



In collaboration with

Structural Engineering Department

Politecnico Milano



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ROCKFALL GALLERIES

A NEW APPROACH

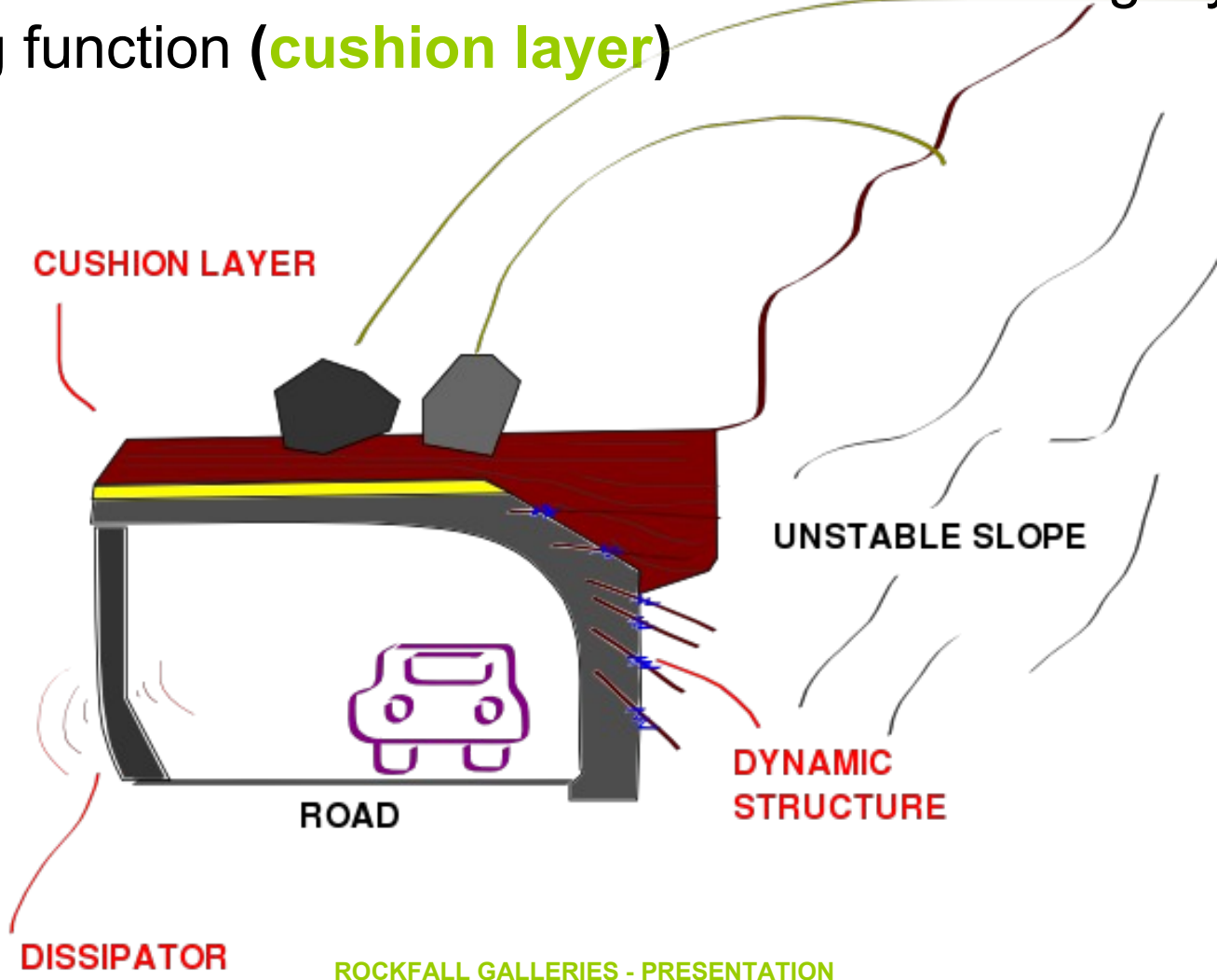
ROCKFALL GALLERY

DEFENSIVE WORKS:

A “passive” defensive infrastructure which solves, often once and for all, the problems related to falling rocks by **diverting**– and also **stopping** – the **boulder** trajectory

ROCKFALL GALLERY

FACTS: a concrete or steel **structure** + covering layer with a damping function (**cushion layer**)



ROCKFALL GALLERY

standard project

- Problems during the **design phase...**
 - Empirical formulae (Kar-Montani)
 - Overestimation of the impact of forces on the structure

