The Emergency Planning for Large Dams in case of Flooding and Seismic Hazard. The Italian Procedures

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YP ITCOLD and Romagna Acque Società delle Fonti S.p.A.

Papers of Reference

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"THE ITALIAN EMERGENCY PLANNING FOR LARGE DAMS IN CASE OF FLOODING AND SEISMIC HAZARD"

Q105 – Incidents and Accidents concerning dams, ICOLD 2022

Armando Lanzi[2], M. Cristina Bramati[1], Rosella Caruana[1]

"THE ITALIAN EXPERIENCE OF POST-EARTHQUAKE INSPECTION AND SAFETY EVALUATION OF LARGE DAMS"

Q106 – Surveillance, Instrumentation, Monitoring and Data Acquisition and Processing, ICOLD 2022

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Regulatory Framework for Civil Protection

June 1985
Disaster of Val di Stava

1986 Circ. LL.PP. 1125 Acoustic signaling devices, warning signs, artificial flood propagation studies for unloading maneuvers

1987 Circ. LL.PP. 352 Dam Operation and Maintenance Document (FCEM) with the attached document containing the conditions that must occur for the civil protection system to be activated and the procedures to be implemented; artificial flood propagation studies for hypothetical dam collapse

1995 Circ. P.C.M 22806 Technical recommendations for the mapping of areas at risk of flooding following maneuvers of the discharge organs or hypothetical collapse of the dams; determination of the maximum flow in the downstream riverbed area

1996 Circ. P.C.M. 7019 Provisions relating to civil protection activities within the basins where dams are located - Civil Protection Document

2004 Directive P.C.M. 27/2/2004 Operational guidelines for the organizational and functional management of the national, state and regional alert system for hydrogeological and hydraulic risk for civil protection purposes

2014 Directive P.C.M. 08/07/2014 Operational guidelines concerning civil protection activities within the basins where large dams are located.

Civil Protection Document

CIVIL PROTECTION DOCUMENT
According to
Dir. P.C.M. 08/07/2014

Establishes:

1. activation conditions of alert phases for the safety of dams and risk management for the valley areas and defines the actions consequent to the activation of alert phases in the case of events and scenarios, feared or in progress, relevant for the alert and activation of the Civil Protection System.
2. functional and procedural links between the various parties involved in the preparation, activation and implementation of actions aimed to guarantee the safety of the barriers and prevent the downstream hydraulic risk.

Developed by the Control Authority
(Ministry of Infrastructures – General Direction for Dams)
together with the hydraulic authority in charge of the downstream riverbed, the operator and the regional civil protection, and approved by the prefecture.

Clearly defines which actions are necessary to guarantee the dam safety for the population, and who are the subjects involved into the preparation and implementation of these actions. It also defines the interactions between the parties involved, in terms of communications and technical-administrative procedures

Civil Protection Document

News introduced by the 2014 Directive into the Civil Protection Document

Detailed description of the types of risk to be considered.

Description of the relationships between the subjects involved.

Assignment of specific tasks to certain technical figures such as the Responsible Engineer.

Civil Protection Document

RISK ASSOCIATED WITH LARGE DAMS

DAM HAZARD

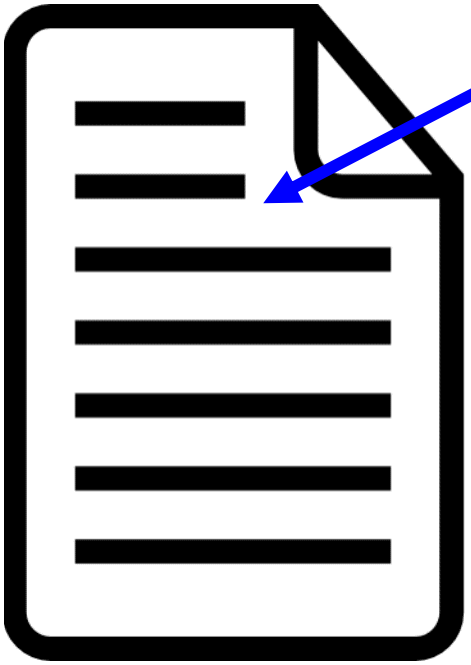
Possible events involving the dam or part of it, which may have an impact on the safety of the dam itself and of the territories downstream of it.
Seismic hazard is included.

