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Towards the resilience of Attica Region's Provincial Road 3 in Greece, due to slope failure by applying civil engineering techniques and Rock Engineering System assessment

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The problem

In Dekelias Street (District Road 3, under the jurisdiction of the Region of Attica in Greece) between National Motorway of Athens-Thessaloniki and Kymi Avenue in the Kaliftaki area, **near the Chelidonous stream**, which is a tributary of the Kifissos River, **failures have been occured on the road surface**.

Those failures can be attributed to surface erosion because of inadequate drainage of rainwater and to wider phenomena instability of the adjacent slopes due to the erosive action of the stream.

Excerpt from a Google map showing Dekelias street (yellow line), Chelidonous stream (thin blue line), Kifissos river (heavy blue line) and the areas under investigation (orange semi-circular). This place is located in the north part of Athens, the capital city of Greece, adjacent to the National motorway Athens to Thessaloniki.

How the problem was faced

The idea of facing those failures was based on establishing a solid understanding of what contributes to the under-examination road disaster resilience and how it can be measured.

In the context of the roadway rehabilitation, geotechnical site investigation as well as stability, and rehabilitation study of the roadway, was conducted by Directorate of Technical Works of Attica Region.

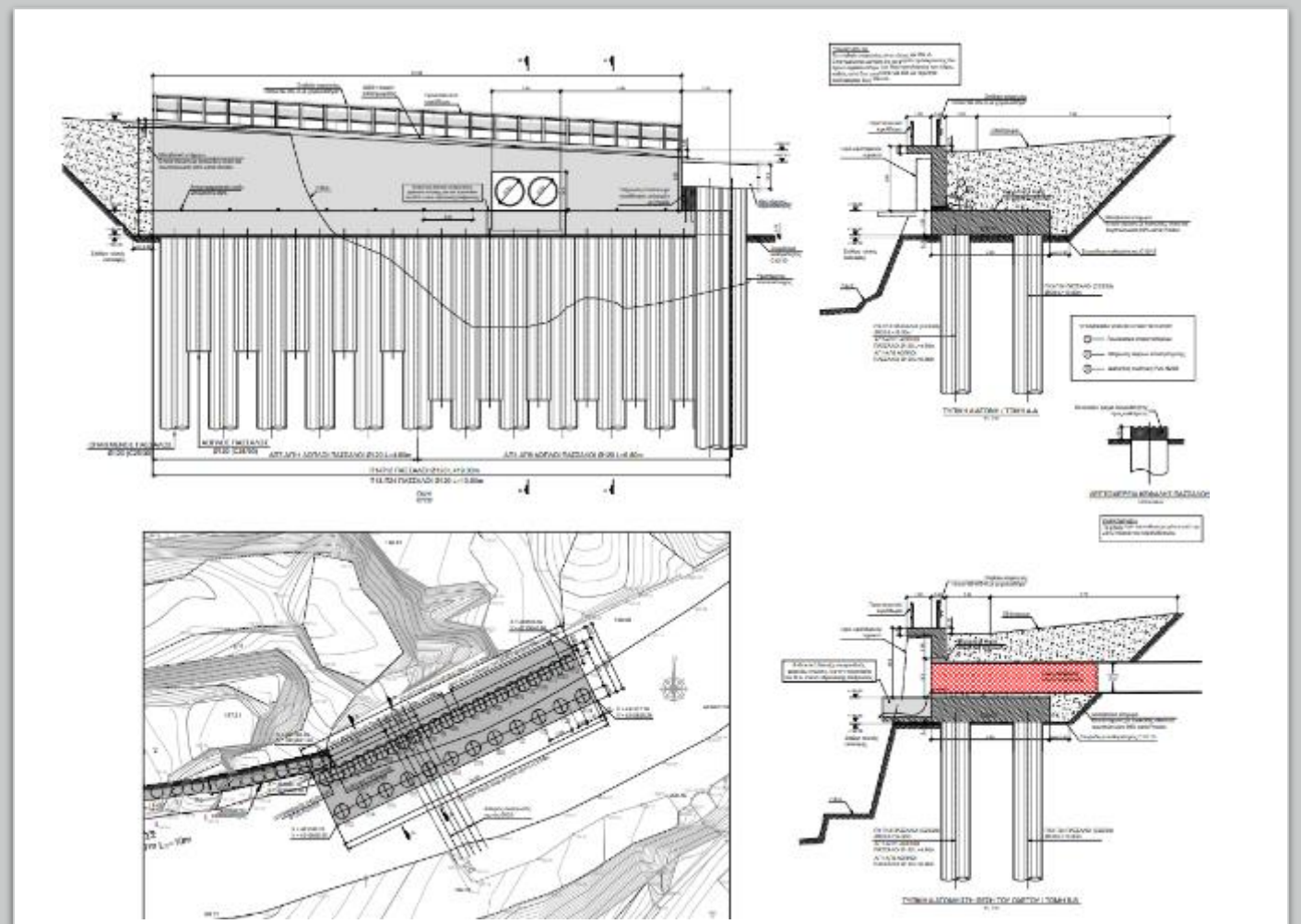
DEM (pixel analysis 5X5m) of Attica Region, Greece (Tavoularis et al., 2021)

View from the slope failure (fall) of the examined road (Directorate of Technical Works/Region of Attica, 2020)

Geotechnical study

The proposed solution is an example of targeted resilience strengthening investment and action.

