Deterioration Modelling of Protection Structures against Natural Risks

Application to Monitoring and Preventive Maintenance of Check dams

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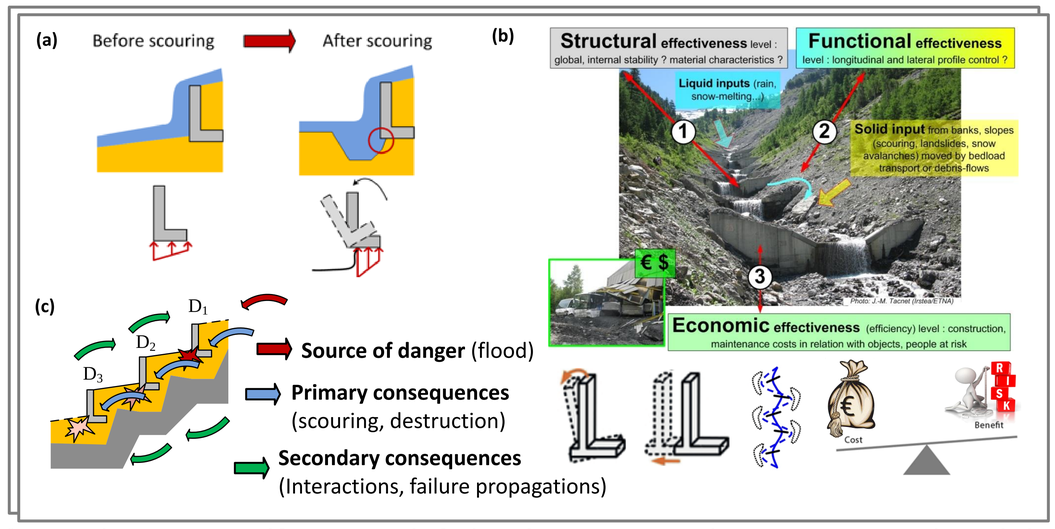
Context: Natural phenomena in mountains (e.g. Torrential floods) induce severe damages and put people and assets at risk. Protection structures (e.g. check dams) deteriorate over time. Their deterioration can have dramatic consequences and their maintenance costs much. Therefore, one main decision-making issue consists in choosing the best maintenance strategy.

Objectives of the PhD

- Identifying **dependencies** between possible failure modes of the structure (functional and structural failures).
- Assessing the **time-dependent efficacy** of check dams from functional, structural and economic points of views.
- Analyzing the **bidirectional dependencies** between structures located in series (cascading events).
- Supporting the **maintenance decision-making** of check dams.



(a) Local scouring (functional failure) triggering loss in external stability (structural failure); **(b)** Three components involved in a check dam's efficacy assessment; **(c)** Bi-directional dependencies between dams located in series.

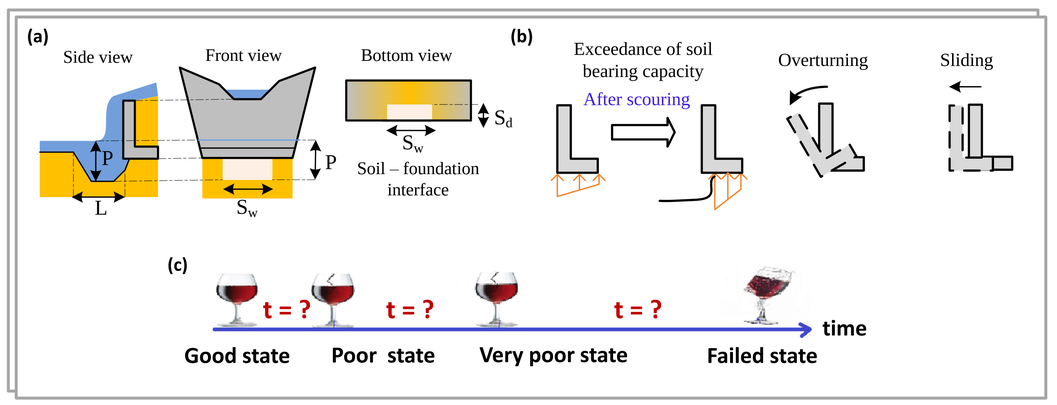
Methodology

(1) Physics-based modeling

- Torrent's bed evolution (**LOGICHAR**)
- Check dam's scouring and stability calculation
- Degradation indicators time-dependent evolution
- Dam's states definition and transition times estimation

(2) Reliability-based modeling

- Degradation, inspection and maintenance processes modeling (**Stochastic Petri nets SPNs**)
- Maintenance strategies simulation and comparison



(a) Scour pit and Local scouring dimensions; **(b)** External stability justification (three stability indicators); **(c)** Evolution of a system from one state to another.

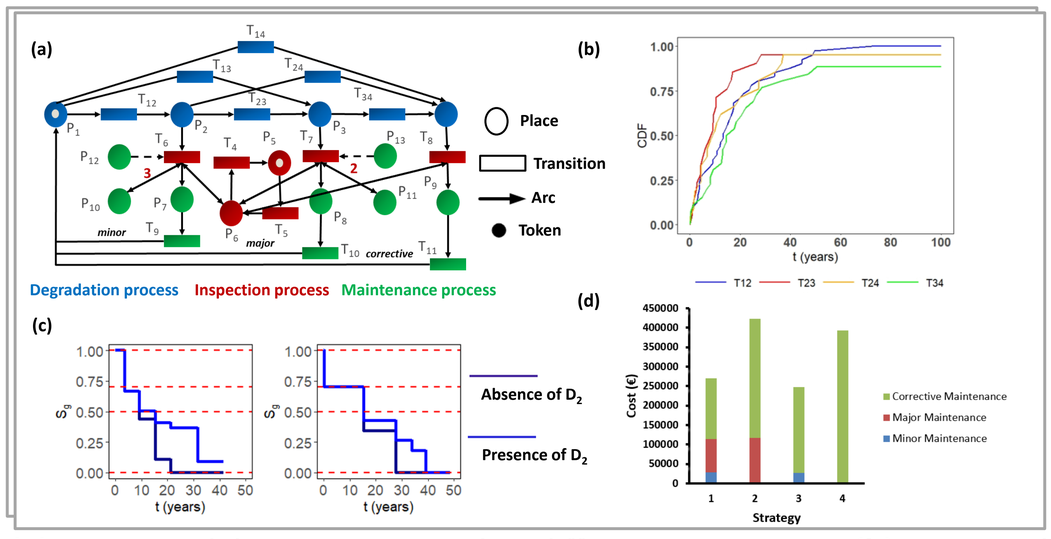
Applications - Expected Results

(1) Complete check dam model (Manival torrent – France)

- Mean sojourn time of the dam in each defined stat
- Average expected total cost of each maintenance strategy

(2) Multi-component system (System of two check dams)

- Which dam fails first (upstream dam D_1 or downstream dam D_2)?
- What types of interaction exists between both dams?
- To what extend does the presence or absence of one of the dam affects the behavior of the other?
- Which dam has the priority to be maintained?



(a) SPN model representing the different processes; **(b)** Empirical cumulative distribution functions of stochastic transitions involved in the SPN model (Application 1); **(c)** Time-dependent evolution of the global stability indicator (Application 2); **(d)** Total cost of each defined maintenance strategy (Application 1).

Risk
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