SEISMIC VULNERABILITY OF HIGH-RISE TUNNEL-FORM BUILDINGS

PIONEERING RESILIENCE
Est. 2007

***Şahin Dede*, PhD Student**

Tiziana Rossetto, Professor

Fabio Freddi, Associate Professor

What is a Tunnel-Form Building?

Modular, prefabricated tunnel-formworks tailored to particular project

Monolithic casting of a single story in one pouring operation

Easy stripping, high mobility and re-use of formworks

Lightly reinforced slender shear walls, squat coupling beams, and thin slabs

A particular architectural form constrained by the tunnel-formwork application

Enables rapid and economical construction of mass housing projects

What is the Significance of Tunnel-Form Buildings?

BARNES Türkiye

TOKİ Has Built Over 1.3 Million Buildings in 20 Years

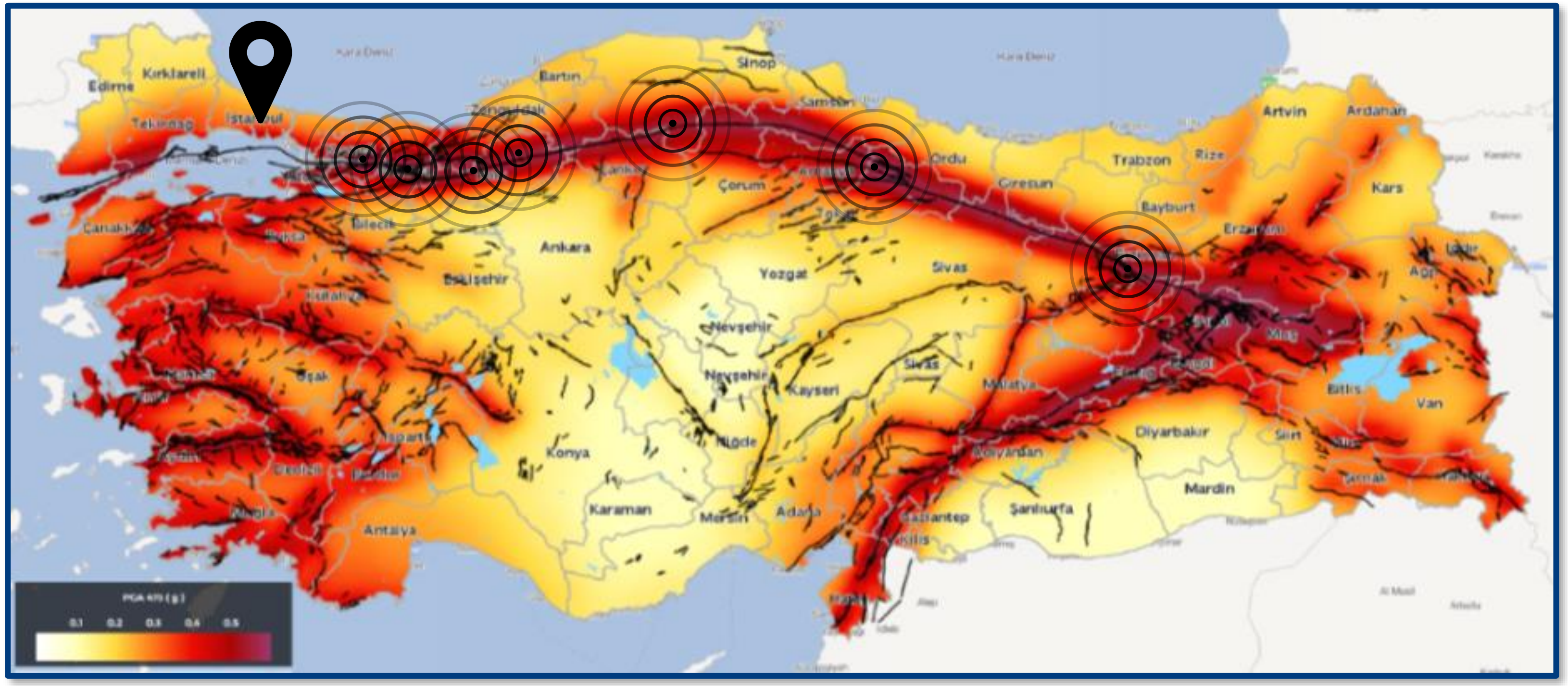
News Tuesday 18 June 2024

Earthquake tenders exceed 75 billion TL

According to the calculation made based on the total bid size and the number of houses, the average cost per house is approaching 1.8 million TL.