To address the erosive mechanisms, it was proposed to construct pile walls made of intersecting piles of different diameters and walls on piles anchored, due to the significant resistance heights obtained, with a passive anchoring system of deadman type.



Cross-sections of the designed works, (EDAFOS Consulting Engineers, 2018 – Region of Attica / Directorate of Technical Works)

What happens now? (Construction phase)

The stabilization – civil engineering works started on September 2020, and due to pandemic of COVID-19, the progress of the project is now equal to about 60%.

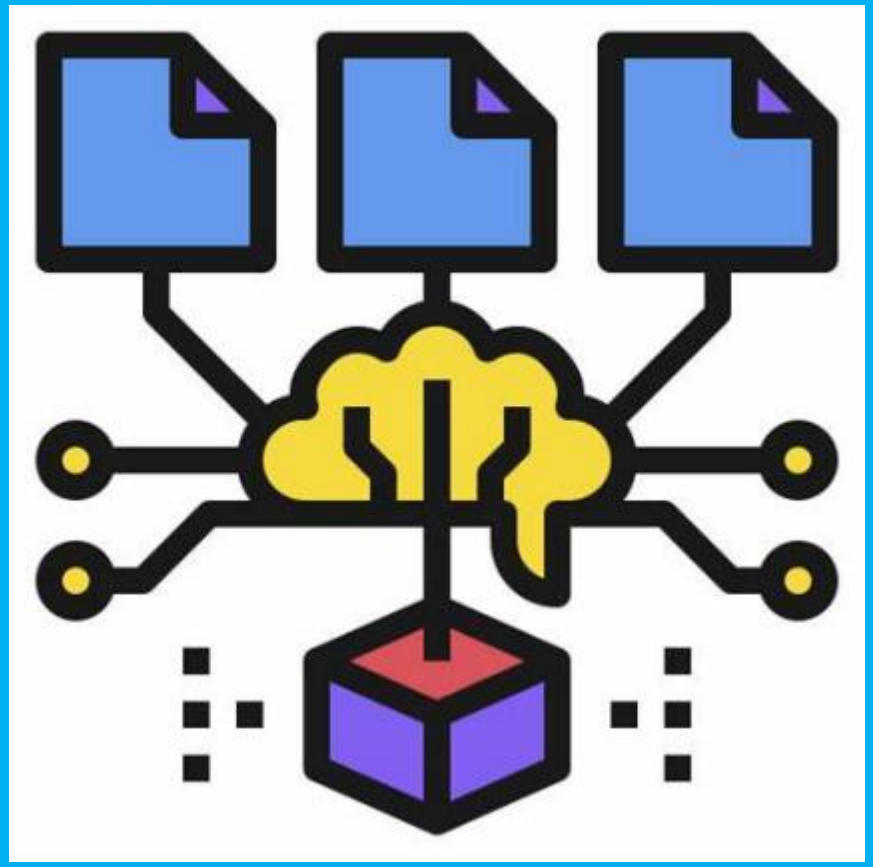
Different views (on the right) during the construction phase (Region of Attica)

The hazard of the existing dangerous (concerning stability) condition of the stream slopes and their adjacent road was confirmed by using a semi-quantitative methodology named **Rock Engineering System (RES),** firstly introduced by Hudson (1992).

This methodology is mainly based on the correlation of mechanisms between landslide parameters through a matrix-table and uses slope failure factors that can potentially be identified during the preparation phase of a preliminary, final or implementation study of a civil engineering project.

