe abutments and tumble downstream. By modifying the ballast provided for each Fusegate and the elevation of the intake well, each Fusegate can be designed to tip at a different (pre-determined) pool elevation so that an excessive flow increase does not occur downstream. Small drain holes exist at the base of the Fusegates to help drain any leakage through the seals so that uplift pressures do not occur until water elevation reaches intake wells.

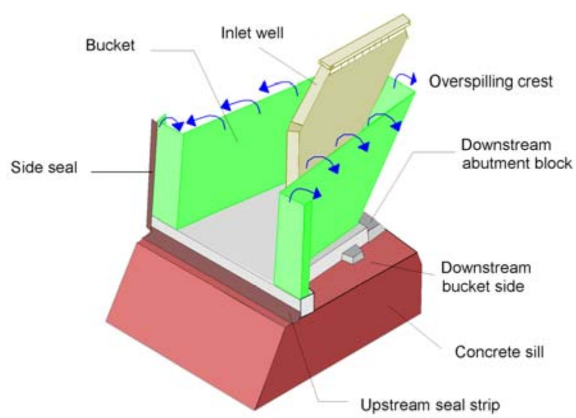

Fig. 1
3-D view of a Fusegate

Inlet well
Bucket
Side seal
Upstream seal strip
Concrete sill
Downstream bucket side
Downstream abutment block
Overspilling crest

The crest of the well in each Fusegate is set at a different elevation so the gates do not tilt in unison. In this manner, the increase in discharge over the spillway, as a function of reservoir elevation, can be precisely controlled. Fig. 1 and 2 show the three dimensional views of a labyrinth crested Fusegate.

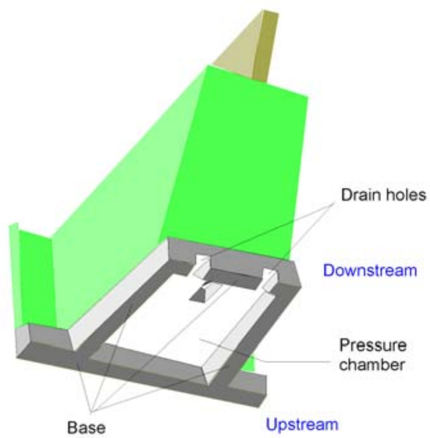

Fig. 2
Bottom view of a Fusegate

Base
Upstream
Pressure chamber
Downstream
Drain holes

3. OTTER BROOK APPLICATION

3.1 PROJECT BACKGROUND

Otter Brook Dam, located near Keene, New Hampshire was constructed in 1958 as a flood control structure on a tributary of the Connecticut River. It is owned and operated by the USACE, New England District. The dam consists of a 40.5 m high and 392.6 m long rockfill embankment impounding 22203 dam3 of water to control 121.7 km2 of basin area. A pool of 6.1 m depth is maintained behind the dam for recreational purposes. The remainder of the storage volume is available for floodwater containment.

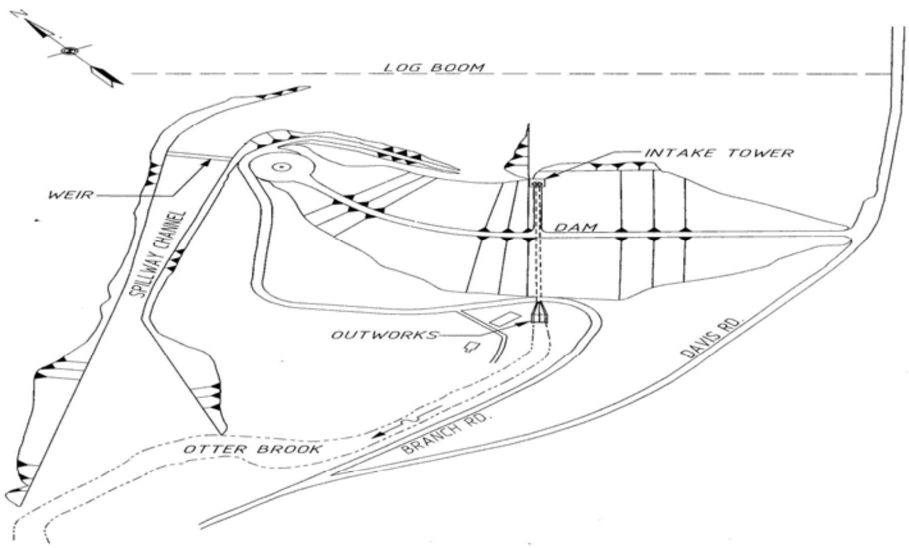

Fig. 3
Otter Brook dam plan view

Log boom
Weir
Spillway channel
Dam
Intake tower
Outworks
Otter Brook
Branch Rd.
Davis Rd.

