

Sessione 2.1 – Seismic hazard for critical facilities



CAN EARTHQUAKES TRIGGER SERIOUS ACCIDENTS IN ITALY? SOME LESSONS FROM THE 2009 L'AQUILA (I) EARTHQUAKE.

Stefano Grimaz^{1,2} & Alberto Maiolo³



¹ Dipartimento di Chimica Fisica Ambiente – Università di Udine (I)



² Centro Studi e Ricerche SPRINT – Università di Udine (I)



³ Corpo Nazionale dei Vigili del Fuoco - Roma

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IMPACTS OF 2009 L'AQUILA EARTHQUAKE

OVERVIEW ON:

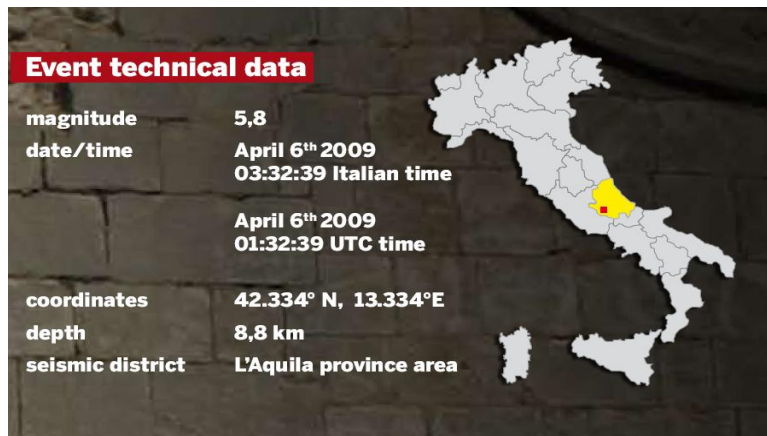
IMPACT ON INDUSTRIAL FACILITIES

IMPACT ON LIFE-LINES, TRANSPORT FACILITIES AND UTILITIES

LESSONS LEARNT

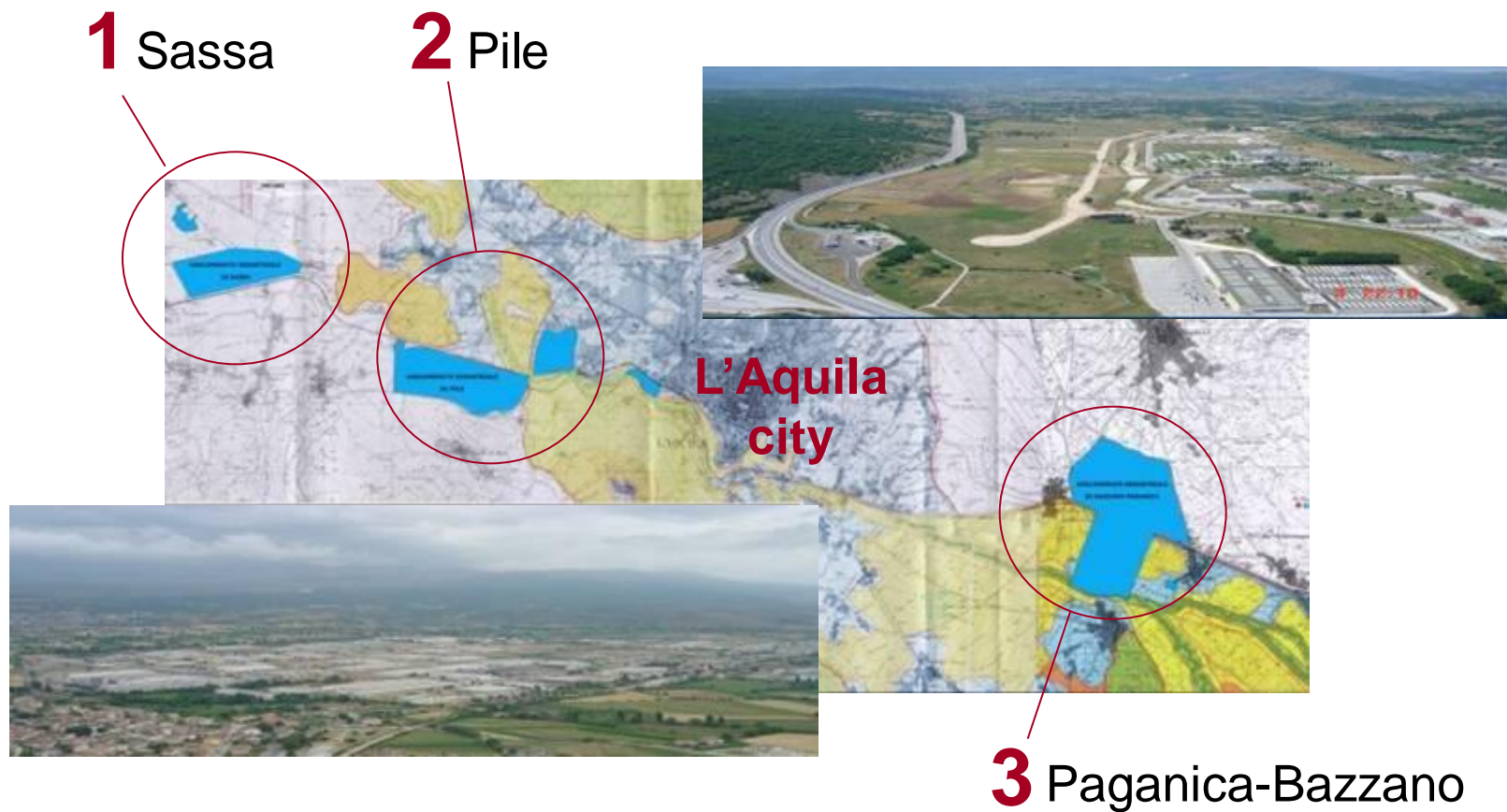
CONSIDERATIONS IN TERMS OF NATECH RISK

L'Aquila experience



Few days after the L'Aquila earthquake Engineers of the Italian National Fire Department and of the University of Udine, investigated and analyzed the damage occurred on industrial facilities and life-lines in order to individuate the major and recursive criticisms and to obtain useful lessons learned for safety improvement.

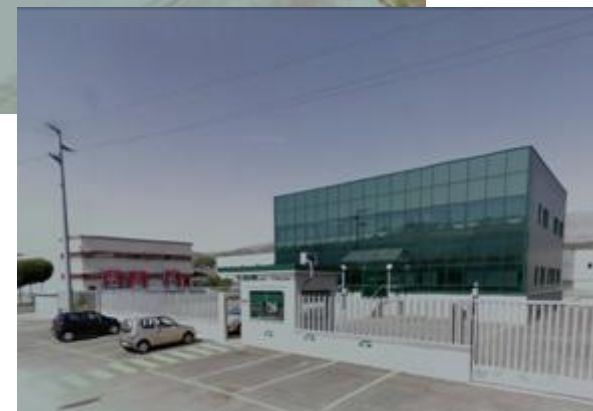
Industrial zones in the affected area



INDUSTRIAL
ACTIVITIES

