Monitoring and analysis of the stability of basin-infrastructure system of large dams

Tutor Giacomo Russo cotutor Diego Di Martire

The safety of the reservoirs of large dams has to be permanently monitored throughout the service life of the infrastructure. Both the dam section and the reservoir banks are in fact subject to the evolution of stability conditions, increasingly due to climatic changes potentially leading to the occurrence of extreme events, to which the infrastructure systems have not been designed. Monitoring of relevant factors makes possible to quantify the ability of the basin-infrastructure system to support actions and stresses deriving from extreme events. Monitoring is also the basis for operational early-warning systems, strategic tools when safety of infrastructures means safety security for the territories in which they are built.

Recently remote sensing techniques for ground movements induced by gravitational slope instabilities have grown rapidly, allowing the development of methods suitable for both landslide hazards analysis (taking account of typology of landslide phenomena and territorial contexts) and for control of large infrastructures such as embankment dams. An approach combining the use of satellite monitoring results with ground monitoring results is particularly effective in investigating the behaviour of basin-infrastructure systems, allowing the development of reliable analyses by numerical modeling.

The development of an integrated monitoring approach is focused on the case study of Menta basin-infrastructure system. Menta dam is located in the heart of Aspromonte, 40 km east of Reggio Calabria, and with its storage capacity of about 18 million cubic meters is the main reservoir of the new aqueduct system serving the city of Reggio Calabria. From the geological point of view, the Menta reservoir basin is formed by micascists and paragneiss, with local passages to schists and gneiss. Menta dam is a rockfill dam with an impervious bituminous upstream facing, with a maximum height of about 90 m. The embankment behaviour is under monitoring, and its behaviour during the experimental storage phase is well represented by the historical series of collected data. Currently no monitoring data are available for the basin banks, which are not part of a specific monitoring activity, although the stability of the banks is a crucial aspect for the safety of the reservoir, with particular reference to seismic conditions, as recalled in the recent D.M. 26.06.2014 "*Technical standards for the design and construction of dams*"

In the perspective of reassessing the stability conditions of the banks in the current operating conditions of the reservoir, the research activity is aimed at identifying the influence of the variation of relevant parameters governing their stability, such as the fluctuations of the reservoir level (linked to the functioning of the infrastructure) and the seasonal variations of the environmental parameters (temperature, irradiation, evapotranspiration, infiltration).

The initial stage of the proposed research is focused on the selection of representative bank sections of the reservoir to be subjected to monitoring activities for the measurement of the relevant factors. The sections must first be defined from a morphological point of view, through a survey activity with techniques such as laser scanner and unmanned aerial vehicle photogrammetry, and then characterized by geomechanical surveys. The activities described will constitute the reference for initial conditions of the bank sections. The behaviour of the sample sections referred to time intervals prior to the research activities starting will be reconstructed on the basis of the interpretation of interferometric data of the area.
The research activity will allow the assessment of the stability of the banks of the reservoir under operating conditions, taking into account both "ordinary" conditions, governed by the variation of reservoir levels due to the operation of the infrastructure, and related to extreme weather events and seismic events. A specific activity will be carried out to validate the correlation between monitoring with DInSAR techniques and ground measurements, in order to calibrate the interpretation of interferometric measurements by traditional measurements and consequently to assess their reliability. Satellite monitoring will be a fundamental tool for the implementation of *quasi*-early warning systems, which will be one of the relevant products of the proposed research. The measurement of the relevant parameters and their variation, as a consequence of the variation of the forcing quantities previously mentioned, will then allow comparisons with results coming from the numerical models, based on finite element or distinct element numerical codes. The validation of numerical models will allow to implement a *real time analysis* of the conditions of stability of the reservoir within the early - warning system.

Proposal for a PhD position

A PhD position will be required for a candidate who will develop the proposed research activity, which could validly be completed within the three years of the PhD cycle.
The work programme will include a literature study on geological and geotechnical problems of reservoirs. On-site activities will be carried out using the available state of art equipments of DiSTAR of University of Napoli Federico II. At DISTAR the PhD student will have the opportunity to acquire technical skills related to remote sensing methods, monitoring of large infrastructures, geomechanical characterization of rocks, and stability analyses in static and seismic conditions by advanced calculation methods.
Training courses of the "Doctoral School" will be available for the PhD student at the host University, in order to improve his knowledge on different topics.
The work program of PhD student will include a 5 months secondment to a foreign Institution allowing to learn different analytical and numerical methods, the interaction with other PhD students and Reserachers to further develop his career.

Progetti

Contratto di Ricerca fra la Società delle Risorse Idriche della Calabria (SoRiCal S.p.A) e il Dipartimento di Ingegneria Civile e Meccanica dell'Università degli Studi di Cassino e del Lazio Meridionale per la "*Consulenza Geotecnica di supporto alle attività di controllo del comportamento idraulico, statico e dinamico delle opere sul torrente Menta nel corso degli invasi sperimentali*". Responsabile Scientifico: prof. ing. Giacomo Russo. Importo complessivo del progetto 107k€.