...lead to

Structures with a strong visual impact

Heavy structures >>> global stability

Difficulties in setting up building yards

Structures with a limited architectural value

Long completion time

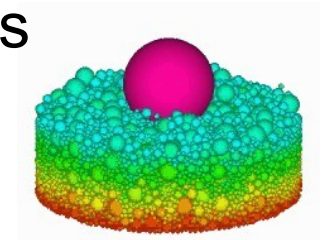
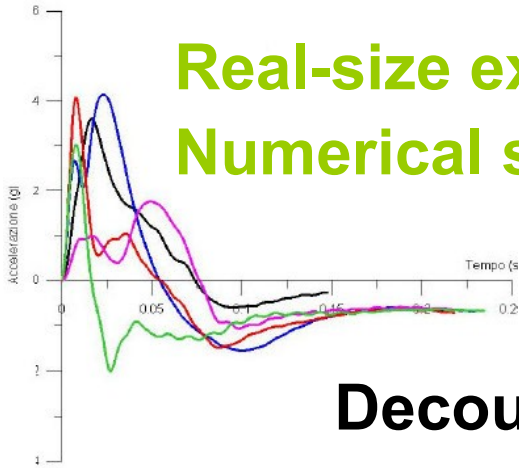
High costs

ROCKFALL GALLERY

NEW APPROACH

Real-size experiments (test scale 1:1)

Numerical simulations with distinct elements



Decoupling of the impact phenomenon



INTERACTION

**BETWEEN BLOCK
AND CUSHION**



TRANSMISSION

**MATERIAL
CUSHION**



RESPONSE

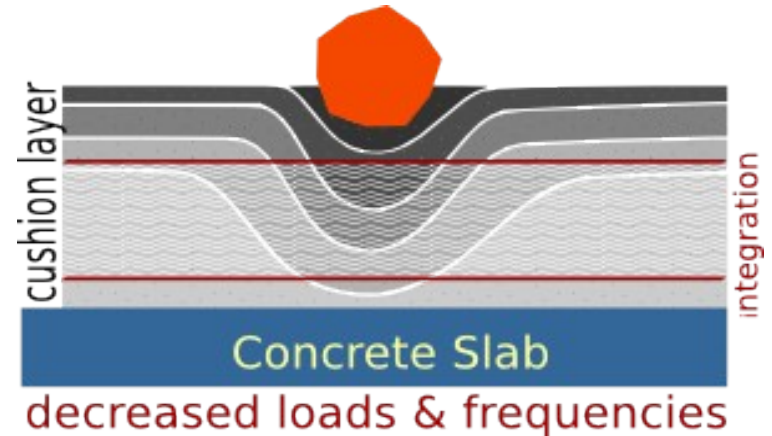
**STRESS
STRUCTURE**

ROCKFALL GALLERY

NEW APPROACH- SOFTWARE

Software inputs

- **Block** dimensions
- Impact **speed**
- Cushion thickness
- Cushion typology* (material)



Outputs

Cushion stress data

* The mixture of materials in the cushion has a considerable impact on the system performance rate

ROCKFALL GALLERY

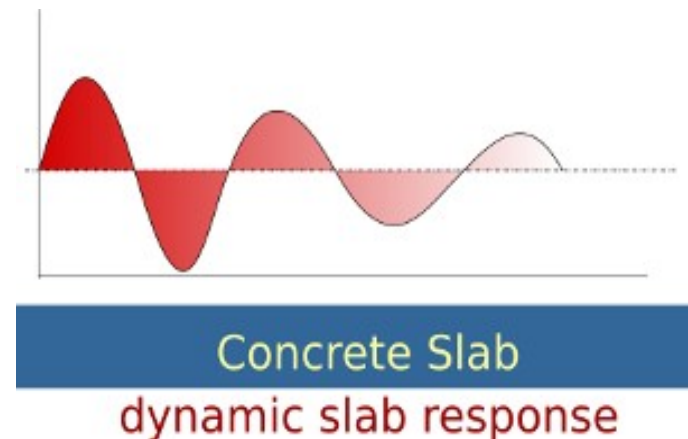
NEW APPROACH - OPTIMIZATION

Results from the analysis of cushion stress:

- Response of the **slab**
- **Reflected wave** of the slab
- **3D stress** on the structure

