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Case Study **Dam Monitoring** **Earthquake Early Warning**

In Cooperation With
GeoSIG Partner



MARTIL DAM
HIGHSPEED-RAIL
DAR KHROFA DAM
MY HASSAN I DAM

Case Study

Dam Monitoring
Martil Dam
Tétouan, Morocco

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Background

The city of Tétouan, nicknamed the White Dove, is located in northern Morocco. It and its neighbouring areas had a deficit in drinking water. It was decided that they would be best served by building a dam to regulate the water of Wadi Mohjerat, one of the main tributaries of Wadi Martil — 15 km from the town of Tétouan. This would provide additional water to eliminate the deficit in drinking water, satisfy future water demand, allow for irrigation for part of the agricultural land downstream of the dam, and aim to protect the city of Tétouan from floods. The project for provisional watering of the dam began in January 2016; and final watering started in October 2018.

According to the Ministry of Equipment, Transport, Logistics and Water, the project is one of the area's most complex dams given the delicate geo-technical characteristics of its location.

Martil Dam is the 6th highest dam in Morocco. The maximum height of Martil Dam is 100 m, and the length of the ridge is 600 m. The volume of the dam is 5.6 Mm³, and the volume of the reservoir is 120 Mm³.

Challenge

In high-hazard areas, dams can present risk for downstream residents. Earthquakes are particularly a concern because at this time there is no accurate earthquake prediction. Morocco is affected by moderate seismic activity compared to other Mediterranean countries, largely related to the convergence between the African Plate and the Eurasian Plate. Although we are unable to predict earthquakes, we can strengthen protective measures by making seismic hazard assessments.

Solution

Our Partner in Morocco, SyGeo (www.sygeo.ma), develops reliable, precise and long-term monitoring systems for its customers. SyGeo's main activity is the supply, installation and maintenance of equipment for the auscultation of dams and civil engineering works, hydrology, oceanography, and meteorology.

For Martil Dam, SyGeo installed a seismic monitoring system that included: 3 x GSR-18 seismic recorders, 3 x [AC-73](#) triaxial force balance accelerometers, and [GeoDAS](#) software. The instruments' software processes data in real time. If triggered by a seismic event, it calculates a number of event parameters and reports them to a data centre immediately.

Another solution using GeoSIG instruments and a capable partner showing that quality and reliability can also be cost effective.

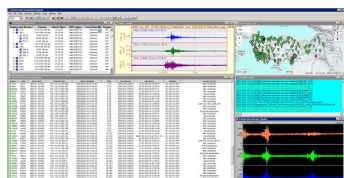
Product links

[AC-73](#)

[GeoDAS](#)



AC-73
accelerometers



GeoDAS software

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The city of Tétouan in northern Morocco is nicknamed the White Dove.



Wadi Martil Dam includes a concrete face fill dam on Wadi Mohjerat, and an earth fill secondary dam.



Martil Dam seismic monitoring station

Case Study

Earthquake Early Warning Kenitra-Tangier High-Speed Rail Line Tangier, Morocco

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Background

Morocco—located in NW Africa—is characterized by a rugged mountainous interior, large tracts of desert and a long coastline along the Atlantic Ocean and Mediterranean Sea. It has a population of over 33.8 million and an area of 446,550 km². When Morocco wanted to modernise its transportation network by installing a high-speed rail line between Tangier and Casablanca, they decided to do so in stages over three decades. The first step was the Kenitra-Tangier High-Speed Rail Line. Morocco's rail company ONCF awarded to the consortium consisting of Ansaldo-STS France and Cofely Ineo, the design and supply of the railway signalling, telecommunications and control traffic centre for the Kenitra-Tangier high-speed rail. Ansaldo-STS France has developed the signalling and train control systems that contribute to the constant improvement in railway safety and capacity on main lines and mass transit railway systems all over the world. For this project, Ansaldo-STS put together a complete system that allows safe and reliable commercial operations on the new line, up to 320 km/h.

Challenge

Unlike some of the more highly seismic countries in the Mediterranean, Morocco is affected by a moderate seismic activity largely related to the convergence between Africa and Eurasia. Still, every year there are earthquakes felt by the population and in some cases they cause extensive local damage. Historical documents show that much larger earthquakes have occurred in the past in Morocco, particularly along the Atlantic coast between Tangier and Agadir. In addition, the 14 Euroduplex double-deck trains purchased for the high-speed rail line are each capable of carrying 533 passengers. The potential for injury is elevated should anything deform the tracks or if any ground motion should generate forces to affect the safe travel of the train at high speeds. Passenger safety is of utmost importance.

