ROBUSTNESS and CONSEQUENCE BASED ASSESSMENT of an existing dam

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OUTLINE

1. **RELIABILITY-BASED DESIGN:** how does it works?

2. **EXTREME SITUATIONS and ACTIONS:** Why? When?

3. **ROBUSTNESS and CONSEQUENCE-BASED DESIGN**

4. **EXAMPLE ON AN EXISTING DAM:** Agaro Dam

5. **CONCLUSIONS**

Reliability-based design

Structural Safety

Probability distributions

Actions → Design situation → Design rules

- Seismic, Wind, Snow…
- Anthropic

- Serviceability LS
- Ulitimate LS
- Collapse LS

BASES OF STRUCTURAL DESIGN

Structural Safety

Probability distributions

Actions

Design situation

Design rules

- Seismic, Wind, Snow…
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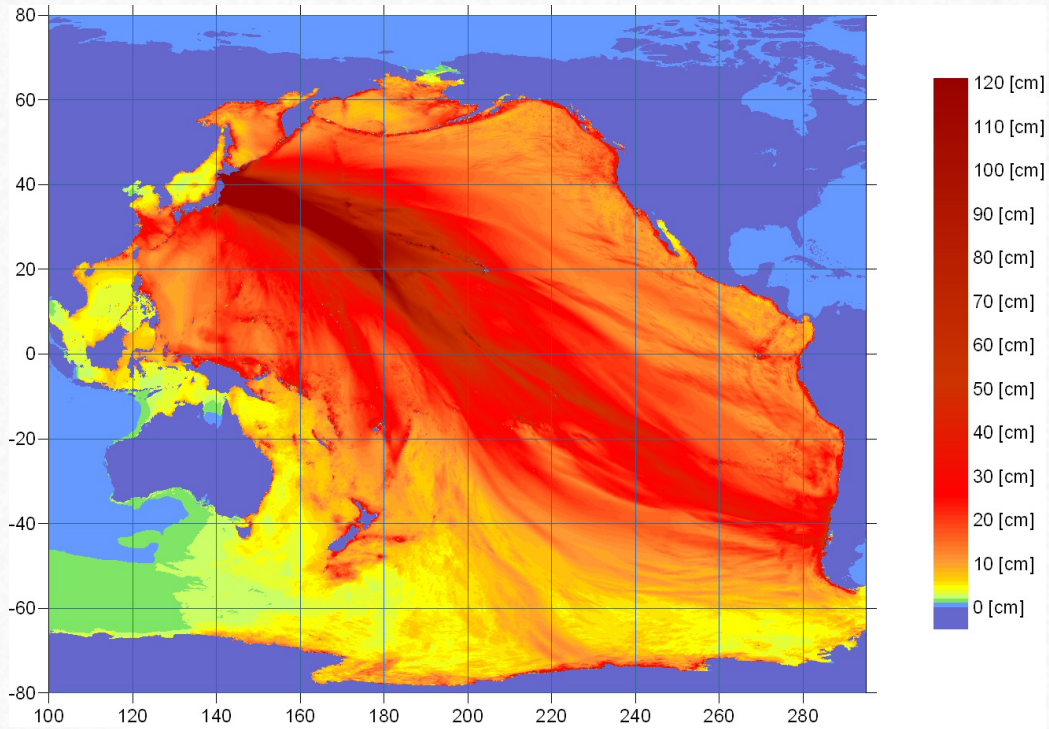
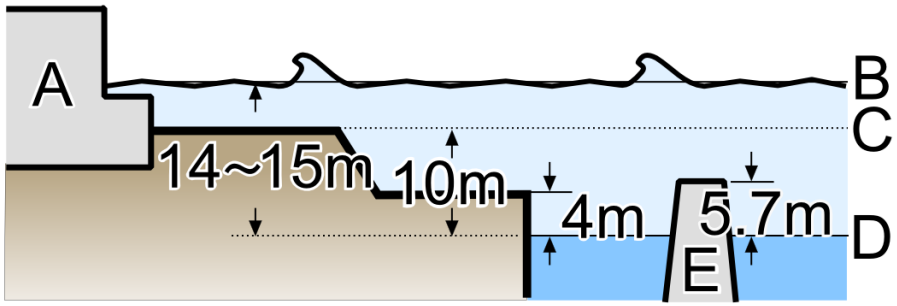
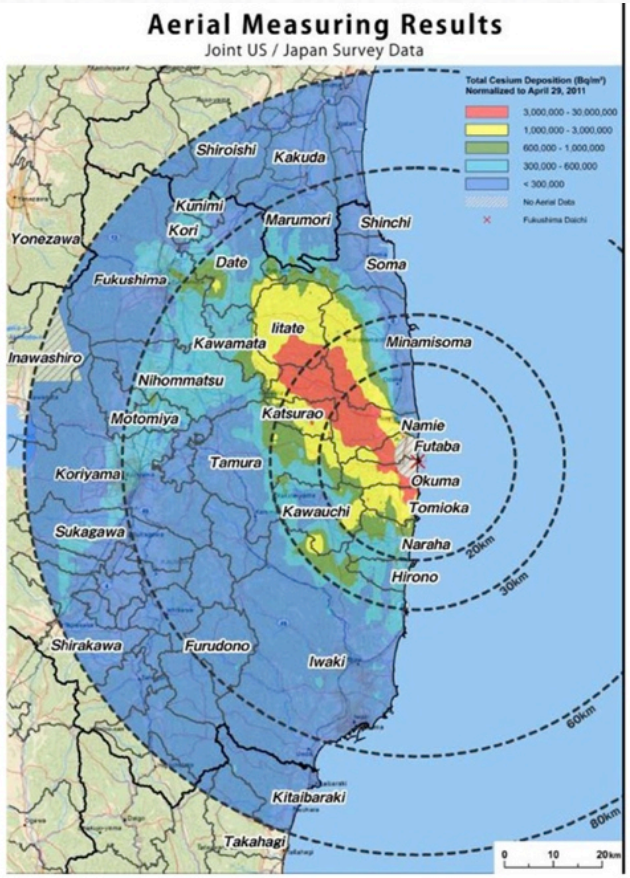
GREAT EAST JAPAN EARTQUAKE