DOWNSTREAM HYDRAULIC HAZARD

Activation of the dam discharges, which causes flows in the downstream riverbed that can lead to artificial flood waves and flooding hazard

RESPONSIBILITY OF ACTIVATING ALERT PHASES IS IN CHARGE OF THE OPERATOR

Civil Protection Document



At the beginning of the document:

DATA RELEVANT TO THE DAM

- geographical location,
- geometric characteristics
- maximum and minimum authorized water levels.
- discharges
- data relating to the reservoir

AUTHORITIES AND OFFICES INVOLVED

- control authority
- hydraulic authority
- Prefectures
- regions
- provinces
- municipalities

SIGNIFICANT FLOW RATES FOR LIMIT CONDITIONS

- Q_{Amax} → maximum flow rate contained in the riverbed (by operator)
- Q_{min} → dam discharge caution flow (by hydraulic authority)
- ΔQ → incremental flow thresholds for specific communications

Dam Hazard

ALERT PHASES FOR DAM HAZARD

EARLY WARNING

in case of adverse hydrometeorological conditions, when these conditions determine a certain water level in the reservoir, which often coincides with the maximum regulation, and the weather forecast is worsening

REINFORCED SURVEILLANCE

Incremental flow thresholds that, if they are reached, the dam Operator is required to give specific communications

DANGER

Incremental flow thresholds that, if they are reached, the dam Operator is required to give specific communications

COLLAPSE

Incremental flow thresholds that, if they are reached, the dam Operator is required to give specific communications

Dam Hazard

EARLY WARNING

FLOOD
in case of adverse hydrometeorological conditions, when these conditions determine a certain water level in the reservoir, which often coincides with the maximum regulation, and the weather forecast is worsening

EARTHQUAKE
when the magnitude of the event is such as to activate the execution of immediate controls on the dam.

REINFORCED SURVEILLANCE

FLOOD
when the increasing water in the upstream basin could cause exceeding of the maximum reservoir level

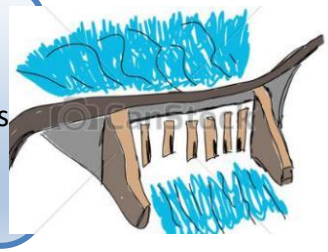
EARTHQUAKE
when the results of immediate post-event controls have revealed minor damages to the dam

Dam Hazard

DANGER

FLOOD – EARTHQUAKE

When irreversible damage is highlighted, failures, cracks or anomalous movements of the dam, or landslides on the banks the evolution of which can compromise the water regulation function of the dam



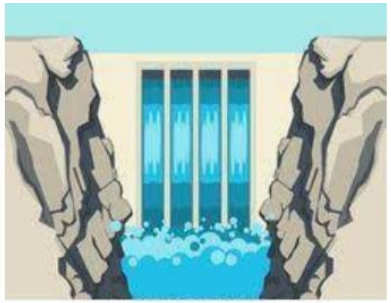
COLLAPSE

FLOOD - EARTHQUAKE

At the beginning of a dam break or damage that can lead to uncontrolled release of water and risk of loss of lives

Downstream Hydraulic Hazard

EARLY WARNING → ***FLOOD*** activated by the Operator upon the arrival of a flood event that determines the opening of the dam discharges



WARNING → ***FLOOD*** activated by the Operator when the Qmin flow rate threshold set for the downstream watercourse is exceeded

Communication Flow

OPERATOR → Activates the alert phase → immediate communications specifying the conditions of the reservoir

CONTROL AUTHORITIES

PREFECTURES

REGIONS

CIVIL PROTECTION → Coordinates local authorities in implementation of local emergency plans

MUNICIPALITIES

Post-earthquake inspection and safety evaluation of large dams

- In order to ensure both **functionality** of the water infrastructure and **safety** of downstream communities, large dams in Italy are continuously monitored by operators and Italian Dam Authority.
- Special measures must be taken after any exceptional event such as a flood or an **earthquake.**