The embankment constitutes a flow restriction, with resultant outlet capacity of up to 37 m3/sec with the pool at the spillway crest. The water is dammed from a channel invert elevation of El.208.2 m, up to the spillway crest elevation of El.238 m and up to a top of dam elevation of El.244.5 m.

There was a 44.2 m wide concrete ogee spillway with a gently sloped (1% grade) 91.4 m long unlined approach channel and a more steeply sloping unlined spillway exit channel (8.2% grade, reducing after 182.9 m to 4.7% grade). The discharge capacity of this spillway was 963 m3.

Flood routing simulations based on the updated storm data have revealed that the dam would be overtopped by 30.5 cm during a PMF event as the new spillway discharge capacity requirement was to pass 1642 m3/sec.

3.2 THE SHORTLIST OF OPTIONS CONSIDERED

Initially reviewed were options to raise the dam, widen the spillway, lower the spillway, store floodwaters, remove the dam, and construct an extra spillway. Six basic options were then selected for more detailed study. These were the options to:

1. replace the spillway weir with Fusegates, by either:

1.1 raising of the dam 0.9 m in order to maintain 1.0 m freeboard, or

1.2 excavation to reduce the sill level and restore the sill elevation by Fusegates

2. raise the dam 40 cm and widen the spillway 15.2 m.
3. raise the dam 1.0 m and widen the spillway 7.0 m.
4. add a partial fuseplug mechanism through either

4.1 an erodible fuseplug 20.4 m long as a new auxiliary spillway to supplement the existing spillway, or

4.2 a mechanical spillway 20.4 m wide as a new auxiliary spillway to supplement the existing spillway

5. remove the existing spillway weir and excavate the spillway channel down 0.9 m to obtain a new crest "weir" capable of passing the PMF
6. widen the spillway the full 23.8 m required to maintain an acceptable freeboard without raising the dam. Options 5 and 6 increased downstream flows for significant storms smaller than the PMF, and so some investigation of design and historical storms needed to be performed.

3.3 PROPOSED FUSEGATE DESIGN

Option 1.2 was selected as the most viable, since it limited the construction to the existing spillway weir structure and approach channel, requiring wetland mitigation in the upstream wetland only. Under this scenario, the existing concrete spillway was removed and its foundation was excavated down to elevation El.235.3 m. A new broad crested concrete weir was then constructed with the same top elevation as the existing spillway, which formed the base for Fusegates. This ensures that the existing capacity of the reservoir and flood attenuation behavior is not compromised. The Fusegates will topple over as the upstream water level in the lake is increased due to the extreme storm, thus increasing the capacity of the spillway channel. Fig. 4 shows the three dimensional view of a straight crested Fusegate, which offered the most suitable type of Fusegate for the Otter Brook application.

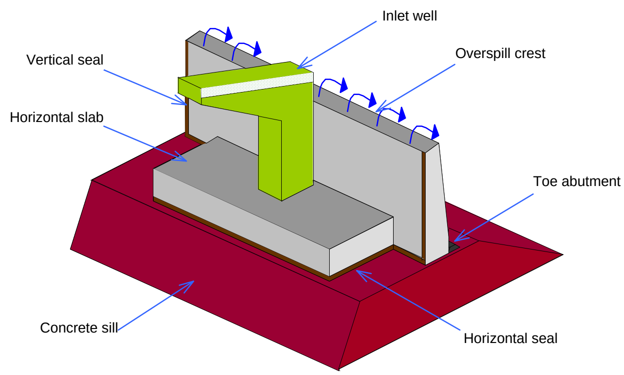

Fig. 4
3-D view of a straight crested Fusegate

Vertical seal
Horizontal slab
Concrete sill
Horizontal seal
Toe abutment
Overspilling crest
Inlet well

The choice to excavate in the spillway approach channel, rather than raise the dam, saved the construction costs for a wall on the upstream side of the dam and avoided the need to raise the threshold of the control structure. Excavation on the environmentally sensitive east bank of the downstream channel is avoided through the use of a 80.8 m long dike, which is needed to contain the floodwaters within the spillway discharge channel.

The Otter Brook application includes the installation of six 2.7 m high 7.3 m wide straight crested Fusegates on a newly constructed 44.3 m long and 3.4 m wide concrete spillway platform. The top of the platform was set at El.235.3 m on the 36.9 m long portion of its right bank and at El.236.5 m on the remaining 7.4 m long section on the left bank. The higher section of the platform was designed to accommodate the last Fusegate to tip for the full PMF, thereby protecting the wetland located downstream from frequent overspilling. The approach channel was excavated in such a way that it sloped down to El.235.0 m at the spillway sill location with a 1% gradient. No major excavations were required downstream of the new sill. 18 cm wide abutment walls were to be constructed on the left and right banks of the spillway to support the watertight seals that were installed between the Fusegates and the spillway abutments. A 22.9 cm thick pier was also constructed between the lower and elevated sections of the platform to install the watertightness seals on two adjacent Fusegates.