Unexpected Design Situation

BASES OF STRUCTURAL DESIGN

Structural Safety

Probability distributions

Actions → **Design situation** → **Design rules**

- Seismic, Wind, Snow…
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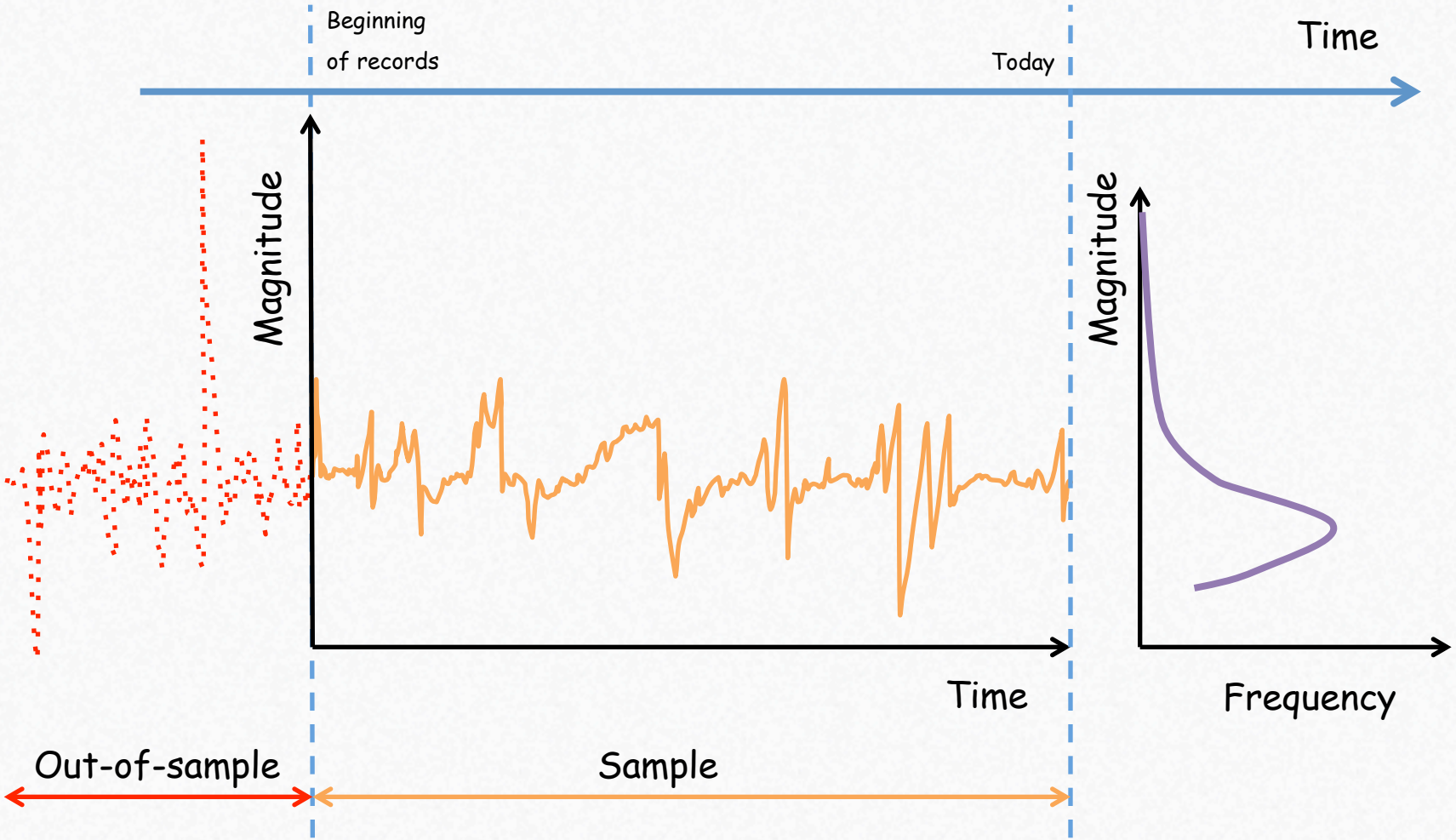
OUT OF SAMPLE DATA