Post-earthquake inspection: timeline procedure

- 1988 – ICOLD, Bulletin 62
- Inspection of dams after earthquakes - Guidelines

2002 – Italian Authority

FIRST PROCEDURE for post-earthquake inspection of large dams

2009

L'Aquila Earthquake

2012

Emilia Earthquake

2016-2017

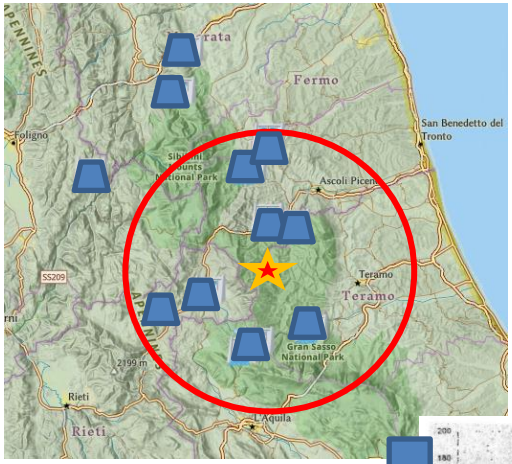
Central Italy Earthquakes

2018 – Italian Authority

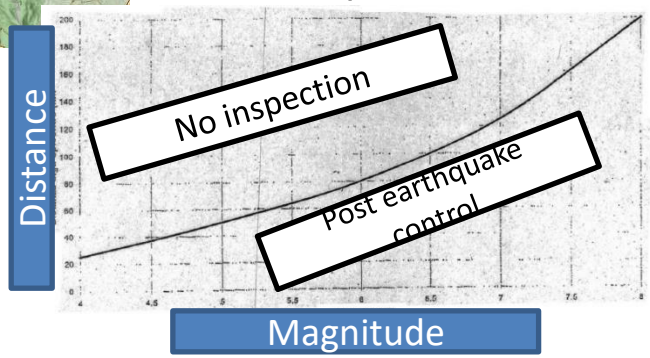
NEW PROCEDURE for post-earthquake inspection of large dams

2002 Procedure for Post-earthquake inspection

- According to the ICOLD criterion, the **screening area** is a circle, centered on the epicenter of the earthquake, with radius D defined as a function of the earthquake magnitude M.
- Post-earthquake inspections are always required if the shaking is felt by personnel on site.
- Type and extent of inspections are defined by the Dam Authority in agreement with the dam operator.



The relation M-D was obtained by application of ground motion prediction equations



2018 Procedure for Post-earthquake inspection

- After 15 years it was realized that the criterion defining the screening area was **very conservative**, resulting in the need of performing the same types of immediate inspection and controls both for dams in the epicentral area and for dams very far from it.

Therefore, in order to increase the efficiency of dam surveillance, in 2018 the Dam Authority issued a new procedure

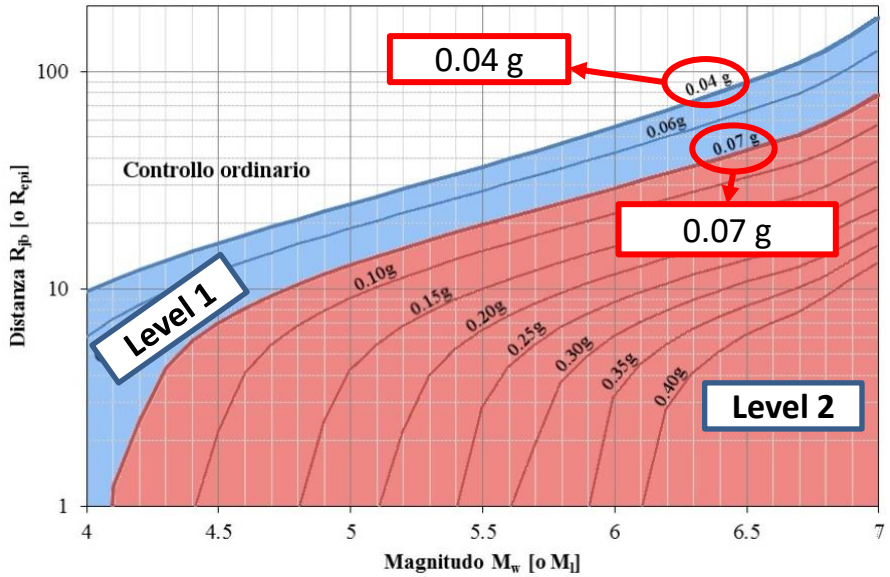
2018 Procedure: main changes

The new procedure introduces three major changes:

- It defines **two levels** of inspections (*Level 1*, less detailed and L*evel 2*, more accurate) depending on the severity of the shaking at the site;

- it explicitly defines **values of acceleration thresholds** which determine the activation of post-earthquake inspections, thus defining the radius of the screening areas for both levels.

