Session Report

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Authors of these conclusions: Natalia Pérez, Yasmina Boussafir and Paul Nowak

TECHNICAL SESSION 13.2. RESILIENCE OF EARTHWORKS. PART 2
FRIDAY, FEBRUARY 11, 12:30 PM TO 14:00 PM

1. KEYWORDS

Resilience, earthworks, natural hazards, case studies, land slides, etc.

2. PRESENTATION OF THE SESSION ~~(XX COPY THE SAME TEXT AS ON THE WEBSITE XX)~~

This session is Part 2, presenting a series of approaches and case studies for incorporating resilience into Earth Structures. Resilience is becoming a key consideration in the design, operation and maintenance of Earth Structures as asset owners strive to identify risk associated with extreme events and develop robust earthworks solutions to support road infrastructure. The session presents (1) a summary of Case Studies of resilience in relation to Earth Structures (2) Measures for increasing resilience of Earth Structures on the road networks of Canada, Reunion (France) and Spain.

3. PROGRAMME OF THE SESSION

Session Chair: Patrick Boisson
Session Organiser: TC 4.3
Session Secretary: Natalia Pérez

Person	Organisation, Position…	Title of the presentation
Jason Hastings	Chief of Bridges & Structures. Delaware Department of Transportation	Techniques and Innovations in Earthworks – Case Studies
Patrick Zerr	Project Engineer, McElhanney	Treat the source, not the symptoms
Pierre Azemard	Geological risk referent at CEREMA (France)	Rockfall hazard management on the RN1 Reunion Island
Joaquín Pérez Romero	Geotechnical consultant, Spain	Geotechnical strategies for adaptation and resilience of the Kamichik mountain pass in Uzbekistan

4. TECHNICAL FINDINGS AND DEBATE

In this session, Patrick Boisson (chair of TC 4.3) introduced the first speaker, Jason Hastings, chief of Bridges and Structures of the Delaware Department of Transportation. Jason talked about the case studies that TC4.3, group 2, collected. He mentioned that the group sent an inquiry to collect the cases. They received 36 case studies from 17 countries. One case was about dry compaction, other case classified as material case, some others on technology, erosion and reinforcement. It was mentioned that dry compaction is applied to coarse-grained soils. Jason presented a case study in which crushed glass was used as backfill.

Other cases presented were about slope stability with bioengineering and solutions of karstic areas placing a type of bag.
Following the presentations, Patrick Zerr from Canada, presented a case of a landslide. He showed how the landslide was increasing through the years. He mentioned that some solutions implemented were the construction of timber dams and the slope was also revegetated. Treating the source of erosion appeared as a good solution. The first techniques based on reinforcement and hardening earth-structures didn't work. They adapted their work with soft techniques based on water management, trying to reduce the speed of water along the slope. On his side, Pierre Azemard of CEREMA (France) talked about a national road that was built down a cliff. Several problems were observed right after construction. One of the problems was the rock falls, which was solved with hanging nets and gabions of 4 to 6 m high. In the talk he mentioned that rock falls and precipitation were simultaneously recorded during 20 years. Histograms were shown with the data. He insisted on the importance of this work collecting this elementary data thanks to the maintenance teams. Any time an event appeared the teams noted the amount of rainfall, the location of the event and the volume of rock fall. A database was built with this information and a statistic work was done to extract a law of nature behaviour. This law allowed a safety management of the asset, for example based on cutting one lane and tilting traffic when a certain amount of rainfall is achieved.
The last presentation was done by Joaquin Perez Romero, consultant, from Spain. He presented the study of the Kamchik Pass. The pass corridor was divided in 6 sectors. Joaquin presented the possible problems that each sector could show. For example, sector 1 has problems or erosion in the marine deposits; sector 2 has rock falls but they do not disturb the highway because it is wide enough for the rocks to fall along the side of the road; sector 3 has altered rock and block instability; sector 4 has no problem as the material is basalt, and sector 5 has a high risk; material can fall. At the end of the presentation, Joaquin indicates some measures that can be utilized to reduce the risks : monitoring, reinforcement or, sometimes, no action.
To finalize the session, some questions were posed. The first question was for Joaquin. He was asked if he knew the solutions for the project and if he knew the cost. He said, he did not knew the economics.
Yasmina Boussafir mentioned that the project of Patrick Zerr is very interesting; Patrick Zerr indicates that the works are still going on. Yasmina asked Joaquin if they do the same kind of analysis to other places. He said, no because of the differences in geology and type of soils. Joaquin also mentioned that the survey took 2 weeks to be done. Finally, Patrick closed the session saying that it was an excellent session in which many case-studies were presented.

18 persons attended this session.

5. RECOMMENDATIONS FOR DECISION MAKERS, FOR PIARC OR FOR INTERNATIONAL ORGANISATIONS

In the session, many case-studies were presented. It is worth mention that the solutions can be analysed to see if they can be utilized in other countries.
Documented case history and lessons learned are of great importance for understanding and preparing future works. Resilience is somewhere in **improving techniques of reinforcement/construction thanks to lessons learned**: when a technique does not work, the designer change and adapt the work (Patrick Zerr). Treating the source of the problem of instability appeared as a good solution when the hazard is due to water (Patrick Zerr). **Mapping the hazards along the lane** with cross evaluation between type of hazard, intensity of hazard, evaluation of vulnerability of the infrastructure for an estimation of a risk level (=engineering geology), that appeared as a good tool to possibly prepare the resilience for an infrastructure (Joaquin Perez Romero). A **strong documentation of the hazard with many data coming from the maintenance teams** allowed statistic work for a safety management of the asset (Pierre Azemard).

6. PREPARATION OF THE SESSION

This session was planned, designed and organised as follows.

Patrick Boisson, Natalia Perez, Yasmina Boussafir, Paul Nowak, Jason Hastings, Alexandra Ferreira (TC4.3)