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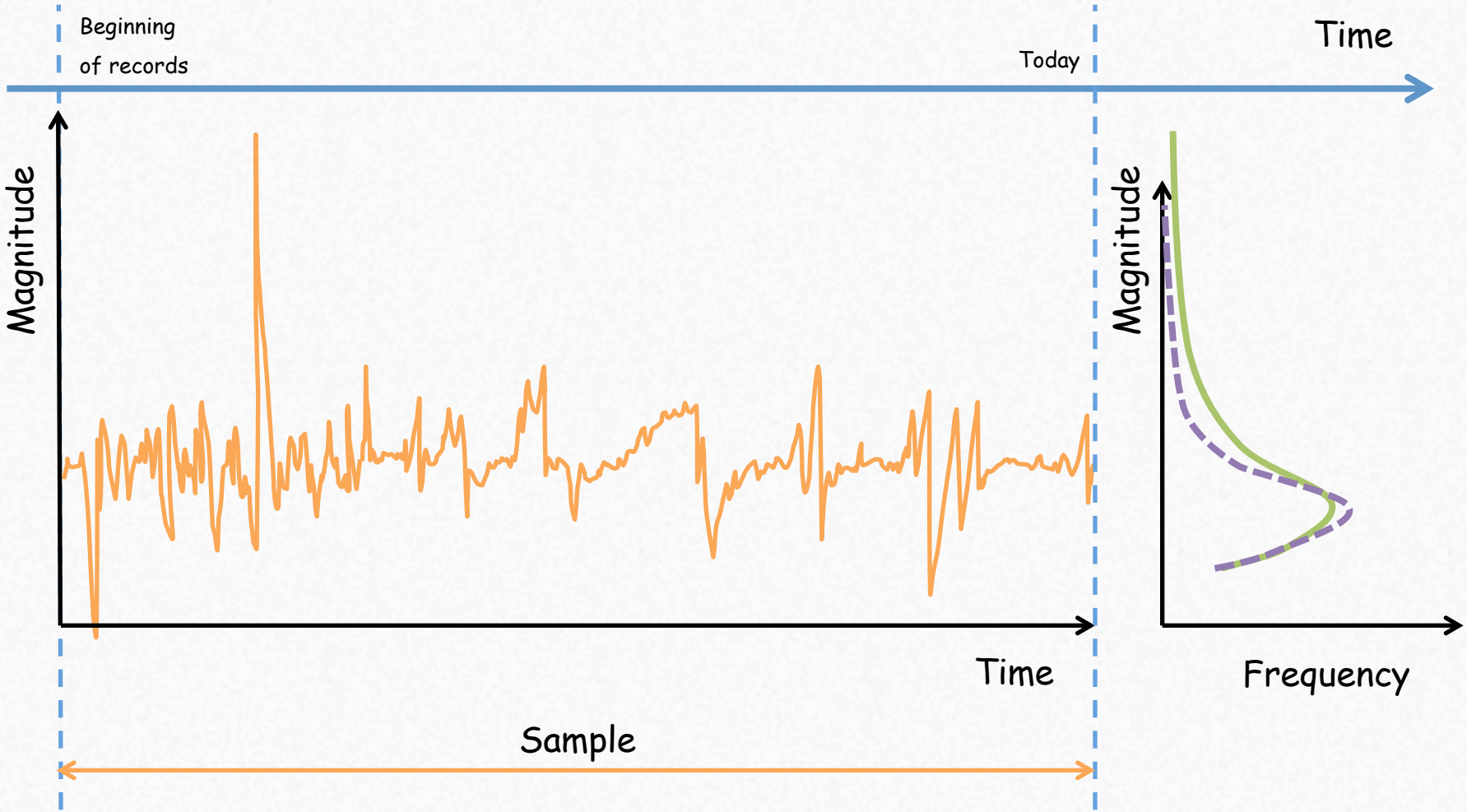