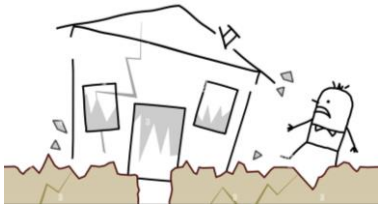
- it allows consideration of **real-time earthquake data** recorded by seismic monitoring systems at the dam site, when available.



2018 Procedure: main changes

Level 1 controls are always required if on site personnel feels the earthquake (level V of the Mercalli scale.)

Level 2 controls are always required if damages are observed after Level 1 inspections.



The scope of Level 1 controls is to **verify the absence of damages or failures** in the dam, including potential instability of the abutments or the basin slopes.

The scope of Level 2 controls is to **verify the safety conditions of the dam**.

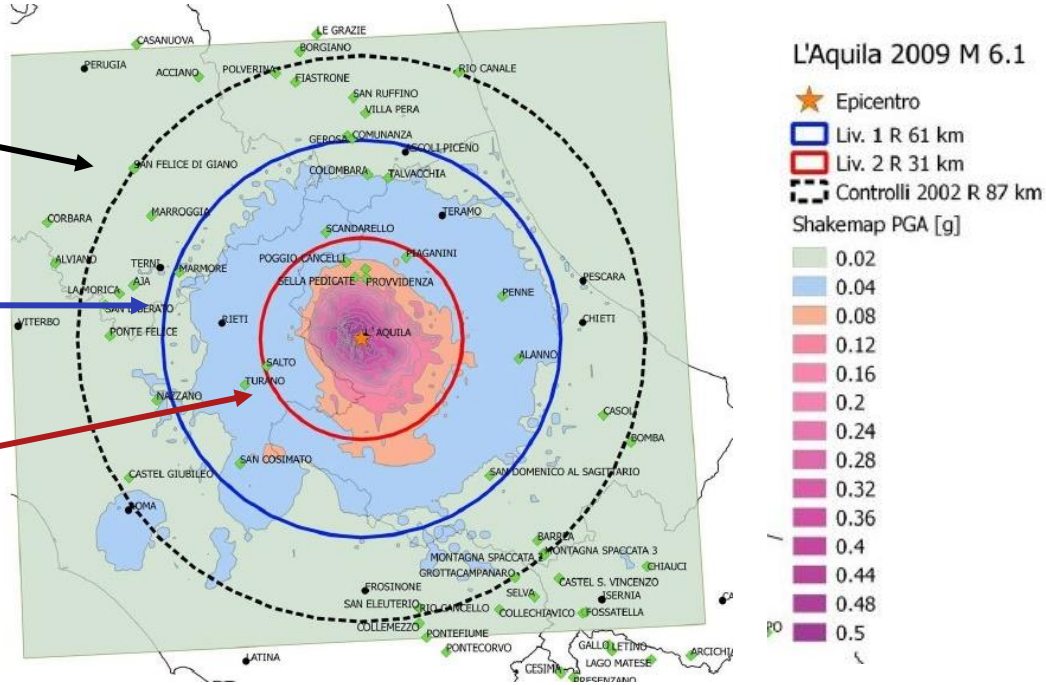
The 2018 procedure also suggests a list of controls to be performed for both types of inspections and provides details for its application in the case of aftershakes.

