Constructing dams globally

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WITH RCC (roller compacted concrete) placement ongoing at the 1.6 million m^3, 173 m high Ayvali Dam, and construction recently started at the 70 m high Kotanli Dam, both in northeastern Turkey, ARQ's dam activities for 2013 will also encompass a number of smaller dams, including the 23 m high Umti and the 18 m high Wadi Kalboh dams in Oman, the 30 m high Mndwaka and the 24 m high Port St Johns dams in South Africa, the 24 m high Mukurumudzi Dam in Kenya and the 16 m high Arnaud Dam in Mauritius. In addition, ARQ is assisting with repair works and a new spillway at the 20 m high "My Own Dam" in Mpumalanga.

UMTI DAM, OMAN

ARQ will have its first experience of hardfill in 2013 at the Umti Dam in central Oman, having generally been involved in high- and medium-paste content RCCs to date.

The Wadi Umti project was recently awarded by the Ministry of Regional Municipalities and Water Resources to Omani contractors Premier International Projects (PIP), and ARQ is providing assistance in various forms to PIP in the planning and implementation of the proposed dam structure.

Although the proposed flood alleviation and wadi-recharge dam is only 23 m in height, deep excavations, significant foundation treatment, the requirement for permanent road access for upstream residents and no space for river diversion in the steep-sided valley imply that the intended 12-month construction programme is rather ambitious. With PIP having no previous experience in RCC/hardfill dam construction, ARQ is playing a significant role in the programming and plant resourcing, as well as the design and development of the hardfill mix. The characteristics of the natural gravel at Umti are particularly favourable for hardfill, with minimal processing required.

In fact, it is anticipated that the natural material can be used to produce a good quality, impermeable RCC in certain zones of the dam with as little as 120 kg of cementitious materials. The bulk hardfill will contain 60–80 kg/m^3 of cementitious materials, to achieve a 90-day compressive strength of 4 MPa.

Accelerated cylinder curing will be used as part of the hardfill mix development programme, which commenced in April of this year. Hardfill placement for the dam should be completed by the end of 2013.

WADI KALBOH DAM, OMAN

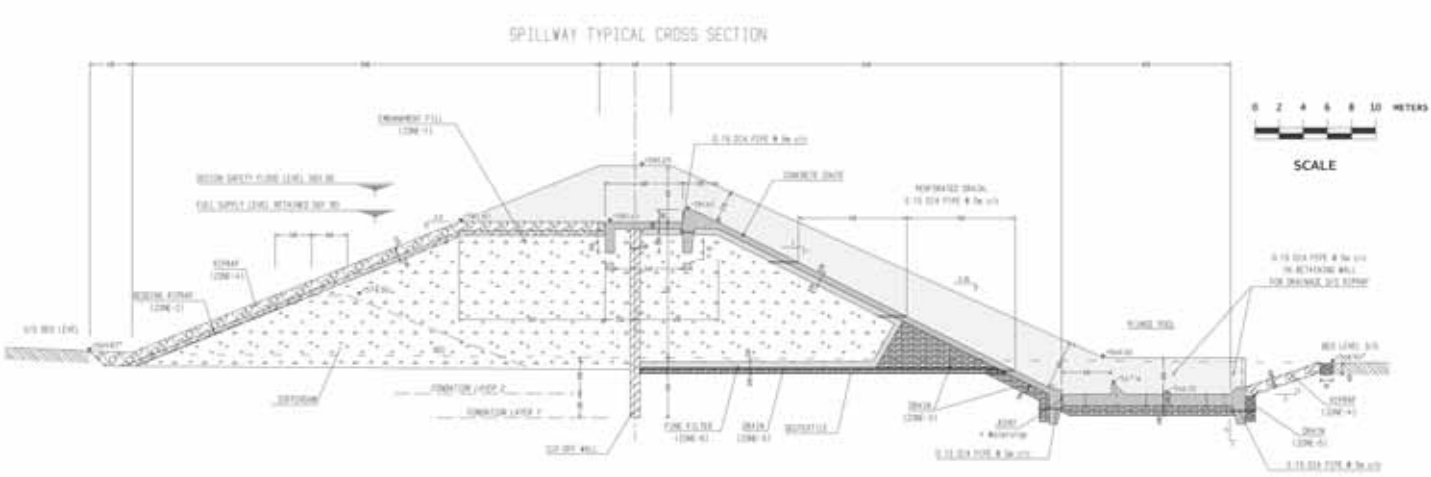
ARQ is also providing technical assistance to PIP Oman on the 18 m high Wadi Kalboh Dam, recently awarded to the company by the Ministry of Regional Municipalities and Water Resources.