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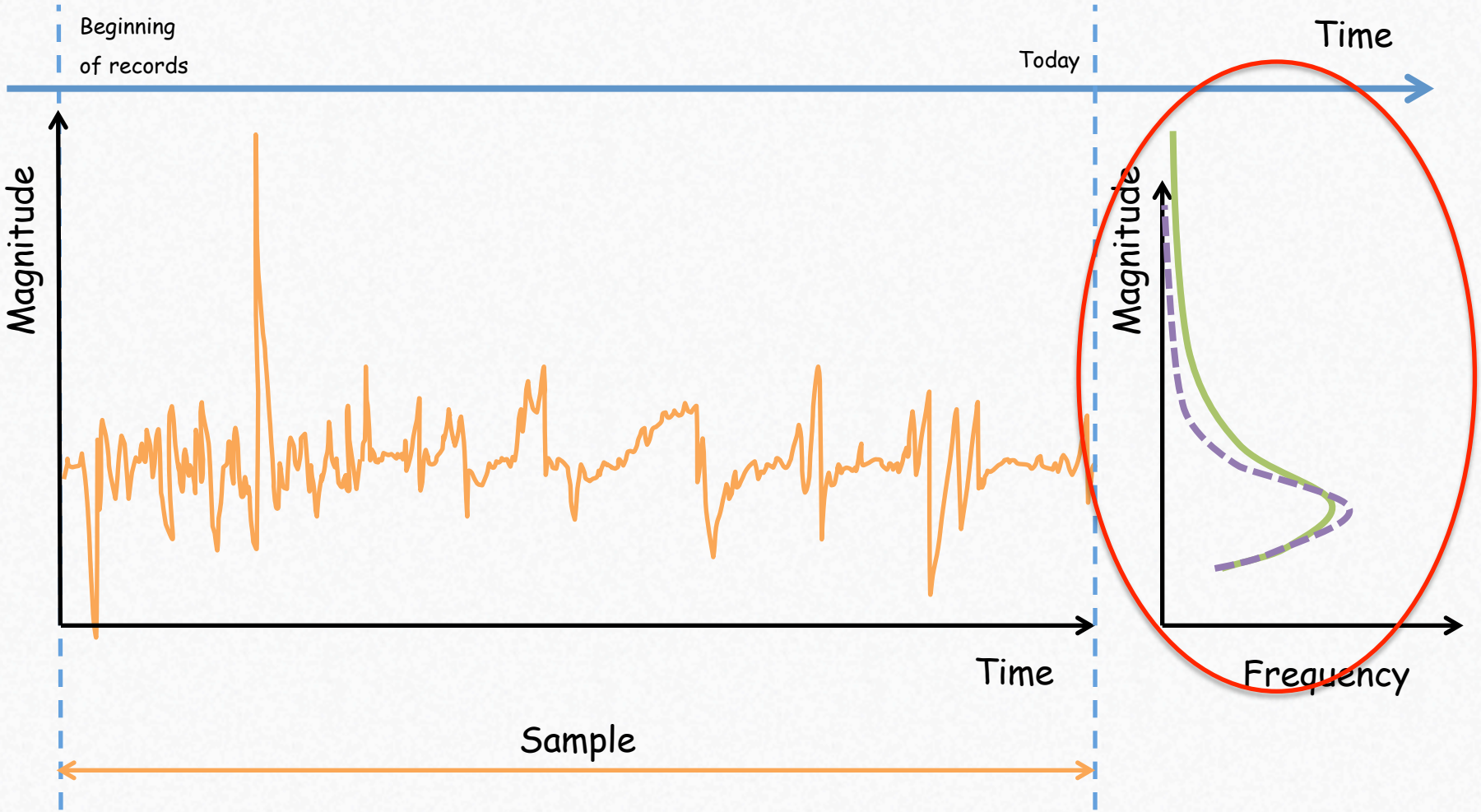