Solution

Our Partner in Morocco, [SYGEO](#), is experienced in the supply, installation and maintenance of monitoring equipment for the inspection of civil engineering, dams, hydrology, oceanography, laboratories and meteorology. SYGEO provided instruments from GeoSIG for a high-speed train seismic monitoring system, which can be used to take emergency actions for critical infrastructure in case of detection of a damaging seismic event.

There were 18 seismic stations inside stainless steel field housings consisting of a three channel GMSplus recorder with an internal triaxial AC-73 sensor and with all necessary accessories as an integrated single unit, deployed at 10 km intervals along the tracks, either near or inside signalling stations. These were linked to the SMS-AEP computer at the data centre over LAN/FO. The seismic station continuously monitors and records the ground motion and periodically sends state-of-health and other files to the data centre. In case of a threshold exceedance, a digital alarm signal is immediately sent to the data centre and made available to the train control system utilising GeoSIG's proprietary GeoDAS software, which assists the system operator to decide whether to take actions to slow down or stop trains. GeoDAS uses special optional software modules which provide an advanced configuration interface for voting logic, an intuitive alarm / status display as well as an industry standard ModBUS communication to the train control system.

Another solution using GeoSIG instruments, effectively showing that quality and reliability can also be cost-effective.

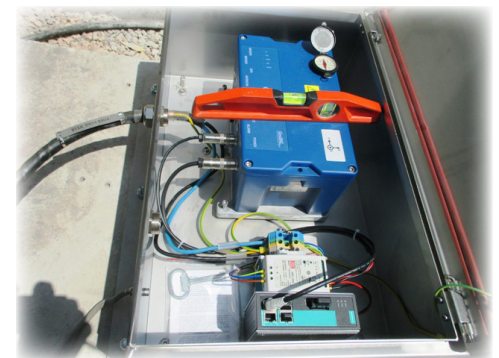
Product links

[GMSplus](#)
[AC-73](#)

[SMS](#)
[GeoDAS](#)
[ETH-FLAN](#)



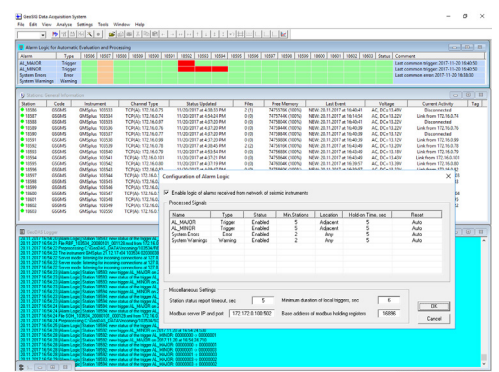
SYGEO engineers installing the seismic station.



Precise levelling and orientation of seismic instruments are important for correct operation of the system.



Rugged concrete vaults and heavy covering slabs protect installed instruments from the environment and vandalism.



GeoDAS software in the data centre displays status of all the seismic stations and their Early Warning alarms.

Case Study

Dam Monitoring
Dar Khrofa Dam
Ksar El Kebir, Morocco

GeoSIG
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In Cooperation With
GeoSIG Partner



Background

Morocco has prioritised putting in place effective, integrated water resources reforms. The Dar Khrofa Dam was part of this initiative. Located 20 km north of the city of Ksar El Kebir, in the province of Larache, on Wadi El Makhazine, the Dar Khrofa Dam aims to provide about 130 Mm³ of water annually to meet the increasing demand for drinking and irrigation water in Larache and Tangier regions.

The regulated water is planned to irrigate more than 21,000 ha of agricultural land downstream of the dam, and supply 40 Mm³ to the Tangier region to cover the expected deficit in meeting the drinking water demand and future needs. The project is expected to contribute to the protection of lands downstream of the dam from floods, as well as to the increase of regulated surface water in the kingdom through the storage and utilization of Wadi El Makhazine floods.

The dam is a zoned dike with a clay nucleus, and has a height of 73.5 m and a ridge length of 405 m.

Challenge

With an investment this substantial, it is clear that maintenance is an essential component of the project. Additionally, dams can present risk for downstream residents. Morocco is affected by moderate seismic activity compared to other Mediterranean countries, chiefly related to the convergence between the African Plate and the Eurasian Plate. To best protect the people near the dam as well as the dam infrastructure, seismic hazard assessments are an integral part of the project.

Solution

Our Partner in Morocco, SyGeo (www.sygeo.ma), develops reliable, precise and long-term monitoring systems for its customers. SyGeo's main activity is the supply, installation and maintenance of equipment for the auscultation of dams and civil engineering works, hydrology, oceanography, and meteorology.

