TECHNICAL COMMITTEE 4.3 – EARTHWORKS

4.3.1. Measures for increasing resilience of earthworks

Strategies / Objectives

- Identify the main factors and agents of damages earthworks including those due to climate changes.
- Identify materials, design, earthworks techniques for enhancing resilience of earthworks.
- Encourage coordination with other TCs and TFs, such as *T.C.1.4 – Climate change and resilience of road networks, T.C. 2.2 – Accessibility and Mobility in Rural Areas* and *T.F.4.1 Road Design Standards.*

Resilience is a new term which can explain the adaptation of the road infrastructure to an external event. The infrastructure is considered resilient when, after an extreme and destructive event, its repair makes it possible to return to a sufficient level of use, close to the one preceding the event.

Challenges? Minimize the delays of shut down for axis of transport. Some can be identified as major or critical for mobility. The disorders caused to earthworks are often disorders affecting the entire structure, generally cutting off traffic and mobility on this axis and making dangerous the immediate surroundings.

The damage, caused by a climatic event and / or a natural hazard, are numerous and varied. They range from the complete destruction of the section, to obstruction or degradation of the quality of use by cracking, deformation or rutting.

The natural hazards in question are most often:

- earthquakes,
- landslides,
- rockfalls,
- erosion phenomena,
- storms, tsunamis, hurricanes
- rising water,
- drought, fires,
- collapses of cavities

One frequently cited example of the need for resilient infrastructure is earthquake disasters. An earthquake generates in a few seconds or minutes significant damages and casualties around its epicenter. The material damages evolve shortly after the event, while the number of victims can double or even triple if access to affected areas, are not quickly re-opened to help.

Often linked to the transport infrastructure, the water network, telecommunications and energy networks (electricity, gas) are sorely lacking after an earthquake and networks failures worsen the situation. A health disaster is added to the natural disaster.

(extract RGRA n ° 961, G. Rul) "The floods of June 2016 in the Loiret led to the cutting of the A10 motorway, strategic axis between the center of France and Paris, and to the paralysis of the northern sector of Orléans. That same year, the forest fire near Marseille requiring the closure of the highway had repercussions on all transport networks. Finally, the landslide of Chambon in 2015 caused the closure of the tunnel on the RD1091, the isolation of the population and the paralysis of a whole valley. "

The 5th generation road will have to be thought as resilient from the moment of its conception. For that, it can be proposed the following:

- Road designers will have the list of hazards that can likely affect sections of roads, and these hazards will be listed from the worse to the less important on each sections of identical issues.

- Stakeholders will have to define the minimum level of use they want to maintain in the event of a hazard, and in the same time, the maximum tolerable delay during which the infrastructure cannot be used, and therefore the delay for its repair.

- The design will assess the economic and social risks associated at the occurrence of the hazard.

The subject of resilience for earthworks is a new subject. Therefore, it requires specific thinking that can first be based on key definitions. A consensus will have to be found around these definitions. The Report drafted by Technical Committee *T.C. D.4 - Rural Roads and Earthworks* (SP 2016-2019) "Management of Earthworks" should be completed by the way.

The return to an optimal or sufficient level of use, strongly depends on identified parts of earthworks i.e.: embankments, natural ground, construction tracks, unpaved roads, fills… The proposal is first to identify the damages that are related to these parts and how they affect the mobility on the road. The following question will be to define the level of use for the stakeholder, and what are the expectations for a return to normal infrastructure.

The level of use will have to be defined from sufficient to guarantee the transport of relief or goods, to extreme mobility in any weather or any type of vehicle. In other words, what is the level expected for resilience? And, what is the place of earthworks in reaching the expected level of resilience for the stakeholder?

This subject is a real opportunity to show that earthworks occupy a significant place in the road. The global level of the infrastructure strongly depends on the relative "good" condition of the earthworks. Previous reports have shown that few countries maintain their earthworks, often for cost reasons.

The *T.C .4.3* may be an ideal place to identify the main damages that affect earthen structures.

Working on specific damages that affect earthworks may suggest their importance in a global scope of road management, and it may lead to a methodology that could increase the client's awareness and point out the main challenges.