The Fusegates at Otter Brook are designed to tip for extremely low probability events. The first Fusegate will tip for a flood corresponding to 55% of the full PMF. Considering that the first and only time water has flown through the spillway was in 1987 with the water level 0.5 m above the spillway sill, the magnitude of such a flow, which creates a 4.7 m high water elevation above the sill, can be better understood.

3.4 Construction stage

The construction works at Otter Brook Dam began in May 2005. The works consist of removing the existing ogee weir and spillway sill from the spillway channel; excavating the spillway channel floor upstream and downstream of the existing weir; placing a new concrete sill, a concrete pier and concrete abutment walls on both sides of the spillway channel; and installing six Fusegates on the new spillway sill. Associated with this work was also reconstruction of a wetland upstream of the Fusegates and construction of a dike on the left side of the spillway channel. Fig. 5 shows the concreting of the new broad crested weir after the removal of the old ogee weir.

Fig. 5
Construction of the new sill

The Fusegates can be manufactured or constructed either in steel or concrete. Otter Brook Fusegates were made of pre-cast concrete by Old Castle Precast of Auburn, Maine with stainless steel inlet wells. This selected material came out the most economical for Otter Brook with added advantages in terms of long life expectancy and extremely low maintenance costs. The Fusegates weighed 40 tons each at the time of delivery from the plant before their concrete ballasts and inlet wells were attached.

Fig. 6
Pre-cast Fusegates transported to the site

The general contractor for the construction works was George R. Cairns and Sons, Inc. from Windham, New Hampshire. The construction works were delayed for about three months due to 45.7 cm of rain in nine consecutive days during the month of October 2005. The rain caused the swelling of every local brook, stream and river, some beyond flood storage. And at the end, many roads were washed away and many houses were flooded.

After cleaning up works following the October flood, the concreting of the new spillway sill began. In the meantime, the pre-cast Fusegates had been completed and were ready to be shipped to the dam site.

Before the installation of Fusegates, all concreting works related to the new spillway sill, toe abutments and the pier separating the elevated and lower section of the sill were completed except for the side abutment walls.

Fig. 7
Downstream view of Fusegates and lugs

Once the Fusegates were delivered to the dam site, they were directly placed in their final position. Fig. 8 shows the placement of Fusegates and the inlet wells.

Fig. 8
Upstream view during installation

Figures 9 and 10 show the upstream and downstream view of Fusegates after the installation works were completed. The final stage was the excavation works and dyke construction at the left abutment

Fig. 9
Downstream view of Fusegates

Fig. 10
Upstream view of Fusegates

4. CANTON DAM APPLICATION

4.1 PROJECT BACKGROUND

Canton Dam is located on the North Canadian River approximately 125 km northwest of Oklahoma City, Oklahoma. It is composed of an earth filled embankment, 4614.7 m in length with a maximum height of 20.7 m above streambed. The top of the dam is at elevation El.502.3 m. The dam includes a 237.1 m wide service spillway at the right abutment with 16 Tainter gates. Each gate is 12.2 m wide and 7.6 m high. The spillway crest elevation is at elevation El.491.6 m.

Fig. 11
Satellite view of the Canton dam service spillway

Hydraulic studies have highlighted that the existing spillway is unable to discharge the new Probable Maximum Flood and that the dam is likely to fail during major flood events. The discharge capacity of the existing service spillway is 9600 m3/sec and the new PMF studies revealed a total spillway discharge capacity requirement of 17358 m3/sec.

Fig. 12
Upstream view of service spillway

Fig. 13
Downstream view of service spillway

4.2 ALTERNATIVES INVESTIGATED

In order to remediate the spillway inadequacy problem, it was proposed to construct an auxiliary spillway either at the right or left abutment. The Engineering Assessment prepared in 2001 addressed 10 alternative plans dealing with the left abutment. However, further analysis had revealed that the project objectives were not met and the right abutment was selected as the best location for the auxiliary spillway. For the right abutment study, seven alternatives were evaluated; three with Tainter gates and four with Fusegates:

1. Tainter Gates, Sill Elevation El.488.1 m: This alternative consists of five, 15.2 m wide Tainter gates on an agee weir.
2. Tainter Gates, Sill Elevation El.489.5 m: This alternative consists of six, 15.2 m wide Tainter gates on an agee weir.
3. Tainter Gates, Sill Elevation El.490.5 m: This alternative consists of six, 15.2 m wide Tainter gates on an agee weir.
4. Fusegates, Sill Elevation El.490.7 m: This alternative consists of nine Fusegates on a broad crested weir.
5. Fusegates, Sill Elevation El.490.7 m: This alternative consists of nine Fusegates on a broad crested weir.
6. Fusegates, Sill Elevation El.491.3 m: This alternative consists of ten

Fusegates on a broad crested weir.