High-tech, pharmaceutical, construction,
mechanical and manufacturing industries

Typologies of industrial buildings



The most diffuse typology:

PRECAST CONSTRUCTIONS

Precast panels

Reinforced frames with concrete block walls

Steel or light metal frames with precast panel walls

Typical damage on industrial facilities



Damage mainly concentrated in nonstructural elements



Short column failure

WEAKNESS

Weakness of the columns-beams joints

Excessive movement of the beam on the column corbel support

Diffuse collapse of partitions and ceiling tiles

Typical damage on industrial facilities



WEAKNESS

Connections between the secondary element and the structure

Inadequate anchorage between the wall panels and the roof and floor framing members

Typical damage on equipment

EQUIPMENT DISPLACEMENT



4 cm

EQUIPMENT DISPLACEMENT

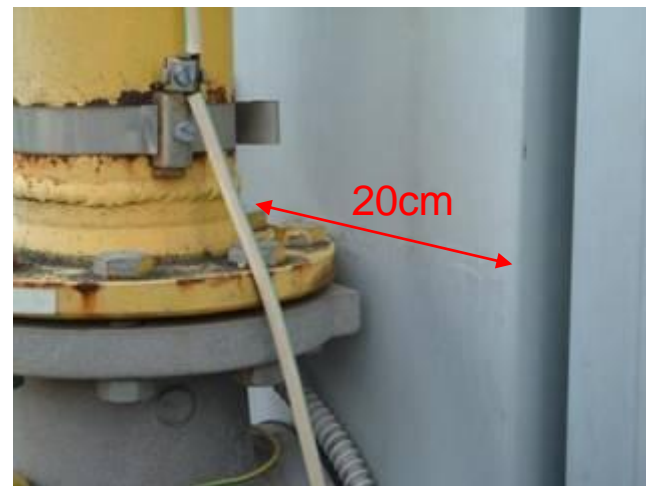


10cm



5 cm

PIPE INTERPENETRATION



20cm

PIPE OSCILLATION

The case of VIBAC in Bazzano area



Three tall steel silos storing polypropylene suffered heavy damage (one silo crumpled at the base)



Silos collided with the adjacent precast warehouse partially crushing the concrete wall and leaving an impact imprint