Site for the proposed RCC/hardfill Umti Dam in central Oman

Wadi Kalboh is a groundwater recharge dam, designed to feed aquifers and a main falaj in the Nizwa wilayat of Oman. The dam is located on 25 m deep wadi gravels, which overlay serpentinized harzburgite. A water supply falaj is located approximately 19 m below the base of the dam wall.

Both the partial cut-off, which penetrates 5 m into the wadi gravels below the dam wall, and the core of the embankment dam are to be constructed using plastic concrete, with very different methods of construction to form this impermeable element below and above natural ground level. A reinforced concrete spillway, with an energy dissipation apron, is located over 200 m of the 320 m long embankment.

ARQ is assisting PIP with the construction methodology, the necessary resourcing, construction programming and the plastic bentonite concrete mix design. In addition, technical and quality assurance assistance will be provided throughout the construction period. A construction contract of approximately 14 months will see the completion of the dam in mid-2014.



Cross section of the 18 m high Wadi Kalboh Dam in Oman, a groundwater recharge dam

Construction in progress on the Mndwaka Dam in the Eastern Cape between Elliotdale and Coffee Bay

RMC dam construction, like here on the Mndwaka Dam, typically creates five times more person-days of employment than would be the case for an embankment dam

The start of construction work on the Port St Johns Dam in the Eastern Cape; the dam will be a single-curvature, arch/gravity structure

MNDWAKA DAM, EASTERN CAPE, SOUTH AFRICA

With the preparatory work completed last year, 2013 will see the placement of rubble masonry concrete at Mndwaka on southern Africa's largest example of an RMC (ready-mix concrete) multiple-arch buttress dam. Situated close to Hole in the Wall, between Elliotdale and Coffee Bay in the Eastern Cape, the Mndwaka Dam is being constructed as the storage component of the Mncwasa Water Supply Scheme, which will provide domestic water supply to 63 rural villages.

While its height of 30 m will make Mndwaka Dam the highest RMC dam yet to be constructed in South Africa, its RMC volume of approximately 30 000 m^3 also makes the dam the largest of this type yet constructed in southern Africa. RMC dam construction offers advantages in terms of lower cost on a small scale and in a remote location, but it is the high utilisation of labour, with associated skills development and the insensitivity to floods during construction that makes this particular type of dam construction so attractive in rural southern Africa. RMC dam construction typically creates in excess of five times more person-days of employment than would be the case for an embankment dam.

With foundation excavation completed by the beginning of the year and RMC trials on site having demonstrated the contractor's ability to produce the necessary quality of RMC, construction work on the dam wall itself commenced during February.

At Mndwaka, ARQ is providing design and construction supervision assistance services to Sontinga Consulting, while the construction is being done by contractors ZMJV, a joint venture between Zana Manzi Services, WSSA and Amanz' Abantu Services. Completion of the main dam structure is scheduled for late 2014.

PORT ST JOHNS DAM, EASTERN CAPE, SOUTH AFRICA

Opening of the foundation on the site of the planned Port St Johns Dam revealed a rock mass with a higher degree of fracturing than had been suggested by the earlier geotechnical investigations. Evaluating the consequential mechanical strength properties, it was apparent that insufficient sliding resistance would be provided for the thin RMC arch initially proposed.

The design was subsequently optimised on the basis of the tested shear properties of the rock mass and site topography, and a single-curvature, arch/gravity structure was developed. With the necessary excavations completed early in 2013, placement of rubble masonry concrete was initiated during the second quarter of this year.