7. Fusegates, Sill Elevation El.492.3 m: This alternative consists of thirteen Fusegates on a broad crested weir.

The options 4 and 5 are similar in terms of the spillway dimensions and the control system. The difference in alternative 4 is that the excavation material from the new auxiliary spillway would be spoiled at the toe of the dam’s left embankment, whereas, in option 5 the material would be spoiled at an offsite location.

4.3 Selected alternative

The proposed plan is based on option 5 and consists of an auxiliary spillway on the right abutment containing nine Fusegates at a sill elevation of El.490.7 m. The excavated material from constructing the auxiliary spillway would be spoiled below the left embankment to address the seepage and seismic issues. The rotation of the Fusegates would lower the spillway crest elevation, increasing the spillway capacity by 7762 m3/sec to sufficiently discharge the PMF without overtopping the dam.

This alternative was selected as it offered a non-mechanical spillway control system with more economical feasibility on the construction and O&M costs. The projected path of the auxiliary spillway is shown in Fig. 14.

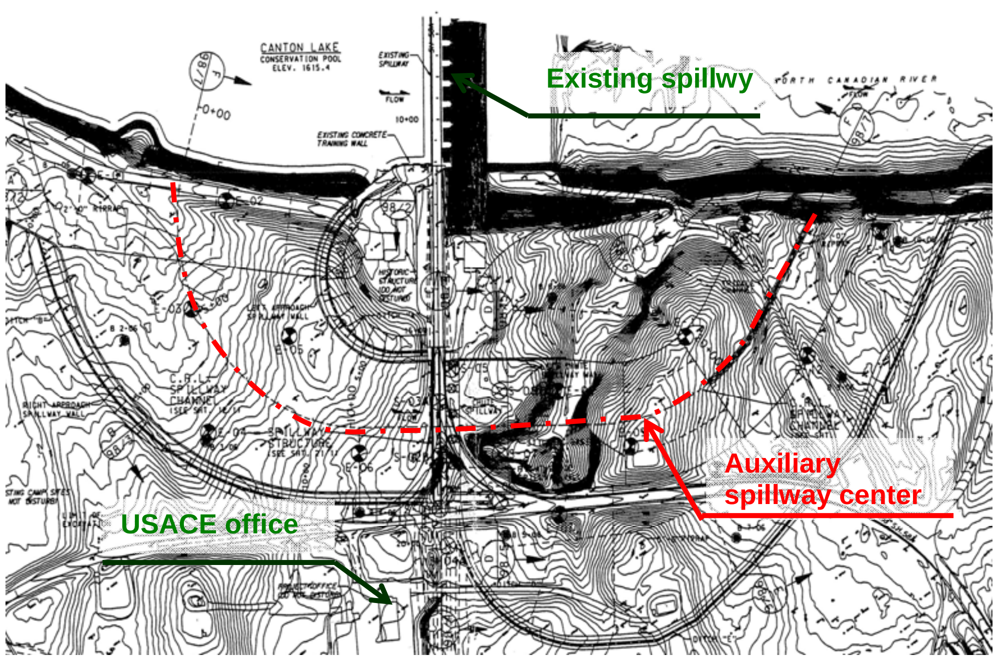

Fig. 14

Proposed location of the auxiliary spillway

Existing spillway
USACE Office
Auxiliary spillway center

4.4 PROPOSED FUSEGATE DESIGN

For Canton Dam, a total of nine Fusegates are required, each 9.1 m high and 16.3 m wide. The nine Fusegates will fit into the 146.3 m wide auxiliary spillway channel.

The Fusegates will be accommodated on a broad-crested weir having an upstream to downstream width of 7.2 m at the control section of the emergency spillway, which is at El.490.7 m. With 9.1 m high Fusegates, the normal pool elevation (Fusegates crest) will be set at El.499.9 m. The approach channel will be maintained at El.488.7 m and there will be a 0.5% slope in the return channel downstream of the Fusegates.

Fig. 15 shows the cross section of the broad crested weir that will accommodate the Fusegates. The Fusegates will be retrofitted on the flat section of the sill denoted as L.