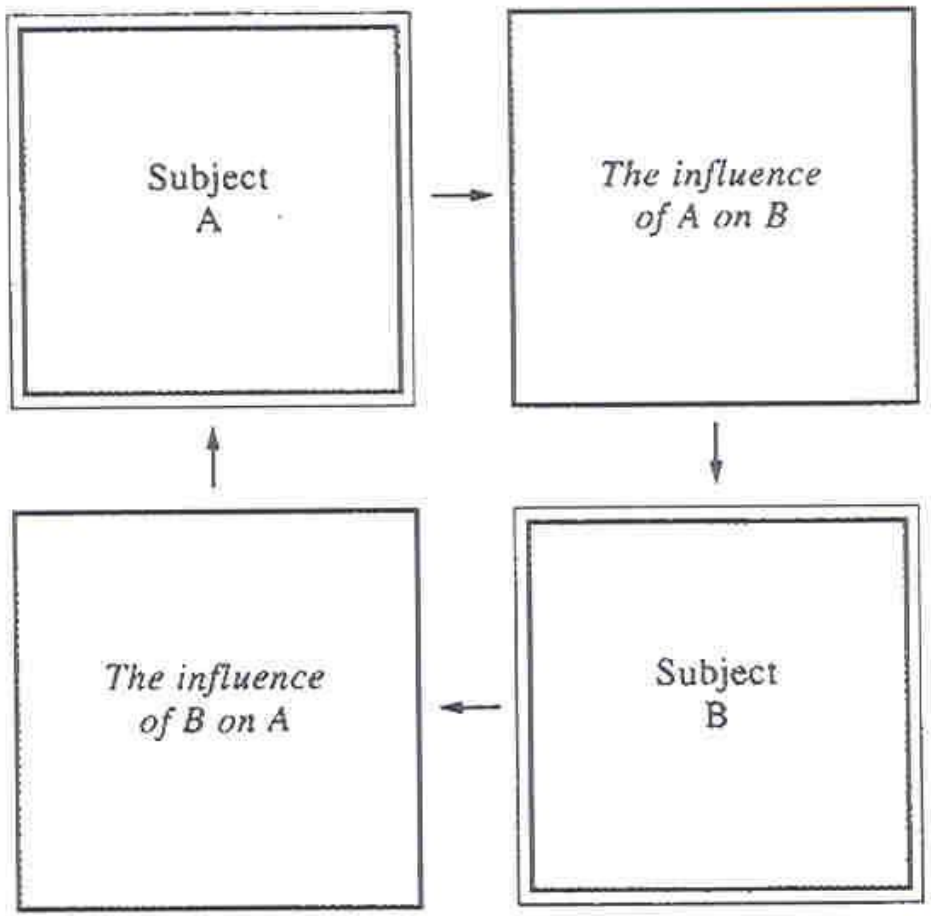
The scope of using RES, is to estimate the landslide instability index which results in generating landslide susceptibility, hazard and risk maps.

RES could be characterized as a predictive model aiming to quantify disaster resilience