From the list of disorders affecting earthworks, it could be interesting to establish a list or a classification of soils or rocks that can be used in earthworks, from the most to the least vulnerable to natural hazards or climate events.

Damages, once they exist, must be repaired to ensure the resilience of an infrastructure. This, whatever the conditions of intervention, which can be difficult or even dangerous. Therefore, to investigate from different case studies could be an approach.

A full report would be drafted based on the case studies collected.

Outputs	Expected Deadlines
• Literature review.	• December 2020
• Collection of case studies.	• June 2021
• Full report.	• December 2021

4.3.2. Techniques and innovation for construction and maintenance of earthworks

Strategies / Objectives
• Identify existing techniques for building and repairing earthworks even in extreme situations: harsh weather, inaccessible sites, technological risks, etc. • Identify maintenance techniques. • Identify innovation, new methods and equipment for the construction, monitoring and maintenance of earthworks (robotics, drones, equipment, GPS, monitoring, BIM, etc.) • Encourage coordination with other TCs and TFs, such as *T.C. 2.2 – Accessibility and Mobility in Rural Areas, T.C.3.3 – Asset Management,* and *T.F.4.1 Road Design Standards*

The techniques of construction in earthworks all around the world may be subjects of differences as well as technical and scientific questions, both for earthmoving companies and for contractors when they are faced with companies from other countries.

These questions have already been raised at European level when it came to writing the European standard for earthworks. Highlighting the differences in international practices and bringing out the specific advantages or disadvantages of each practice is a topic that can be very motivating for *TC.4.3* members.

This subject can help to understand the design of earthworks and can reveal the specificities of each country. LMIC could find here a way to valorize their specificities, highlighting the difficulties of their sites, the geology and type of materials, or even the constraints imposed by the administrative rules.

Maintenance and resilience: these are two prospective topics for earthworks companies as well as for stakeholders. Consultation can be conducted in a way that brings out existing maintenance practices, if they exist, and what should be the best practices?

As a new topic, it should be very interesting to discuss about the need of maintenance or not of earthworks? What are the difficulties, the needs, the levels of maintenance that can be thought, the link with the desired resilience?

Maintenance is easily accepted when it is for the benefit of the stakeholder or the user. There is reasons to think about the benefits and costs of maintenance. But maintenance does not mean repair: the separation between the two functions will have to be clarified.

Adaptation is the key word of earthworks companies: it is vital to be able to adapt to all situations and constraints when working soils and rocks. The design is not the only way to find good solutions and the company is a real force of proposal when works begin to be difficult. It brings their technicity and their means, sometimes innovative, that should be highlighted.

Adaptation does not necessarily mean innovation. For that, forward looking should be done within *TC.4.3* highlighting the innovations in equipment or practices that companies or experts have developed to improve today's earthwork and what can be expected for the next few years.

Innovation can also be the answers of not well-formalized needs: the *TC.4.3* can be a place to discuss the future prospects of earthworks 2.0.

Innovations are sources of motivation and progress for men, companies and stakeholders. For example, earthworks monitoring is a completely prospective subject. Currently reserved for researchers, monitoring can be a way of information that should help to define the level of performance of the works, or the need of specific maintenance. It can also be a source of information on the state of the structures, the location of a localized damage and its importance, and the triggering of appropriate maintenance or repair operations.

A collection of case studies would be carried out to gathered best practices. And a full report based on those findings would be drafted.

Outputs	Expected Deadlines
• Collection of case studies	• June 2022
• Full report	• December 2022.

4.3.3. Update Earthworks Manual "Design and Construction of earth-structures"

Strategies / Objectives
• Update Earthworks Manual "Design and Construction of earth-structures".

The Earthworks Manual was developed within the framework of the issues defined in the PIARC 2012-2015 by *TC.4.4 "Earthworks and Unpaved Roads"*. The Earthworks Manual is a collection of rules and good practices with the purpose of enlightening and sensitize readers on Earthworks management, at the design stage of earthworks, the project and the execution of earthworks. The Manual takes into account the different PIARC technical reports produced in previous sessions.

In the context of this topic, the manual is to be updated with regard to new rules and findings with regard to current *TC 4.4* reports.

Outputs	Expected Deadlines
• Update of the Earthworks Manual	• Up to June 2023