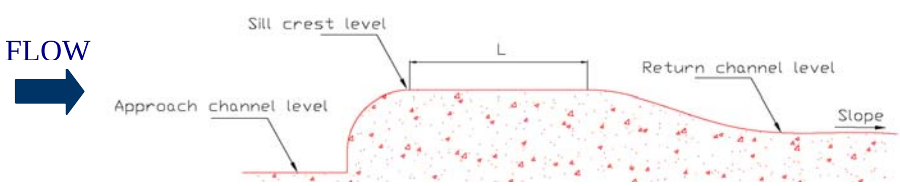

Fig. 15
The proposed cross section of the weir at the auxiliary spillway

Flow
Sill crest level
Approach channel level
Return channel level
Slope

The Fusegates are semi-labyrinth crested and will be constructed in reinforced concrete. The inlet wells will be made of stainless steel. The watertightness will be maintained by installing EPDM seals between the

Fusegates as well as between the Fusegates and the spillway sill. The photo of an example of the semi-labyrinth Fusegates are shown in Fig. 16.

Fig. 16

Photo of the 25 ft high semi-labyrinth Fusegate at Jindabyne dam in Australia

Intake wells are normally constructed as part of the Fusegate. Due to the shallow approach channel and wave action, the intake wells at Canton are gathered within a protective enclosure (called wet well tower) equipped with a bottom port and conduit to allow flow to enter. Pipes embedded in the concrete sill connect individually the intake wells to the base chamber of the Fusegates. A similar arrangement was used in the scope of Terminus Dam project in California.

4.5 Hydraulic features

There will be five tipping sequences for the Fusegates, where the tipping elevations range for a water level between El.500.0 m and El.500.4 m (Maximum Water Level).

Below is the flood routing hydrograph of the PMF through the Fusegated emergency spillway. It will be noted that the maximum flow to be simulated is 17840 m3/sec.

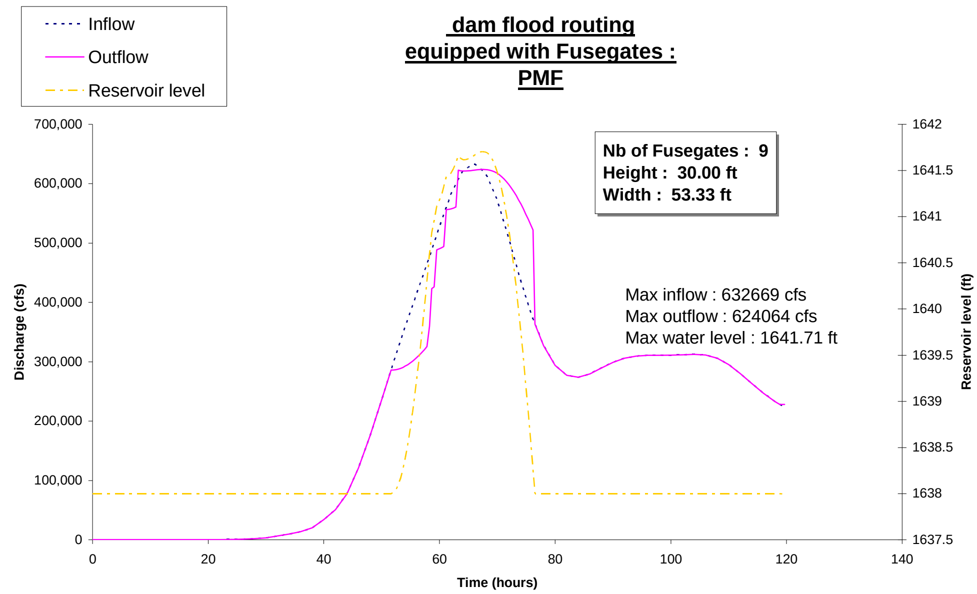

Fig. 17
PMF routing hydrograph of the Fusegated spillway

Inflow
Outflow
Reservoir level
Discharge (cfs)
Time (hours)

The Fusegates are designed to tip consecutively for extremely large flood events. At Canton dam, there will be no spilling over the Fusegates crest before a flood that is in excess of 50% of the PMF. Moreover, the first Fusegate will tip for a flood corresponding to over 58% of the PMF. This probability corresponds to an inflow of 10871 m3/sec.

4.6 Combined Numerical and Physical Model Study of the Auxiliary Spillway

The USACE has decided to perform a model study of the proposed auxiliary spillway in order to optimize the structures and to ensure that the selected configuration will pass the PMF. The model study is being conducted by Alden Research Laboratory in Holden, Massachusetts.