Objectives

- **Optimized** slab
- Improved **efficiency**

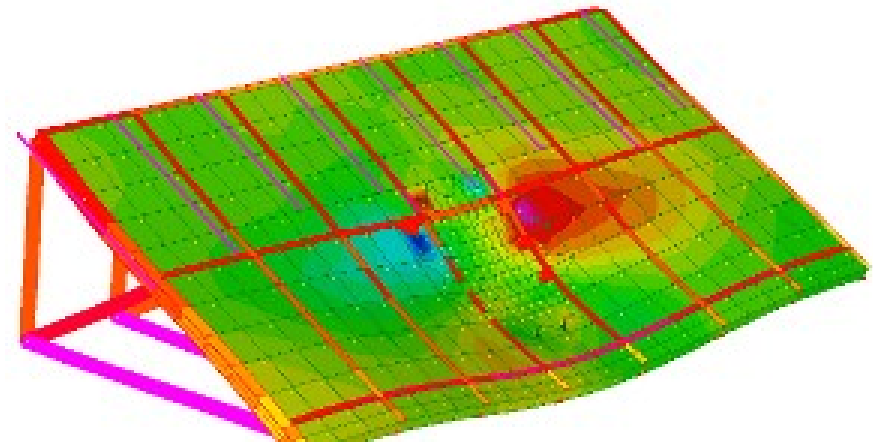
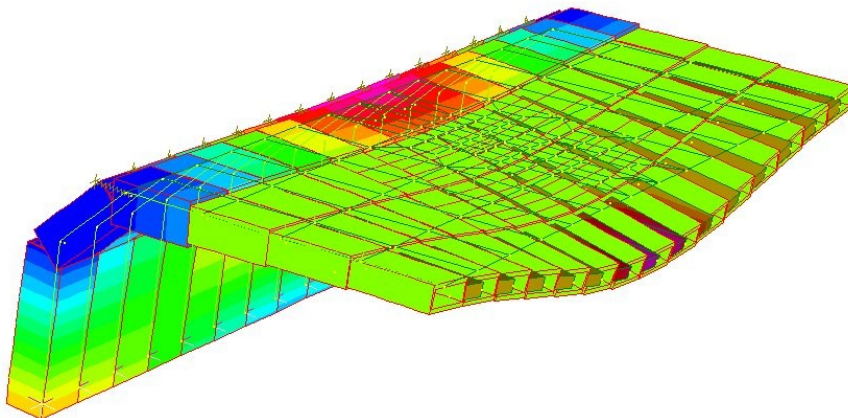


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NEW APPROACH – NEW STRUCTURES

The **propagation** of the effort stands at the basis of the choice for the ideal type of gallery

- Arched gallery
- **Shelf tunnels**
- Polycentric galleries

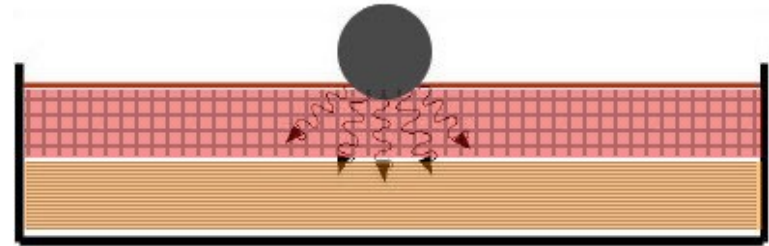


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NEW APPROACH – NEW MATERIALS

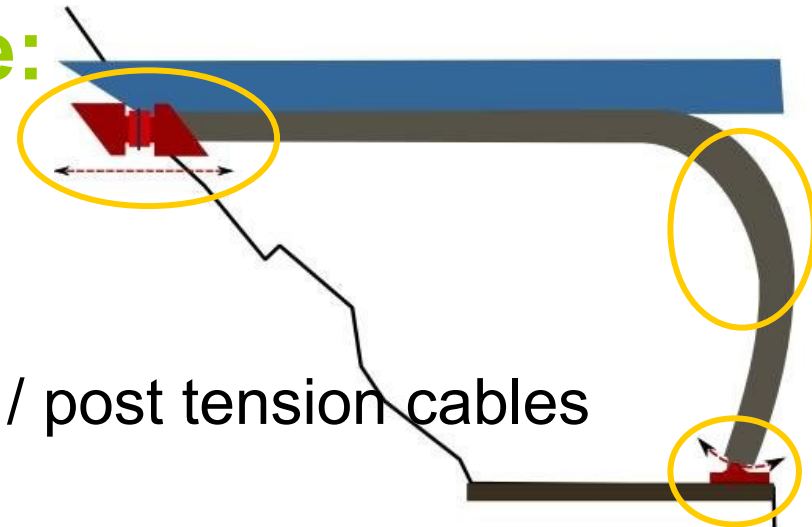
- Materials for the **cushion**:

- Multi-layer components
- **Damping 3D cells**
- **High dissipation** material
- **Integration** with geosynthetic materials, metal grid



- Material for the **structure**:

- Concrete
- **Steel**
- New **dissipating elements**
- Bar tie rods/ strand tie rods / post tension cables



ROCKFALL GALLERY

NEW APPROACH – BENEFITS

- An overall **efficient** work
- **Light** structure
- Better **environment integration**
- An **easy set up** of building yards
- **Aesthetically satisfying** architecture
- Reduced completion **time**
- **Reduced** costs

THANK YOU FOR YOUR
ATTENTION



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