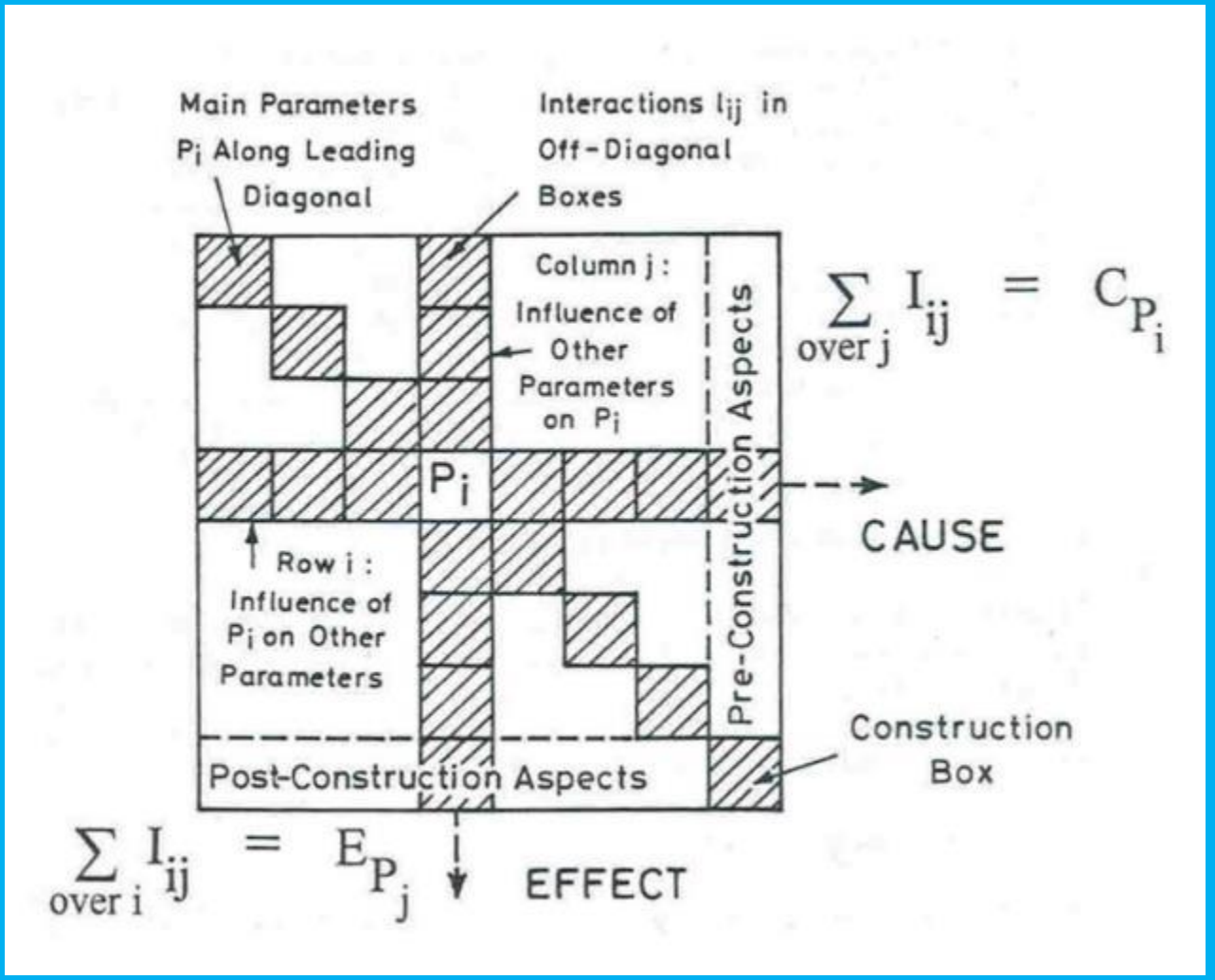


A characteristic example of predictive model (Wikipedia, 2022)

ROCK ENGINEERING SYSTEM (RES)



Basic idea of RES (Hudson, 1992)



Interaction matrix – How it works (Hudson, 1992)

References

1. **Hudson, J. (1992).** “Rock Engineering Systems: Theory and Practice”. Ellis Horwood Limited: Chichester.

2. **Tavoularis N. (2017).** The contribution of landslide susceptibility factors to the prognosis of slope failures. PhD thesis, National Technical University of Athens, School of Mining Engineering, Department of Geological Sciences, https://www.didaktorika.gr/eadd/handle/10442/42295?locale=en

3. **EDAFOS Consulting Engineers (2018).** Support study mitigation measures of Kifisia’s provincial road (E.O.3). Region of Attica, Directorate of Technical Works.

4. **Tavoularis N., Papathanassiou G., Ganas A., Argyrakis P. (2021).** Development of the landslide susceptibility map of Attica Region, Greece based on the method of rock engineering system. Land journal, https://doi.org/10.3390/land10020148

A relative theme to the present work, is the Session called "*Landslides and Soil Erosion*" of the **Workshop** on **Soil Erosion for Europe – Emerging challenges**, taking place **virtually** (participation is free and open) on **20-22 June 2022**, under the auspices of **Joint Research Centre (JRC)** of European Commission.

Workshop on soil erosion for Europe – Emerging challenges

Call for presentations

20-22 June 2022, (WEBEX - Online)

***Moderator**: Panos Panagos, European Commission Joint Research Centre*

***Rapporteur**: Diana Vieira, European Commission Joint Research Centre*

Scope: Exploring the role of soil erosion in relation to land degradation, climate change, food security

The EUSO Soil Erosion Working Group (WG) organizes a workshop split in the following sessions:

1. **Sediments** (including monitoring network). Chair: Nejc Bezak (Nejc.Bezak@fgg.uni-lj.si)
2. **Farm/Field scale modelling**. Chair: Marcella Biddoccu (marcella.biddoccu@stems.cnr.it)
3. **Erosion mitigation & management practices**. Chair: Artemi Cerda (artemio.cerda@uv.es)
4. **Soil organic carbon and erosion** integration. Chair: Negrel Philippe (p.negrel@brgm.fr)
5. **Food security, nutrient losses** with erosion. Chair: Christine Alewell (christine.alewell@unibas.ch)
6. **Large scale modelling**. Chair: Pasquale Borrelli (pasquale.borrelli@unipv.it)
7. **Early Career Research on Soil Erosion**. Chair: Daniel Evans (Daniel.L.Evans@cranfield.ac.uk)
8. **Landslides and soil erosion**. Chair: Nikolaos Tavoularis (ntavoularis@metal.ntua.gr)
9. **Climate change and soil erosion**. Chair: Joris Eekhout (jeekhout@cebas.csic.es)

Overall co-ordination: Diana Vieira (Diana.SIMOES-VIEIRA@ec.europa.eu)

We are looking for presentations for this workshop. If you are interested to present your work, please send your proposal with a **tentative title** (and 5-10 lines of abstract) **to one of the nine Session Chairs** (in cc Diana Vieira). Based on the number of proposals, sessions may be merged, extended or changed.

Deadline for proposals: 29.5.2022

Participation is **free and open** (registration details will follow)

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During the construction phase

Thank you very much for your attention!

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