4.6.1 Physical Model Scale Selection

Flow patterns of free surface flows driven by gravity are dominated by gravitational and inertial forces. Hence, physical models of free surface flows are scaled and operated using Froude number similarity, i.e., the Froude numbers of prototype and model, expressed as the ratio of characteristic inertial and gravitational forces, must be equal. Secondary effects such as viscous forces and surface tension have negligible impact on the flow patterns in the prototype, and will have negligible impact on flow patterns in the model as long as model Reynolds and Weber numbers are sufficiently high.

To reduce scale affects in the model, and, in particular, to simulate the Fusegates and their resistance to motion during evacuation as accurately as possible, the largest model scale possible should be chosen. Practically feasible model scales, however, are limited by laboratory resources such as available laboratory space and flow supply pumps, and by model cost. The physical model at Alden Research Laboratory is being constructed as a fixed-bed, undistorted model with a geometric scale ratio of 1:54. This scale ratio was deemed sufficient to reduce scale effects. At this model scale the model Fusegates will be large enough (17 cm high, 30 cm wide) to accurately simulate their geometry, mass and mass distribution and their resistance to motion. The PMF flowrate of 17840 m3/sec prototype scales to approximately 0.9 m3/sec in the 1:54 Froude-scale model.

4.6.2 Physical model description

The model boundaries were selected to represent the reservoir over a distance of 457 m upstream of the auxiliary spillway entrance, or approximately 762 m upstream of the service spillway, and 305 m along the dam to the left of the service spillway. This upstream distance is required to accurately model approach flow patterns to the two spillways, in particular flow around and over the peninsula-shape outcropping (max El.499.6 m) immediately to the left of the service spillway. The orientation of the model inflow boundary was selected to be perpendicular to the expected dominant reservoir outflow direction, based on the natural funnel formed by the reservoir boundaries. The downstream model boundaries were selected to represent the flood plain over a distance of 457 m downstream of the auxiliary spillway exit or approximately 914 m downstream of the service spillway. This distance provided downstream of the confluence of the two spillways is deemed sufficient to achieve accurate representations of tail water levels and flow patterns in the model. Again, the orientation of the model outflow boundary was selected to be perpendicular to the expected dominant flow direction. The physical model dimensions, including two large pumps, flow meter sections and in- and out-flow control devices are 33.5 m x 21.3 m.

Fig. 18 shows the existing service spillway and the proposed auxiliary spillway. The peninsula shape topography can also be seen at the left side of the service spillway. At the upper right corner of the figure, two pumps are located, which will supply water for the mode.

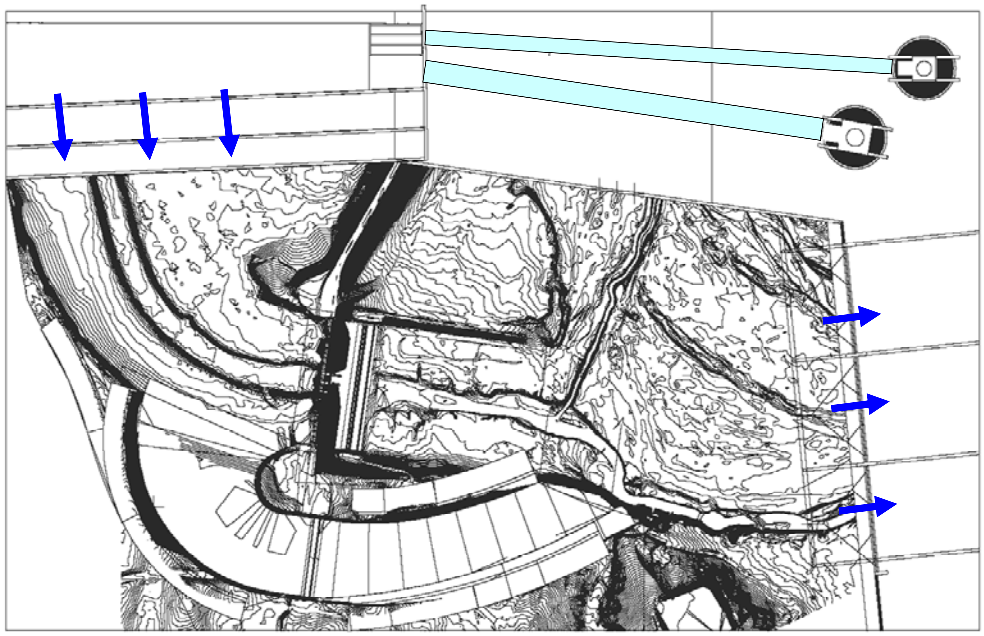

Fig. 18
Layout of 1:54 scale physical model at Alden Research Laboratory. Model footprint is 33.5 m x 21.3 m.