TOWARDS STRUCTURAL ROBUSTNESS

$$R = \sum_i p(H_i) \left\{ \sum_j p(D_j \mid H_i) \left[\sum_k p(S_k \mid D_j) C(S_k) \right] \right\}$$

Probability of occurrence for the hazardous event H_i

Probability that H_i produces a direct damage D_j

Probability that the direct damage D_j causes a final damage scenario S_k

Consequences (€,$) of the final damage scenario S_k

TOWARDS STRUCTURAL ROBUSTNESS

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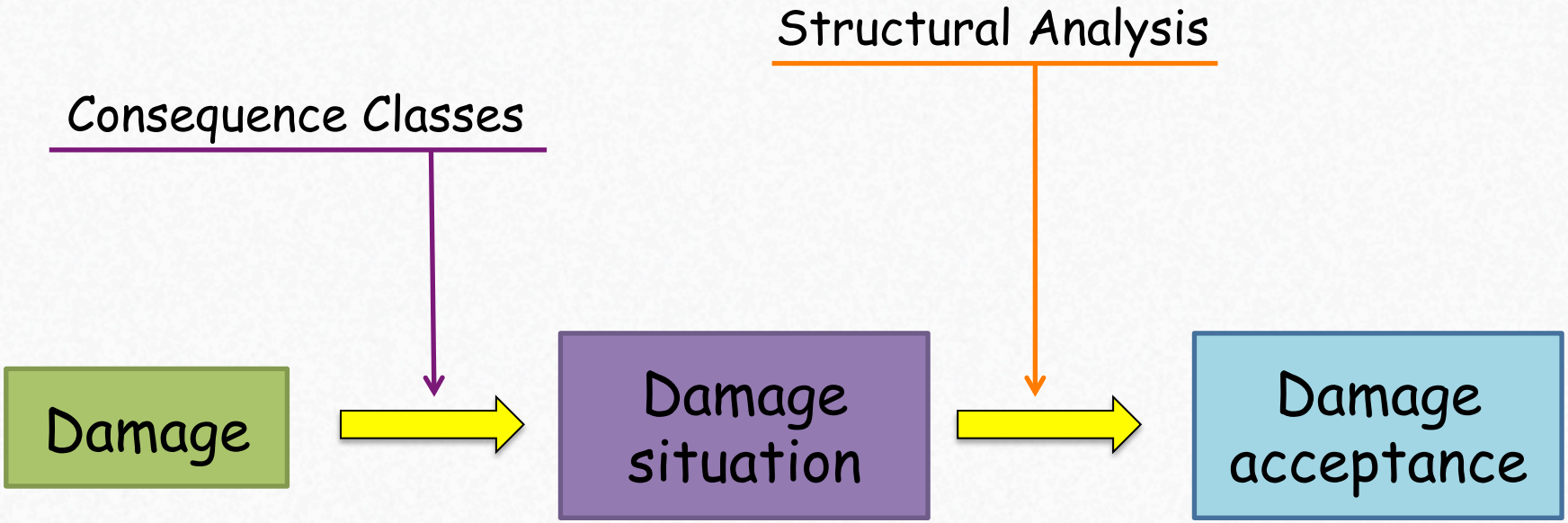
Event Control Strategies

