Assessment and mitigation of liquefaction potential across Europe: a holistic approach to protect structures / infrastructures for improved resilience to earthquake-induced liquefaction disasters

Rapports

Informations projet

LIQUEFACT

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improved resilience to earthquake-induced liquefaction disasters)

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Résumé du contexte et des objectifs généraux du projet

Earthquakes are one of the most destructive natural phenomena. In the 20th century earthquakes were responsible for 1.87 million deaths and approximately $2.935 trillion (adjusted to 2012) total economic losses. Between 1980 and 2009 earthquakes affected approximately 61.5 million people worldwide, resulting in approximately 400,000 fatalities and leaving at least 16 million people homeless. Between 1998 and 2009 earthquake events resulted in approximately 19,000 fatalities and direct economic losses of approximately €29 billion across Europe. While structural remediation/rehabilitation of the built environment against earthquakes is a widely studied subject, the knowledge on foundation improvement to mitigate the effects of earthquakes on buildings and critical infrastructure is limited, with existing remediation techniques being very invasive and costly. This is particularly true when the earthquake results in liquefaction of the soil. Earthquake induced liquefaction occurs when soil strength and stiffness decrease as a result of increased pore water pressure in saturated cohesionless materials during seismic ground motion. Because of liquefaction soil behaves like a liquid and not a solid, resulting in large deformations at the ground surface that causes buildings and lifelines to sink, settle or fall (overturn).

Over the past 42 months, the LIQUEFACT project has studied the potential impacts that an earthquake induced liquefaction event could have on Europe and produced technical guidance on how to quantify the risks at a local (micro-zonation) or site specific scale. LIQUEFACT has compiled a database of past liquefaction occurrences and integrated this with a macro-zonation map that shows the level of risk of earthquake induced liquefaction across Europe. LIQUEFACT has also developed new techniques for modelling the damage caused by an earthquake induced liquefaction event on structures and infrastructures and evaluated three ground mitigation interventions (horizontal drains, vertical drains, and induced partial saturation) to improve soil performance. LIQUEFACT has integrated all the above into a Resilience Assessment and Improvement Framework (RAIF) and software solution (the LRG) for evaluating potential mitigation interventions to improve structure/infrastructure and community resilience. Together the

Travail effectué depuis le début du projet jusqu'à la fin de la période considérée dans le rapport et principaux résultats atteints jusqu'à présent

The LIQUEFACT toolkit comprises:
1. A GIS-based homogeneous, composite historical catalogue of earthquake-induced liquefaction manifestations occurred in Europe in the last 1000 years.
2. Empirical correlations applicable to the European territory linking earthquake magnitude and

maximum epicentral distance at which soil liquefaction was historically observed
3. A GIS-based macrozonation of the European territory for earthquake-induced liquefaction susceptibility, hazard and risk for different return periods.
4. A general methodology for grade III microzonation of a territory at urban and suburban scales for earthquake-induced liquefaction hazard at different return periods.
5. A new soil-structure classification system and analysis methodology for assessing the vulnerability of structures and infrastructures to earthquake induced liquefaction events.
6. State-of-the-art report of soil mitigation measures (both new and existing) that can improve the resilience of structures and infrastructures to earthquake induced liquefaction events.
7. Practical engineering design criteria that can be applied to for both new and existing structures and infrastructures.
8. A resilience assessment and improvement framework with accompanying community resilience, critical infrastructure resilience, and cost benefit tools that can be used to develop the business case for mitigation interventions to earthquake induced liquefaction events as part of routine built asset management planning.
9. A community resilience tool that builds on the UNDRR Ten Essentials for Making Cities Resilient by providing a customised version that addresses earthquake induced liquefaction.
10. A critical infrastructure resilience tool to assess resilience against technical, organisational/management and operational (service delivery) metrics.
11. A cost-benefit tool provides a 5 step model for evaluating the financial benefits of alternate mitigation interventions as part of the options appraisal process.
12. A built asset management decision making framework for use with the LRG software package that integrates all of the tools described above into a single use tool that allows both technical and non-technical users to evaluate their built assets vulnerability and resilience to earthquake induced liquefaction events.
13. Design guidance that is currently being presented to the EUROCODE drafting committee for consideration as part of the revision to EUROCODE 8 - Seismic Design of Buildings.

Whilst LIQUEFACT has developed a range of tools to support resilience assessment and mitigation planning of structures and infrastructures to earthquake induced liquefaction events, the tools are currently at the proof of concept/first prototype stage. Any organisations wishing to use the tools should contact the LIQUEFACT partners for further advice and guidance (www.liquefact.eu).

Progrès au-delà de l’état des connaissances et impact potentiel prévu (y compris l’impact socio-économique et les conséquences sociétales plus larges du projet jusqu’à présent)

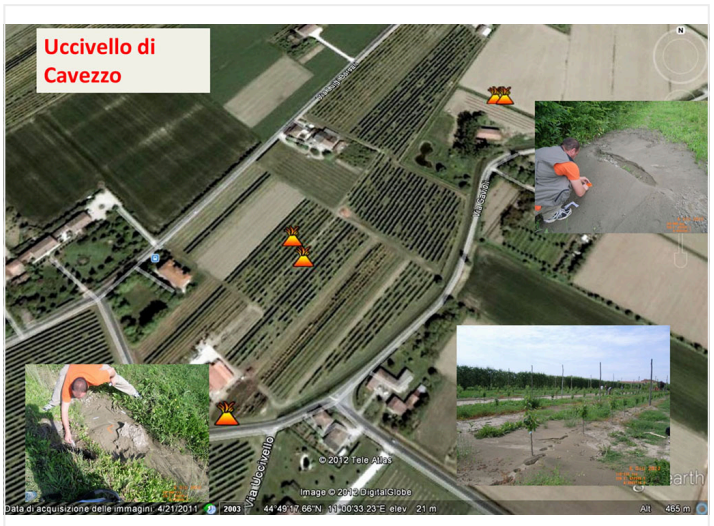
The LIQUEFACT project extends the state of knowledge in terms of the depth of understanding of the earthquake induced liquefaction potential across Europe and in the engineering modelling of the potential impact of earthquake induced liquefaction on structures and infrastructures. The LIQUEFACT project also extended the depth of understanding of the soil liquefaction process and the potential of horizontal/vertical drains and induced partial saturation as potential soil mitigation interventions. The LIQUEFACT project has extended the depth of understanding of the relationships

between earthquake induced liquefaction and community resilience through the customised UNDRR scorecard and critical infrastructure scorecard.

The socio-economic impact from the LIQUEFACT project is realised through the Built Asset Management Framework and LRG software. Both of these deliverables are specifically designed to allow both technical and non-technical stakeholders assess their vulnerability and resilience to an earthquake induced liquefaction event and to develop the business case for reduced vulnerability and/or improve resilience through the integration of soil mitigation actions into new and existing structures and infrastructures. The effective application of the LIQUEFACT tools across Europe should improve the resilience of EU citizens and business organisations to the next earthquake induced liquefaction event.

The scientific/engineering results from the LIQUEFACT project have been presented to the EUROCODE 8 - Seismic Design of Buildings drafting committee for consideration as part of the revision to EUROCODE 8. If included in the revised standard the results from the LIQUEFACT project should improve the resilience of new European structures and infrastructures to the next earthquake induced liquefaction event.

The international impact from LIQUEFACT is also enhanced through its relationship with the New Zealand QuakeCoRE initiative where researchers from LIQUEFACT have presented their toolkits and results.



Deliverable 2.1

Bologna

Kick Off Meeting

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