Model topography/bathymetry is simulated with a sand/cement mortar mix using templates at intervals of every 0.6 m, or 32.9 m prototype, to reproduce the scaled topography and reservoir bathymetry, with properly scaled surface roughness/friction. Spillways and structures are made from dimensionally accurate, machined PVC and metal, and approach and return channels of the auxiliary spillway are made from plastic-coated plywood to reflect the prescribed Manning's "n", which leads to a hydraulically smooth model surface. Templates and model structures are placed in the model with a vertical accuracy of better than ±9 cm prototype, so that model bathymetric elevations will be within ±30.5 cm prototype. The model Fusegates were cast from a resin, "densified" with tin powder to obtain a conservative target density of 2.55 g/cc for reinforced concrete.

Fig. 19

Canton Dam physical model under construction at Alden

Fig. 19 shows the construction of the physical model. The existing spillway can be seen in the forefront of the photo. The approach channel construction will be completed after the CFD runs are concluded.

Fig. 20

Rapid-prototyped model Fusegate

Fig. 20 and 21 shows the production of the Fusegates that will be used for the testing. A custom mould is produced to cast these Fusegates with the correct density

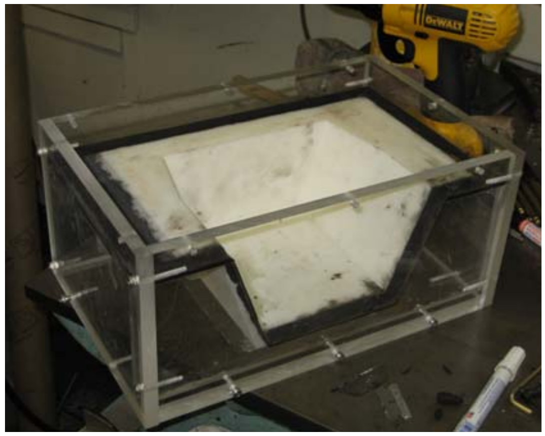

Fig. 21

Custom mould to cast Fusegates

4.6.3 Approach channel optimization with numerical model (CFD)

The approach geometry to both spillways is being optimized using Computational Fluid Dynamics (CFD). The goal of the CFD modeling/optimization process is to find an approach channel configuration that can discharge the PMF over both the existing and the auxiliary spillways at maximum pool of El.500.4 m with the appropriate flow split. Further considerations are enhancing the hydraulic performance of the auxiliary spillway in general and reducing the overall project costs by minimizing excavation requirements. Advantages of this combined CFD/physical model approach are that additional model runs can be made at comparatively lower cost than in the physical model, and until a satisfactory configuration has been achieved. The selected final approach channel design will be constructed and tested/validated in the physical model.

In the CFD simulation the free surface is tracked using a Volume-of-Fluid (VOF) model (Euler-Euler approach). A commercial RANS code (FLUENT v6.3.26, GAMBIT v2.4.6.) with a standard k-e model with wall functions is used. Water is entering through the inflow boundary at the prescribed PMF flow rate. No flow rates are prescribed for the spillways and outlet works, they will establish themselves based on the solutions to the flow equations. The baseline design and two design iterations have been run as of April 2008.

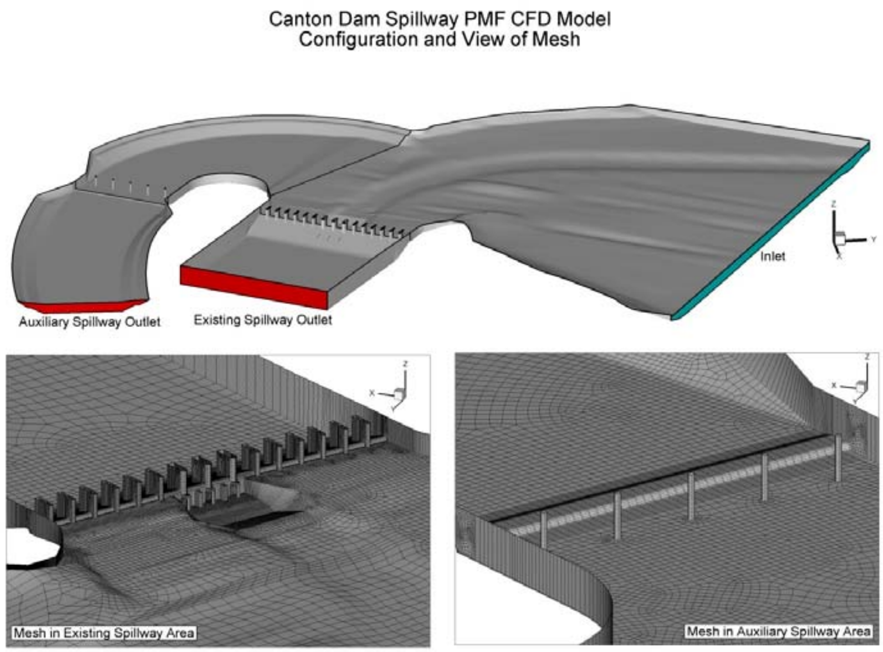

Fig. 22
Canton Dam CFD model configuration

Auxiliary spillway outlet
Mesh in existing spillway area
Mesh in auxiliary spillway area
Existing spillway outlet
Inlet

