DAM OUTLET VALVE CONTROL SYSTEMS

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ABSTRACT

Most dams have an open discharge to air or into a river with flow splitters to dissipate energy. Some dams however require a controlled outlet into canal, pipeline or river system. This paper presents two cases of controlled outlet using self-regulating automatic water control diaphragm valves.

1. INTRODUCTION

Most dams have a system of discharge into open space before entering a river system.

The energy is usually dissipated by means of sleeve type valves which spread the discharge through air to dissipate energy. This system requires considerable space to dissipate the energy.

Figure 1: Discharge into air to dissipate energy

Other outlets which discharge horizontally into a canal system require large civil works to dissipate the energy and reduce the flow to subcritical manageable flow in the canal. The flow rate is then controlled by adjusting a sleeve valve or outlet gate using electro- mechanical mechanisms.

An alternative type of outlet valve which has proved to be successful and efficient in dissipating energy in a relatively small space as well as provide an accurate flow control, are automatic diaphragm valves (DVs) developed in South Africa. These valves also maintain a set discharge rate automatically with a varying upstream water level.

The valves vary in size from 300mm to 1600mm diameter and can control flow with a differential head of water of 1.0m up to 50m.

MAGUGA REGULATING WEIR

Two large 1600mm diameter automatic diaphragm valves (DVs) are installed in a regulating weir downstream of the large Maguga Dam on the Komati River in Swaziland.

20 Mw of hydroelectric power is generated from a discharge of 25 m^3/sec from the dam. This is peak power generation and consequently there are two generating events per day of about 2-3 hours each.

These intermittent large flows have to be controlled at the regulating weir to maintain a constant daily flow downstream into the river. Consequently, the water level in the regulating weir can fluctuate by 3m to 6m during the day to store and then release the intermittent large discharges from the dam.

Figure 2: Maguga regulating weir with valve chambers in the foreground

The two large DVs are self-regulating to maintain the set discharge with the varying upstream water level. The DVs discharge a maximum of 12.5 m^3/sec with a maximum head of 14 m. They discharge radially into an 8mx8m concrete chamber which effectively breaks the energy within the chamber.

Figure 3: 1.6m diam diaphragm valves discharging radially to dissipate energy.

Figure 4: top view showing effective dissipation of energy in the valve chamber.

The water then flows through a series of flow straightening pipes into a stilling chamber before discharging over a crump weir. The civil works for this type of outlet is considerably less than that required for a horizontal discharge into a canal with a measuring weir.

Figure 5: Flow straightened through a bank of pipes

The discharge flow rate is set by a float valve situated at the crump weir and maintains a constant water level over the crump weir. If the water level rises above the set level, the float valve closes slightly to pressurize the diaphragm to close slightly to reduce the discharge to meet the set flow rate. Similarly if the water level is lower than the set level, the DV will respond to release more flow to maintain the set water level at the crump weir.

Figure 6: flow control over a crump weir with the float valve chamber behind

These two large DVs which have been operating since 2006, dissipate the energy efficiently and control the flow accurately.

3 NCORA DAM OUTLET WORKS.

The Ncora Dam is a 35 m high dam on the Tsomo River in the Eastern Cape. It serves a hydro power station and an irrigation scheme via 3 No 1.5m diameter outlet pipes. The water under pressure from the dam is controlled by an old system installed some 30 years ago. There are two equally sized outlet valves each consisting of a closure disc attached to a heavy pivot arm and the valve opening is controlled by a large metal tank acting as a float.

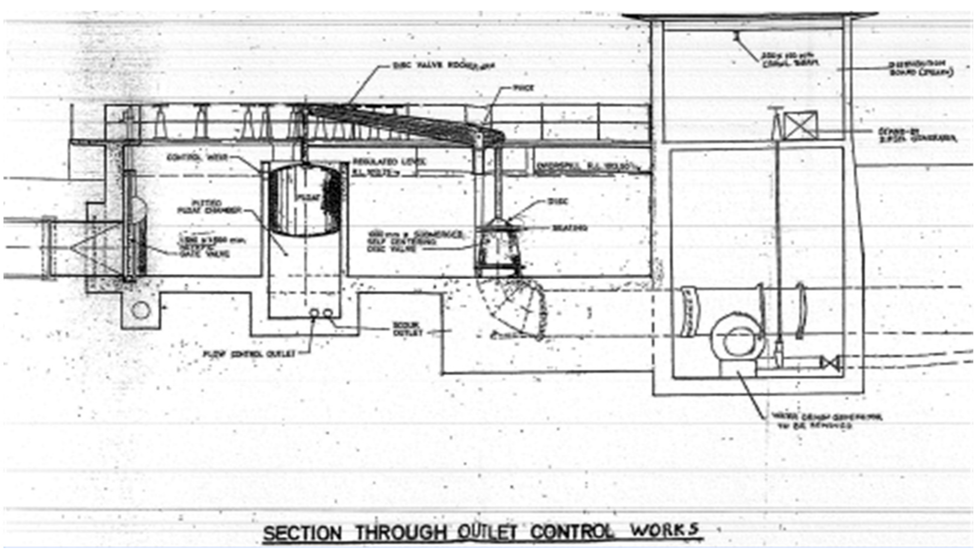

Figure 7: schematic sketch of the original control valve

Figure 8: existing control valve set up

This system was ineffective in controlling the water and suffered mechanical damage as a result of the closure disc oscillating wildly. The adjacent concrete support columns were also badly damaged by the swinging action of the closure disc.