Construction in progress on the Mukurumudzi Dam in Kenya, a 24 m high earthfill embankment dam

MUKURUMUDZI DAM, KENYA

In August 2011, ARQ was appointed as sub-consultant to Wave Solutions to undertake the tender and detail design of the Mukurumudzi Dam, south of Mombasa in Kenya. The dam will provide water supply for the Kwale Mineral Sands Mining project, currently being developed by Australia's Base Titanium Ltd (also see the Kwale Mineral Sands article on page 50 of the April 2013 edition of *Civil Engineering*).

Construction of the 24 m high earthfill embankment dam was initiated at the beginning of 2012 and the cofferdams and river diversion were completed to allow placement of the bulk of the embankment fill during the dry season of early 2013. First impoundment was initiated through closure of the river diversion in April.

Construction of the Mukurumudzi Dam is being undertaken by Kenyan contractor HB Singh & Sons, with separate contracts for the spillway and the embankment. The dam is scheduled to be completed before the end of the year.

ARNAUD DAM, MAURITIUS

The Arnaud Dam is currently being constructed to augment water supply to the Mare aux Vacoas Reservoir on the Tamarin River in southern Mauritius. The Arnaud Dam will increase the yield from Mare aux Vacoas by diverting flow from the adjacent Rivière du Poste catchment.

Construction in progress on the Arnaud Dam in Mauritius

ARQ has been assisting Lux-Consult and PDNA International on the project since 2010, and the company was appointed in April 2011 to supervise geotechnical and materials investigations, and to complete the design of the dam, the spillway and the diversion canal. The subsequent design studies identified an earthfill embankment with an uncontrolled, partially concrete-lined by-wash spillway as the optimal arrangement for the 16 m high dam.

The contract for the construction of the Arnaud Dam and Diversion Canal was awarded to Chinese contractors Sinohydro in mid-2012, with completion scheduled for mid-2013. ARQ is providing technical assistance and guidance to Lux-Consult for the construction supervision.

Ayvali Dam, Turkey – excavation of more than 1.5 million m³ of alluvium was completed in less than six months

AYVALI DAM, BLACK SEA REGION, TURKEY

At the Ayvali Dam in Turkey, the river diversion tunnel and the necessary cofferdams were completed to allow dewatering and excavation in the river course to start by mid-2012. With a maximum depth of alluvium in the river course of almost 60 m, a dewatering well system was established in the shoulders of both the up- and downstream cofferdams, avoiding the need for the creation of deep cut-off walls. Excavation of more than 1.5 million m³ of alluvium was subsequently completed over a period of less than six months, allowing RCC placement to start in December 2012.

At the Ayvali Dam, two RCC mixes are being used, with the bulk of the placement comprising a nominal 15 MPa mix, and a 24 MPa mix being used for the more highly-stressed zones of the structure. Both are impermeable, high-workability RCC mixes, which can be compacted directly by immersion vibrators against the formwork, without requiring additional grout. Designing the crushing plant from the outset to meet a tight aggregate

Site of the Kotanli Dam in Turkey; RCC placement is planned for August this year

Ayvali Dam, Turkey – placement of the 1.6 million m³ of RCC comprising the dam wall is scheduled for completion in mid-2015

specification has allowed the saving of a significant quantity of cementitious materials in both RCC mixes. Initial testing on potential natural pozzolans proved unsuccessful, and the RCC used comprises an ordinary Portland cement blended with fly ash. The use of a set retarder allows the development of good bond between placement layers.

Placement of the full 1.6 million m³ of RCC comprising the dam wall is scheduled over 30 months, with completion planned for mid-2015.

KOTANLI AND KOROGLU DAMS, BLACK SEA REGION, TURKEY

With the final environmental permits obtained and the last property purchases successfully made, Ünal Construction began establishment and the construction of access roads for the Kotanli Dam in Turkey late in 2012. The Kotanli and neighbouring Koroglu Dams will form a cascade with a combined capacity of 130 MW.

