

Zutari's duckbill design put to the test at Garden Route Dam

Zutari's spillway project at the Garden Route Dam was finally put to the test late last month when it began spilling following torrential rains in the area. The dam is the main supply for George in the Western Cape.



Zutari designed the duckbill-shaped spillway to slow down water flow using basic physics principles. Image: Wessel van Heerden

"I am happy to report that the spillway is behaving as expected," reports Dr Frank Denys, associate and expertise leader: dams. "The clever duckbill-shaped spillway significantly increased both the storage capacity of the dam and the discharge capacity of the spillway so as to boost the dam's water supplies without compromising its safety by preventing overtopping," comments Denys. The project won an award for technical excellence in the SAICE Southern Cape Branch Regional Awards 2020.

"The design is relatively new in the engineering world, and as far as we know is not being used in this way in South Africa," says Civil Engineering Services acting director Lionel Daniels. It was extensively researched by Zutari and tested by the Department of Water and Sanitation's Hydraulic Laboratory in Pretoria, with its shape designed to slow down water flow using basic physics principles. "The design is brilliant in its simplicity, and it was a real victory to see the dam overflow and the spillway working so effectively," highlights Daniels.

More resilient water supply system

"The project showcased how relatively small, well-engineered and optimised adjustments can provide a more resilient water supply system without compromising on dam safety. Furthermore, the expansion of existing water supply resources is preferable to the development of new sites, as it limits the environmental impact to an already impacted site. Despite the novel nature of the engineered solution, this unique and innovative project had a low capital cost and also has a small estimated maintenance cost," explains Denys.



Dr Frank Denys, associate and expertise leader, dams at Zutari

The project increased the existing storage capacity of the Garden Route Dam by raising its full supply level by 2.5m via the installation of a new spillway, enlarging the storage volume by 2.5 million cubic metres. The solution centred on a hydraulic design in the form of a non-linear spillway in the shape of a duckbill. Although duckbill or bathtub spillways are not unique, they are rare worldwide.

The Zutari team amended the hydraulic design to ensure that the weir would behave in a safe and predictable manner. The shape of the duckbill causes flow on opposite ends of the overflow flow to collide within the duckbill, causing an upwelling, also known as flow bulking, which breaks the flow's momentum and causes it to lose its energy. The flow from the rounded upstream end of the spillway is not so opposed and causes this upwelling of flow to move toward the exit of the spillway at rapid velocity. This increase in velocity reduces the water level to a lower elevation such that it can safely pass under the bridge over the spillway.



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Relatively minor event

The final duckbill spillway design resulted in a total spillway length of 80m, with a maximum discharge capacity of 570m³/s at a freeboard of 4.1m. The flood event on 22 November was the first time the new spillway overflowed since its completion in December 2019. Prior to the flood event, the water level in the dam was roughly 1m below the crest of the spillway. This volume was rapidly filled up in the course of the early morning and the spillway started overflowing at roughly 8.30am. The peak of the flood occurred at 1pm, according to the Department of Water and Sanitation's water level-data record.



The new spillway overflowed on 22 November 2021. Image: Wessel van Hæerden

The water level recorder logged a maximum overflow depth of 0.509m over the crest, which equates to about 50m³/s in discharge. This thus appears to have been a relatively minor event, with the dam designed to cater for much higher flows. That said, the incoming flood was partially attenuated or absorbed by the storage volume in the dam basin. The flows at the nearby flow logger on the Malgas River likewise recorded a minor flood.

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