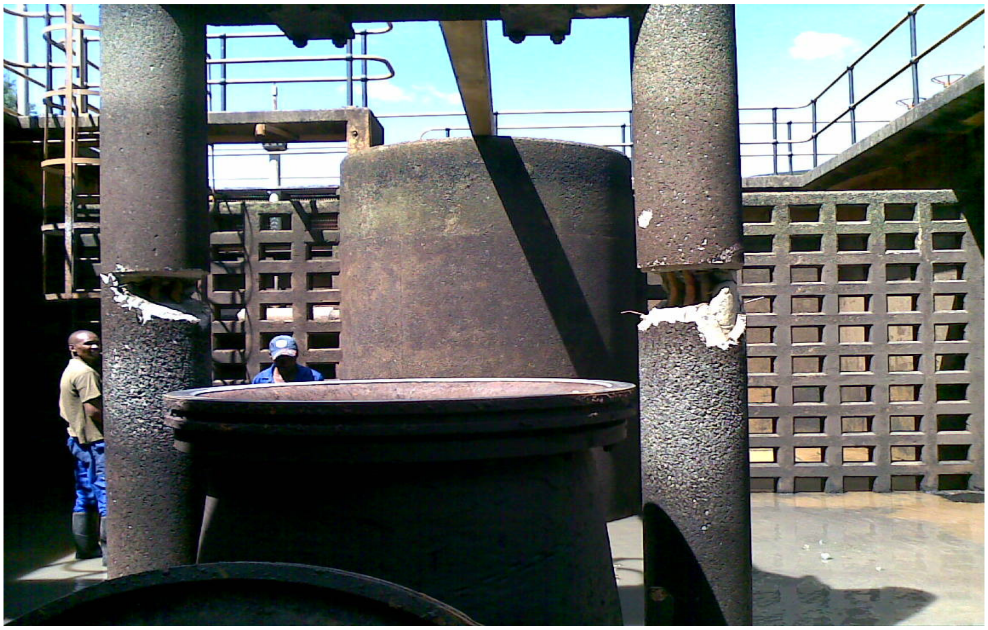

Figure 9 : damage to supporting concrete columns due to oscillating closure disc

The valve did not adequately dissipate the energy within the chamber. The surface was extremely turbulent and water would spray out of the containment. These valves were not efficient control valves and caused a considerable amount of down time and maintenance.

Figure 10: turbulent discharge and spray from the old system

Consequently the Department of Water and Sanitation (DWS) have abandoned repairing these old valves and will now have two new diaphragm valves designed and installed.

The new diaphragm valves are upward facing and will discharge radially into the existing valve chambers. The flow rate is controlled by a diaphragm operating a deflector plate. A float valve is set at a predetermined level and if the discharge from the diaphragm valve raises the water level above float level, the float will close slightly to pressurize the diaphragm to close slightly to reduce the discharge in order to maintain the set water level. Similarly if the water level drops below the set level, the float valve will open to reduce the pressure in the diaphragm. This will cause the DV to open slightly to discharge more water to maintain the set water level.

The top deflector plate has a downward facing skirt to deflect the water downwards into the chamber and hence to dissipate energy within the water body without undue turbulence or spray.

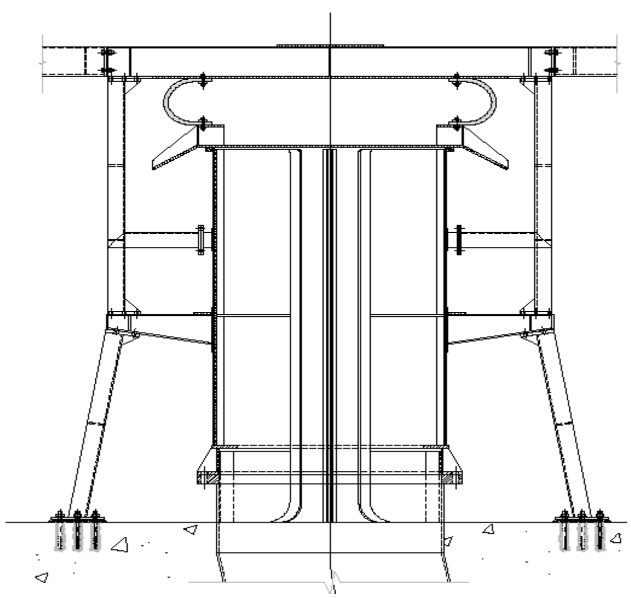

Figure11; Section through the DV with anti-rotation vanes and a top deflector plate operated by the diaphragm.

The existing inlet bend through the chamber floor causes rotation of the water resulting in uneven discharge flow. This was the cause of the damage to the existing control valves where the closure disc oscillated wildly and impacted against the adjacent support structure. This uneven discharge from the bend also created the turbulence and spray in the chamber.

Consequently a series of vertical anti-rotational vanes are introduced into the DV to straighten the flow before it impinges onto the deflector plate. However in order to attain a level of confidence in the DV performance with this strong rotational force a CFD (Computational Fluid Dynamic) analysis was performed by the University of Stellenbosch under the auspices of Professor G Basson. The CFD analysis is the subject of a separate paper presented at this hydraulics structures course.

The CFD proved to be very valuable in arriving at a solution of internal vanes and stiffener rings to straighten the flow. It also provided valuable information on dynamic pressure distributions for the structural analysis.

The DVs are due to be fabricated within the first quarter of 2016 with installation and commissioning following thereafter.

4 CONCLUSIONS.

The automatic self- regulating diaphragm valves illustrated here are effective bottom release control valves for controlled discharges into canals or rivers. They effectively dissipate the energy within a relatively small civil structure when compared to other discharge systems.

Care needs to be taken to offset rotational and uneven flows discharging through the DV and for large DVs it is recommended to perform a CFD analysis as an integral part of the design.