Specific Load Resistance Strategies

Alternate Load Paths Strategies

Consequence Reduction Strategies

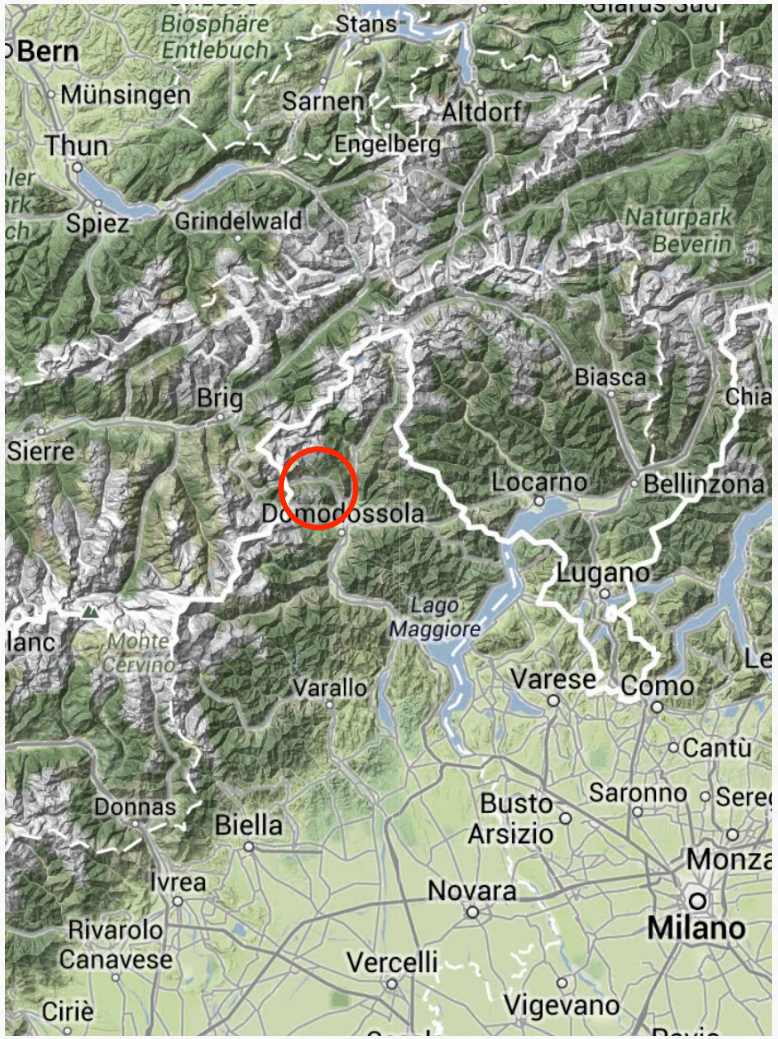
Consequence-based design



- Element removal
- Material degradation
- …

AN EXAMPLE: AGARO DAM

Agaro Dam is set in Lepontine Alps, in the municipality of Premia, in Piedmont region, Italy. The dam construction dates back to 1938.



AN EXAMPLE: AGARO DAM

Mortar Masonry Gravity Dam

Height: 57.6 m

Length: 243 m

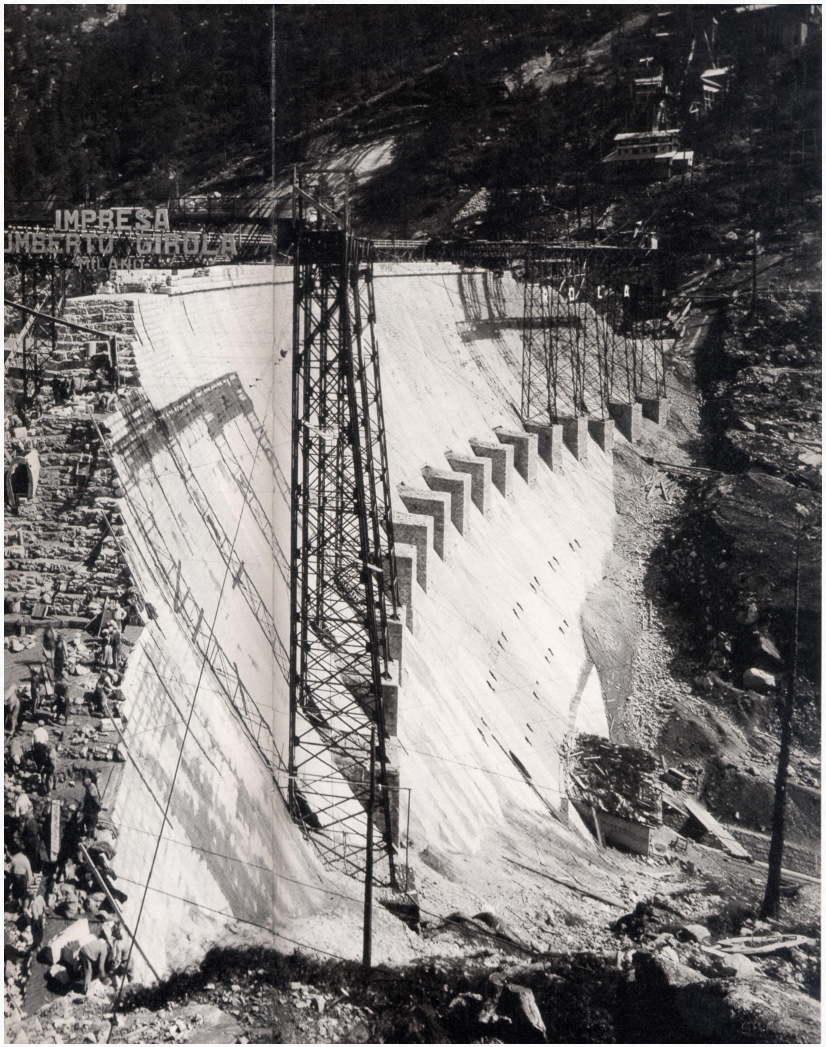
Dam volume: 149 500 m^3.

