

World class achievements as dams reach new heights

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Ted Warren provides an update on development of three of the world's largest hydroelectric dams.

A number of major new hydroelectric and dam projects are under construction or have recently been completed throughout the world, with some of these dams reaching heights approaching 300m tall. A detailed update is provided below on the development at three of these large dam projects along with respective and recognized world class achievements.

Gibe III, Ethiopia

The Gibe III dam and associated hydroelectric project is located on the Omo River in Southern Ethiopia in a very remote region. When completed, Gibe III will be the largest and the tallest RCC dam in the world. The RCC placement operations started in late December 2011, pre impoundment started in August 2014, with early impoundment starting in early 2015.

The project has overcome some very challenging conditions from a design standpoint as well as a construction standpoint. Its size alone makes the project implementation very difficult in itself. Adding to the difficulties is the natural terrain, steep abutments (in some places 45 degrees or steeper), and extreme hot weather conditions.

One of the greatest challenges that was overcome by the contractor Salini-Impregilo S.p.A was the amount of RCC that had to be placed in the dam body to meet the demanding "fast tracked" schedule. The RCC placement operation was well planned and started off well with many ideas from the management team implemented during construction. During the most difficult and critical time in the early stages of the construction operation another great challenge that needed to be overcome was the enormous foundation footprint for which the structure resides its mass.

This involved the cleaning, approval, and final preparations of the geological and site specific features that had to be prepared in accordance with strict specification considering the size of the dam..

During the first year the contractor placed just over 1Mm³ of RCC in the dam.

Over the next 24 months the contractor placed more than 5Mm³ of the 6.1Mm³ required for the dam. During this period the contractor averaged more than 140,000 m³ per month, with a peak month of 250,809m³ in August 2013, which is a remarkable achievement in itself.



On December 11th through December 12th 2014 the Salini-Impregilo team placed 18,519m³ in a single 24 hour period breaking the world record for the most RCC placed in a single 24 hr period for any RCC dam structure worldwide to date.

The previous record was held at the Longtan RCC dam in China and previously again at the Saluda dam in the US with 18,475m³ and 14,135m³ placed in a single 24 hr period respectively. The industry world record achieved at Longtan held for nearly 10 years but it should be noted that the scheme there had two conveyor placement systems, a larger batching plant facility as well as two contractors working independently and simultaneously. Regardless, the achievements at Longtan should not be discounted in the very difficult nature of dam construction.

As there have been over approximately 650 RCC dams completed to date, many of which are over 100m tall and containing as much as 6Mm³, industry experts agreed that the record achievement at Longtan seemed unchallenged and out of the reach of any realm of ingenuity in RCC dam construction.

That all changed during the morning hours of December 12, 2014 after the totals for the previous day were tallied.

At Gibe III the world record was achieved by using a single belt conveyor system, a well-synchronized RCC plant and a single contractor. The RCC aggregate production, batching and conveying system(s) to the dam was a combination of the highest quality plants consisting of Sandvik crushing equipment, Sicoma mixers (Italy) and a very sophisticated RCC conveyor system capable of handling in excess of 850m³/hour by RCC Conveyors USA LLC.

The Gibe III dam, although not entirely completed, is currently the tallest, largest standing RCC dam in the world.

This is truly a remarkable achievement and a tribute to brilliant ingenuity and the hard work of all involved. It should be noted that with an RCC placement operation one of the main advantages is the amount of RCC that can be placed continuously as this always will render good quality construction as well as many other advantages.

It should be noted that the entire operation while very sophisticated, was well planned out, and well managed by the contractor and the results are a true testimony to this achievement and ultimate success of the project. Considering that the dam is located in a remote area, with long supply lines for anything imported, finding cement and even providing fuel (3 million liters per month), this project was also a major logistical challenge. It should be noted that with proper planning and procuring the right equipment, people and resources for any project of this nature are the key to success.

The project is a tribute to the hard work and dedication of the Salini-Impregilo team, leading to one of the greatest achievements in Roller Compacted Concrete dam construction since its inception some four decades ago.

Grand Ethiopian Renaissance Dam, Ethiopia

This 6000MW project - previously named the Millennium scheme - is being built on the River Abbay (the Blue Nile) and will feature one of Africa's largest dams, a 1.8km long, and 170m high RCC structure. The project will feature 16 x 375MW turbines, and is being built by the same team behind the Gibe III project, led by Salini-Impregilo S.P.A.