Early 2013 saw the commencement of the detailed design of the Kotanli Dam and power station, in conjunction with the RCC mix development programme. In preliminary testing, a locally available natural pozzolan demonstrated very promising results, although the cost of establishing a milling plant may finally result in this option not being the most economical solution at the two dams.

While it is hoped that RCC placement at Kotanli will be started in August this year, ARQ is scheduled to initiate design work for the Koroglu Dam in July, once minor additional foundation investigation work has been completed.

YUSUFELI DAM, BLACK SEA REGION, TURKEY

ARQ is providing assistance to consultants Su Yapi and contractors Limak with the final design and construction of the 273 m Yusufeli double-curvature concrete arch dam on the Çoruh River in the Black Sea region of Turkey. In addition to completing the final structural analyses and acting as arch dam specialists, ARQ will be preparing construction method statements, assisting the contractor with his construction planning and logistics, and preparing the concrete mix designs.

The 540 MW Yusufeli hydropower scheme is the largest component of the Çoruh River development and the 2.2 billion m³

impoundment will completely inundate the town of Yusufeli (population 6 400). The contractor's goal of completing the project in a period of five years will require the placement of approximately 3 million m^3 of conventional concrete for the dam in just 42 months.

Yusufeli Dam will be the fourth or fifth highest dam in the world when completed, depending on whether the 315 m high Bakhtiari Dam in Iran is completed first.

RATLE DAM, JAMNU AND KASHMIR, INDIA

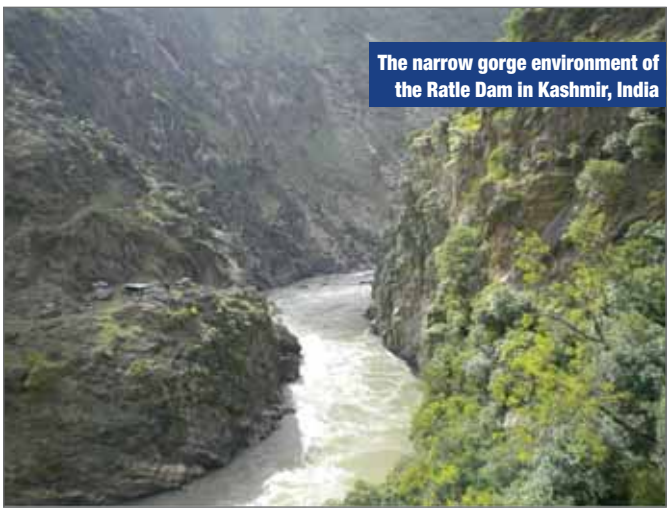
ARQ was recently appointed by Larsen & Toubro for construction design services on the 133 m Ratle RCC dam, which forms the impoundment for an 850 MW hydropower scheme on the Chanab River in Jammu and Kashmir, India. The project is being developed for GVK under an EPC contract, which will see the scheme being brought into operation before the end of 2018. The site is ideal for an RCC arch, which could save more than 500 000 m^3 of RCC, but some significant energy will be required to motivate such a change against the momentum of the Indian bureaucracy. The requirements to discharge a PMF of 13 800 m^3/s into a narrow gorge, to maintain the live storage in a river with a high sediment load, and to accommodate high seismic loadings, represent significant additional design and construction challenges associated with the project.

TRUNG SON, VIETNAM

ARQ is providing specialist input and assistance to AECOM New Zealand on the supervision of the Trung Son 260 MW hydropower scheme in Vietnam, where construction was recently started. The scheme includes an 85 m high RCC gravity dam on the Ma River, comprising approximately 770 000 m^3 of RCC.

Mobilisation of the supervision team started during the last quarter of 2012, and construction of the river diversion works during 2013 will allow the dam works to start in earnest during 2014. The scheme will enter the commissioning phase in late 2016, with completion scheduled for mid-2017. □

The mountainous Yusufeli Dam environment in Turkey



The narrow gorge environment of the Ratle Dam in Kashmir, India

Environment of the Trung Son 260 MW hydropower scheme in Vietnam where construction has recently started

Source:
http://www.saice.org.za/downloads/monthly_publications/2013/2013-Civil-Engineering-June/#/0