Maximum pool level: +1596.60 m

Crest: +1598.60

Impoundment capacity: 18.75 x 10^6 m^3

Lake area: 0.65 km^2.



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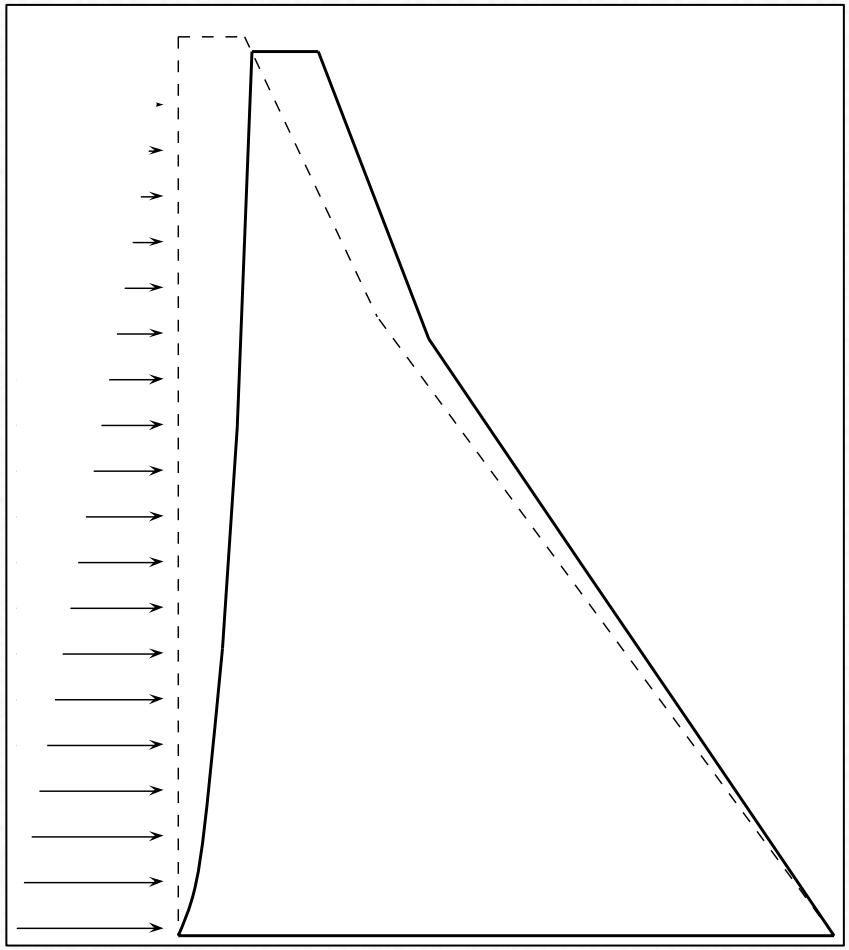