4.6.4 Description of Physical Model Testing

After commissioning and calibration of the physical model, the following items will be studied:

- Discharge of the PMF at maximum pool over both spillways
- Approach channel flow patterns, wave action, velocity measurements
- Head loss/water elevations at up to 48 locations throughout the model using piezometric taps, including at up to 30 locations in the auxiliary spillway.
- Tipping sequence of Fusegates and Fusegate evacuation after tipping
- At confluence of both spillways: energy dissipation, observations of flow patterns, wave action and turbulence
- Rating curve for auxiliary spillway, with or without service spillway operating
- Optimization of the wet well inlet port location
- Study of the inlet well operating levels

4.7 TIME SCHEDULE

Alden is currently undertaking the CFD modeling of the approach channel of the auxiliary spillway, while completing the construction of the physical model. The model tests are planned to be completed in August 2008.

A civil contractor will be selected by the USACE in September 2008 to carry out the excavation of the auxiliary spillway, which will take about 2 years. The concrete works, which includes a new highway bridge, the broad crested weir, the apron and the side walls will start upon completion of the excavation works. The overall completion of the project is planned for early 2012.

5 CONCLUSION

For dam safety rehabilitation projects, the Fusegate System offers a wide variety of reliable and cost effective solutions. Thanks to the versatility of the system, it can be installed on service or emergency spillways, and it can also be combined with most other spillway systems either on the same or separate spillways.

Constructing an auxiliary spillway often offers an attractive solution to severe spillway discharge inadequacy problems as long as a suitable location is available. The effectiveness of such alternatives is in many cases enhanced by the use of a fusible spillway control system designed to fail automatically in case of exceptional floods in order to release some of the flood water.

The Fusegates will minimize the size of a spillway as compared to other non-mechanical spillway control systems such as ogee weirs or fixed labyrinth weirs. They will offer the same benefit of reliability and low cost of operation and maintenance as they are designed to activate only for extremely low probability flood events usually over half the PMF.

REFERENCES

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SUMMARY

Upon successful installation and performance of the Fusegate System at its Terminus Dam in California, the US Army Corps of Engineers (USACE) has been considering the system for more projects. The Otter Brook and Canton dams are two different ways this system can be applied to bring dams with undersized spillways to up to date safety standards.

The Otter Brook scenario involves the modification of the existing spillway; the sill is lowered in order to increase its discharge capacity potential and the storage capacity is recovered with Fusegates. The Otter Brook application - completed in 2005 - involves six 2.7 m high 7.3 m wide Fusegates.

The Canton dam scenario on the other hand involves the construction of an emergency spillway equipped with Fusegates in addition to the existing service spillway with tainter gates; the combined spillways allow for the safe discharge of the design flood. The USACE has decided to perform a model study of the proposed auxiliary spillway in order to optimize the structures and to ensure that the selected configuration will pass the PMF. The model study is being conducted by Alden Research Laboratory in Holden, Massachusetts. Excavation works for the new 146.3 m wide and 609.6 m long spillway channel are expected to start late 2008. Once completed, the 9.1 m high 16.3 m wide Fusegates at Canton project will set the new record for the tallest in the world.

KEY-WORDS – Brasilia Congress

ANGLAIS	FRANCAIS
Abutment	appui
Active storage	reserve utile
Aggregate	
Analysis	
Anchorage	
Apron	
Approach channel	
Ballast	
Ballast blocks	
Base	
Behavior	
Benefits of dams	
Block	
Body of dam	
Bottom outlet	
Broad crested weir	
Canton dam	
Cement	
CFD modeling	
chamber	
Chute	
Concrete	
Conduit	
Construction phase	
Crest	
Dam failure	
Damage	
Dead storage	
Density	
Design	
Design flood	
Discharge	
Diversion works	
Downstream face	
Drainage	
Earth	
Earthfill dam	
Ecology	
Economic study	
Effects of dams on environment	
Emergency spillway	
Erosion	
Excavation	

Spillway
Stability
Stilling basin
Terminus dam
Uplift
Upstream face
Water level
weir