The project is being built in a remote location, although the site topography is far different to that of Gibe III - in particular the terrain is friendlier with a long valley area and gentler abutments.

The project's dam contains some 10Mm³ RCC and includes a 70m rock fill saddle dam. There will be two surface Powerhouses located immediately downstream of the dam at the right and left abutments accordingly, housing the 16 Francis turbines.

Preparatory works for construction started in December 2010. The RCC production for the dam began in late 2013 and by December 2014, some 1.9Mm³ had been placed in the main dam. The corresponding average monthly rate of placement is 142,177. The maximum daily rate is 16,949 which is slightly lower than that achieved at the Gibe III project.

In October, developers Ethiopia Electric Power announced that the scheme as a whole was 40% complete.

When finished, the project will supply much-needed power to Ethiopia and its neighboring countries in the region and contribute to overall development in the region.

Xiluodu project, China

The Xiluodu Hydroelectric project in China is the second largest hydropower plant in China and the third in the world with an installed capacity of 13,860MW.

The dam and hydro complex is located upstream of the world famous China Three Gorges dam on the Yangtze River. China Three Gorges Project is the largest hydropower installation in the world with an installed capacity of 22,500MW followed by Itaipu Hydropower project in Paraguay/ Brazil with an installed capacity of 14,000MW.

The project features a 285.5m high double curvature arched concrete dam consuming 6.2Mm³ low slump CVC (conventional, Vibrated Concrete). It includes two underground power complexes each containing 9 X 770 generating units for a total installed capacity of 13,860MW, two power intake, and a network of complex headrace and tailrace tunnels

Preparatory works for the project started at the end of 2003 but was temporarily stopped in 2005 to allow for completion of the Environmental Impact Statement.

Its official initiation was at the end of 2005. The River diversion was completed in 2007. The concreting operation for the dam started in the last quarter of 2008 and the dam was substantially completed in 2013. The commissioning of the last unit was in July 2014.

The design and construction planning for this colossal structure was well planned out and executed. The arched structure was built with interlocking concrete monolith blocks with nearly "0" slump (10-15 mm) mass concrete and the blocks were constructed simultaneously as the dam rose out of the difficult valley foundation to its ultimate height of 285.5m. There was a network of cooling pipes placed within the mass of the dam for the mass CVC that continued throughout construction and will continue to cool the concrete as it cures.

The project had nearly vertical abutments and the terrain was similar to that of the Hoover dam in the US making delivery of the concrete to respective placements very difficult.

The contractor set up five overhead cable cranes and blenden systems that spanned the valley high above the respective abutments to deliver the concrete to the respective monolith placements. Three concrete batching plants were in place that were dedicated to the concrete production for the dam at the upper right abutment. Each concrete plant has a capacity of some 500m³/ hr. The concrete placements took place 24 hrs a day 7 days a week for just over four years. The concrete was mixed and dumped into 9m³ capacity side dump trucks that delivered the concrete to a loading key at the nearby upper Right Abutment.

From there the concrete was dumped into very large 9m³ capacity buckets hooked to one of the cable cranes and cast across the valley to the respective placement(s). As many as three monolith placements were being constructed simultaneously as the concrete structure grew larger and taller. The concrete within the



respective placements was spread across the placement area using small bulldozers and then compacted with large 150mm gang vibrators mounted on small specially equipped excavators. Hand immersion vibration vibrators were also used in confined areas where the larger gang vibrators could not compact the concrete.

Approximately 9m³ of concrete was delivered into the dam body

continuously every 60-90 seconds 24 hrs a day.

It generally took between 5-7 minutes to deliver the freshly mixed concrete to its final placement in the dam using the side dumpers and cable crane Blonden systems, ensuring quality and fresh concrete was always delivered to the dam.

Each concrete plant had a testing laboratory to ensure that all of the specifications were being met for the various concrete mixes used in the dam.

The success of this project was due to a well thought out design, procurement and construction implementation program and it is now is on line to supplement the national Electric Grid of China with clean sustainable energy.

Ted Warren is a construction Civil Engineer from the US who has assisted in more than 30 RCC dams and hydroelectric projects in more than 20 countries worldwide. He has worked on some of the largest hydroelectric projects currently under construction and maintains records of RCC production and hydropower development achievements through the projects he has worked on over the past 25 years.

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