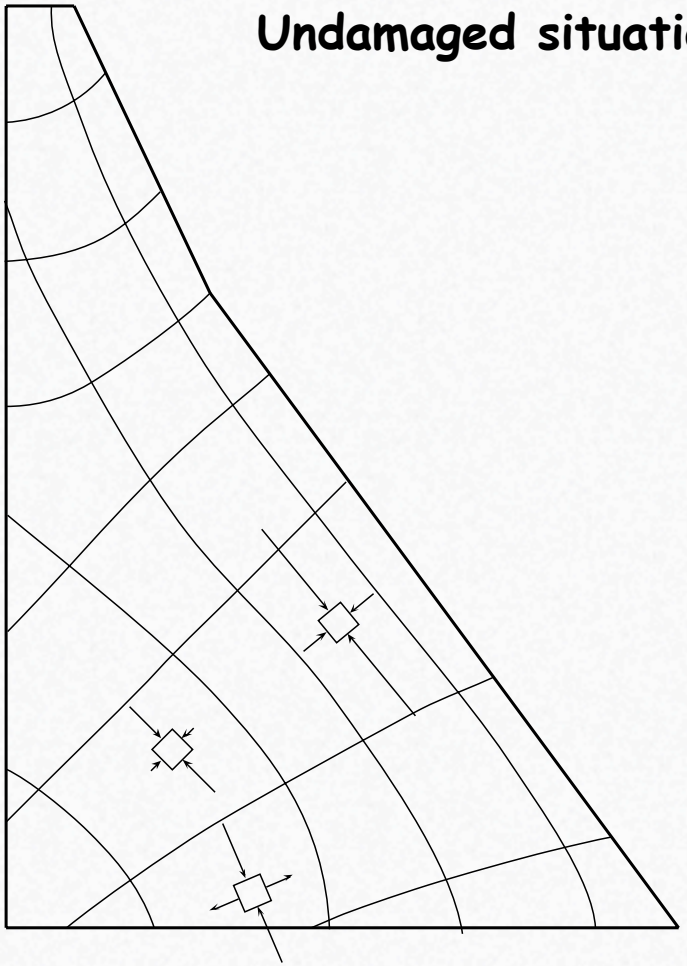

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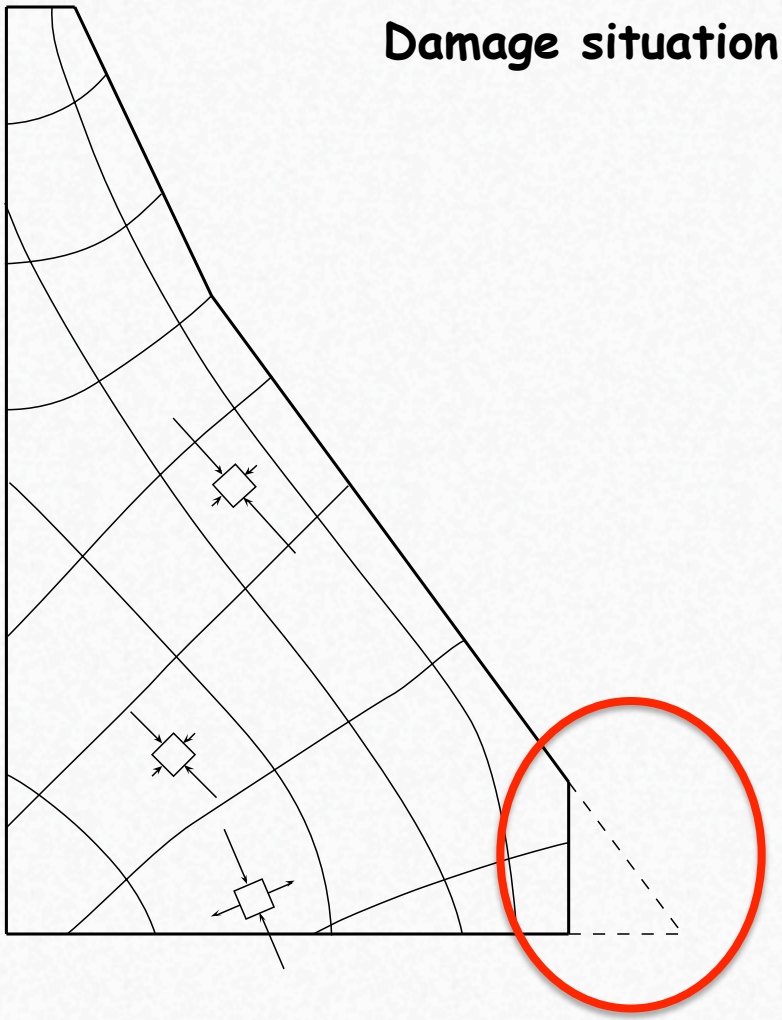

NO QUESTIONS ABOUT THE CAUSES OF THE DAMAGE

IS IT ACCEPTABLE??

AN EXAMPLE: AGARO DAM

Damage situation no.2

IS IT ACCEPTABLE??

High tensile stresses

CONCLUSIONS

- Extreme events with unknown origin and magnitude can interest hydraulic infrastructures, like the dams.
- The common design practices, essentially based on reliability approaches, cannot be used since the statistics of the design situations is not known.
- In substitution, a consequence-based design approach has been suggested. This is based on the evaluation of the effects of damage on the structure, more than on the origins of the damage.
- An example related to an existing gravity dam was proposed.

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