WEAKNESS

SEISMIC POUNDING
COLLAPSE OF THIN STRUCTURES

The case of VIBAC in Bazzano area

DETAILS OF SEISMIC POUNDING EFFECTS



The case of VIBAC in Bazzano area



Operations for removing
the damaged silos

The case of VIBAC in Bazzano area



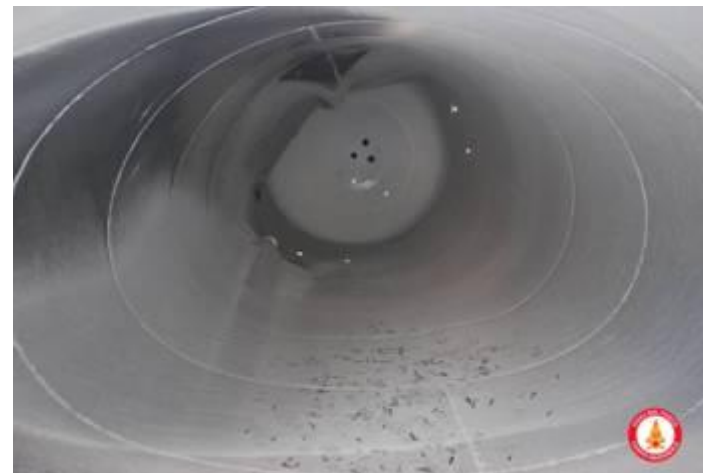
Operations for removing the silos



The case of VIBAC in Bazzano area



Crumpling effect
at the base of silos



Interior view of a
deformed silo



Polypropylene
extraction operation

Transport facilities

A24 and A25 connecting
Tyrrhenian and Adriatic coasts



Bridges and viaducts:
DISPLACEMENT OF CONNECTIONS
(typology: simply supported span)



WEAKNESS

Spans moved off their bearings

Transport facilities

Other bridges in the city
suffered displacements
and were closed



One bridge on the
Aterno river collapsed



Carriageway damage and embankment
deformations was produced
Some roads were closed

Life lines and utilities

WATER SYSTEM

High pressure water pipeline
broke at the crossing
of Paganica fault



Other ruptures were recorded in the affected area
Large areas remained without water



NATURAL GAS

The greater part of the residential gas supply serves autonomous heating



The gas pipelines are largely distributed in the buildings

Collapsed building provoked the rupture of gas pipelines and gas releases (fortunately there were no fires)



Lessons learnt from the L'Aquila case

The L'Aquila earthquake has evidenced:

➡ **SIGNIFICANT SEISMIC VULNERABILITY
OF INDUSTRIAL BUILDINGS**

THE VULNERABILITY IS MAINLY RELATED TO:

- THE TYPOLOGY OF STRUCTURES (PRECAST CONCRETE)
- NON STRUCTURAL ELEMENTS
- EQUIPMENT ANCHORAGES

➡ **SIGNIFICANT SEISMIC VULNERABILITY
OF LIFE-LINE SYSTEMS**

THE VULNERABILITY IS MAINLY RELATED TO:

- BRIDGES AND VIADUCTS
- WATER AND GAS PIPELINES

Lessons learnt from the L'Aquila case

Attention to:

- * DESIGN OF NON-STRUCTURAL ELEMENTS
(connection between primary and secondary elements)
- SPECIFIC PRECAUTIONS ON THE ANCHORAGE OF EQUIPMENT
- ** NaTech RISKS (Technological events triggered by natural events)
- IMPORTANCE OF REDUNDANCY IN THE LIFE-LINES
DISTRIBUTION (RESILIENCE OF AFFECTED SYSTEM)
- INSTALLATION OF AUTOMATIC VALVES FOR IMMEDIATE
BLOCKAGE OF THE GAS SUPPLY IN CASE OF STRONG
EARTHQUAKES (industrial and residential buildings)
- * *CONSIDERED IN THE NEW SEISMIC CODE (NTC2008)*
- ** *NOT CONSIDERED IN THE CODE*

Final considerations

PRECAST CONCRETE BUILDINGS ARE LARGELY DIFFUSE
IN INDUSTRIAL ZONES IN ITALY (also in Seveso plants)

A LOT OF SEVESO PLANTS ARE LOCATED IN HIGH SEISMIC
AREAS

In the case of L'Aquila

FORTUNATELY in the affected area there were no Seveso plants

PIPELINES SYSTEM OF GAS DISTRIBUTION (primary and
secondary) IS MORE EXTENT AND PERVASIVE THAN IN THE
PAST

IF THE EARTHQUAKE PROVOKE GAS RELEASES
SERIOUS ACCIDENTS (FIRES AND EXPLOSIONS) COULD
HAPPEN ALSO IN NON SEVESO INDUSTRIAL PLANTS AND
ALSO IN RESIDENTIAL AREA

In the case of L'Aquila

FORTUNATELY the earthquake happened during the night
(gas released did not find a source of ignition)

Answer to the initial question

CAN EARTHQUAKES TRIGGER SERIOUS ACCIDENTS IN ITALY?

“Unfortunately: Yes, it is likelihood!

even if

the accidents likely will be not as serious as, for example, in Japan but they could be more diffuse.



After the 2009 L'Aquila earthquake Italian National Fire Department has set up a specific working group with the aim of defining technical **guidelines for reducing seismic vulnerability of fire prevention and protection facilities.**

Thank you for your attention