For Dar Khrofa Dam, SyGeo installed a seismic monitoring system that included: 3 x GSR-18 seismic recorders, 3 x [AC-73](#) triaxial force balance accelerometers, and [GeoDAS](#) software. The instruments' software processes data in real time. If triggered by a seismic event, it calculates a number of event parameters and reports them to a data centre immediately.

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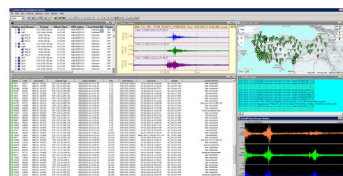
Product links

[AC-73](#)

[GeoDAS](#)



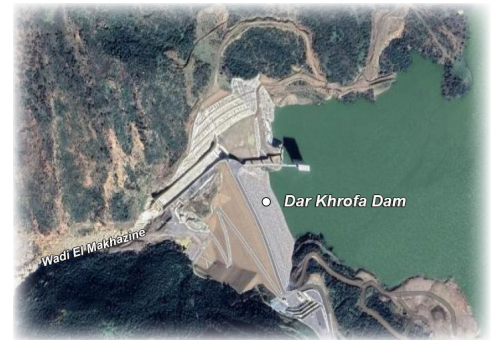
AC-73
accelerometers



GeoDAS software



Above and below: Dar Khrofa Dam is located in northwest Morocco near Ksar El Kebir.



Ksar El Kebir, also known as “the big castle,” is a city in northwest Morocco, about 160 km from Rabat, 32 km from Larache and 110 km from Tangier. It recorded a population of 126,617 in the 2014 Moroccan census. Located near the Loukous river, Ksar El Kebir is one of Morocco's richest agricultural regions.



GeoSIG instruments at the seismic monitoring station at Dar Khrofa Dam.

Case Study

Dam Monitoring
My Hassan 1st Dam
Demnate, Morocco

GeoSIG
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In Cooperation With
GeoSIG Partner



Background

My Hassan 1st Dam is an embankment dam located 19 km northeast of Demnate on the Lakhdar River in Azilal province, Morocco. with a height of 145 m and a ridge length of 380 m, the dam provides water for the irrigation of more than 40,000 hectares of agricultural land. The hydroelectric power station of the dam also generates on average 132 Gw-hours per year.

Challenge

As agriculture in Morocco employs about 40% of the nation's workforce, it is essential that a consistent water supply is available for irrigation and livestock, as well as drinking water for the population. Morocco has been investing in integrated water resources reforms to combat the effects of climate change and safeguard its people from unforeseen calamities. Dams are continuing to be built to ensure water provision is uninterrupted. Morocco is affected by moderate seismic activity compared to other Mediterranean countries, largely related to the convergence between the African Plate and the Eurasian Plate. This presents a risk to dams (and those downstream). Although we are unable to predict earthquakes, we can strengthen protective measures by making seismic hazard assessments.

Solution

Our Partner in Morocco, SyGeo (www.sygeo.ma), develops reliable, precise and long-term monitoring systems for its customers. SyGeo's main activity is the supply, installation and maintenance of equipment for the auscultation of dams and civil engineering works, hydrology, oceanography, and meteorology.

For My Hassan 1st Dam, SyGeo installed a seismic monitoring system that included: a [GMSplusD](#) seismic recorder, 4 x [AC-73D](#) digital triaxial force balance accelerometers, an [AC-73](#) triaxial force balance accelerometer, [GeoDAS](#) (data communication software) and [GeoDAS-DAP](#) (data analysis package module for GeoDAS). [GMSplusD](#) is a self-contained instrument and is equipped with an uninterruptible power-supply, which provides more than 24 hours autonomy. It uses an "Intelligent Adaptive Real Time Clock" (IARTC) with self-learning temperature compensation, improving the accuracy of the RTC or TXCO significantly. The IARTC is able to synchronize with GPS or NTP to UTC timing to provide high timing accuracy. Optionally the unit itself can act as an NTP server as well. The instrument's [software](#) processes data in real time. If triggered by a seismic event, [GMSplusD](#) calculates a number of event parameters and reports them to a data centre immediately.

Another solution using GeoSIG instruments and a capable partner showing that quality and reliability can also be cost effective.



Installing digital cable for the seismic monitoring system.



GeoSIG instruments at the seismic monitoring station at My Hassan 1st Dam.



Triaxial force balance accelerometer, AC-73D, in situ.

Product links

[AC-73](#)

[AC-73D](#)
[GMSplusD](#)

[GeoDAS / GeoDAS-DAP](#)



GMSplusD digital seismic recorder

AC-73D and AC-73 accelerometers

GeoDAS and GeoDAS-DAP