2002 vs 2018 Procedure

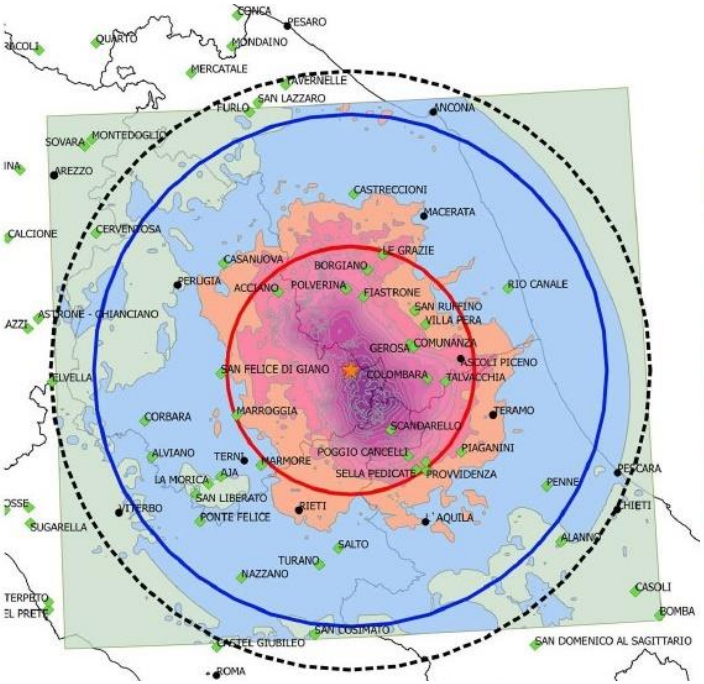
Screening area with **2002** Procedure R=87 km

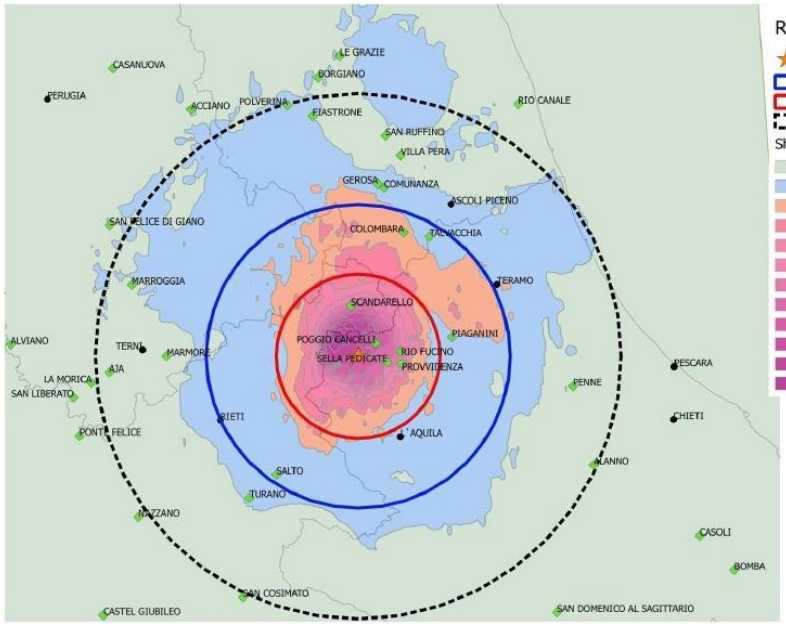
Screening area with **2018** Procedure for **Level 1** inspection R=61 km

Screening area with **2018** Procedure for **Level 2** inspection R=31 km

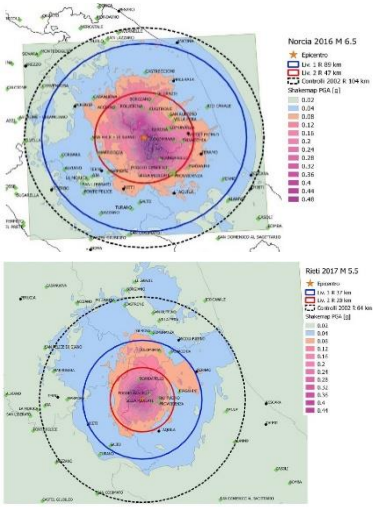


2002 vs 2018 Procedure





Conclusions



The new procedure was found to provide a good estimate of the shaking intensity at the sites.

In the case of low magnitude earthquakes, the number of dams to be inspected is significantly reduced.

The 2018 procedure increases the efficiency of dam surveillance

The procedure has been implemented by each dam operator in its Control Plan.

Thanks for your attention

And

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