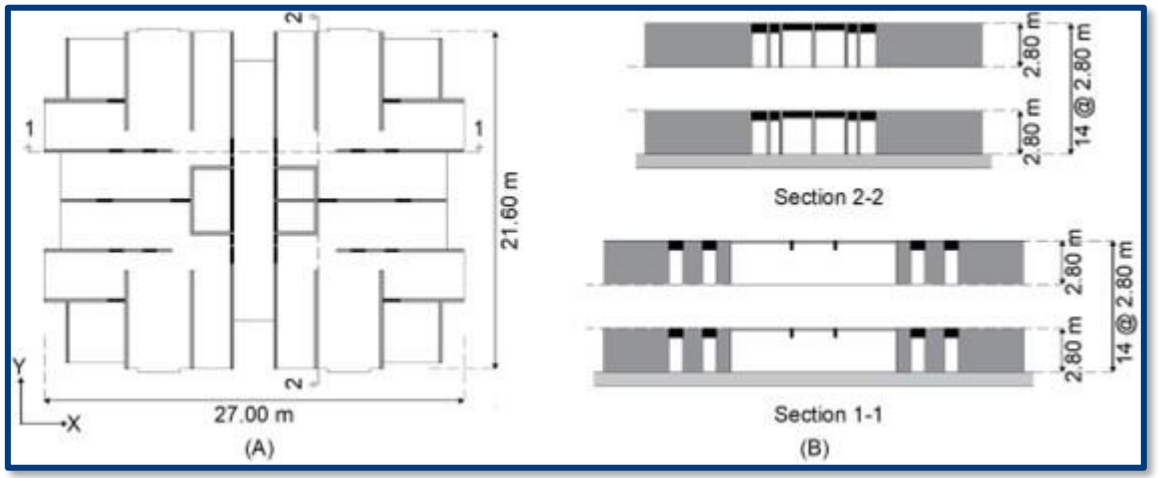
The total size of housing tenders, which TOKİ (Mass Housing Administration) started two weeks after the great earthquake and all of which were conducted through bargaining, exceeded 75 billion TL.

Research Design: Case Study Approach

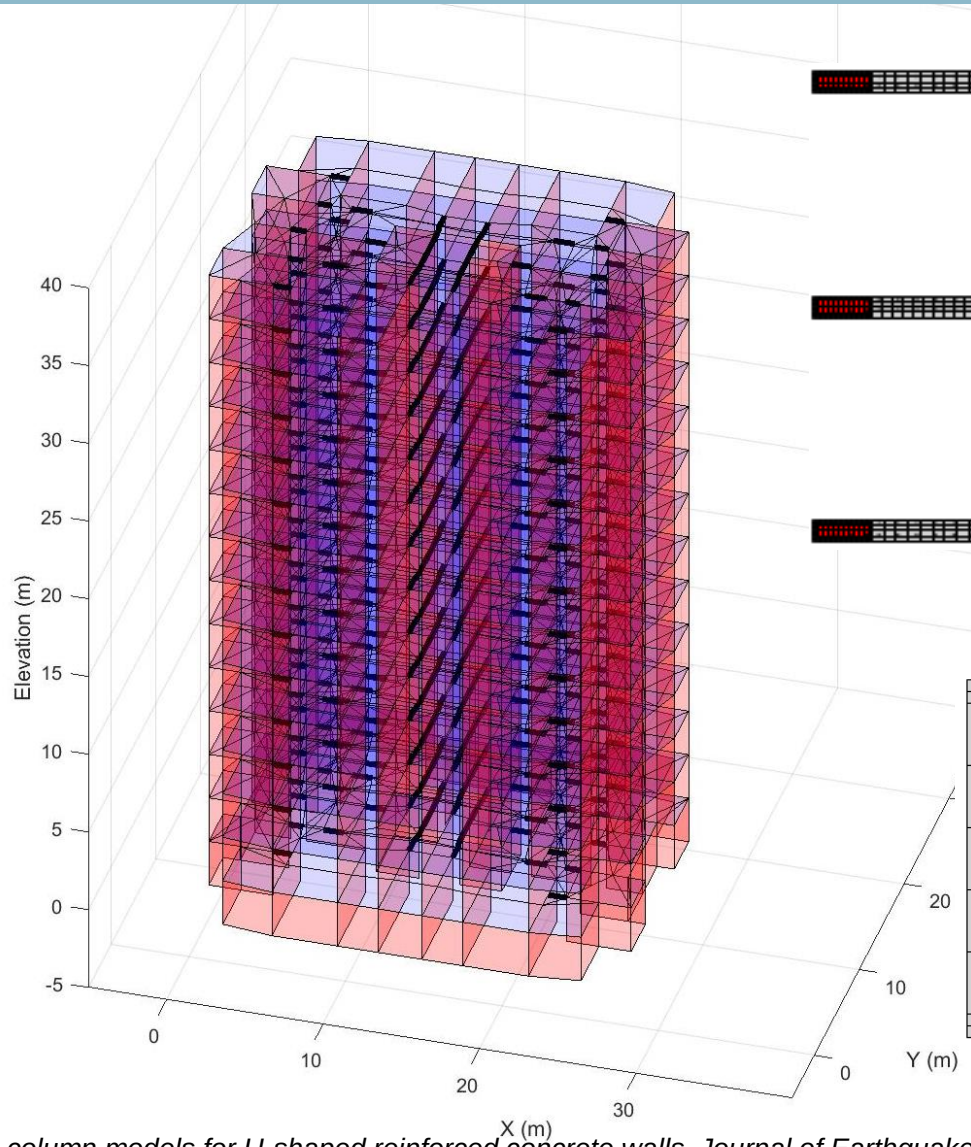


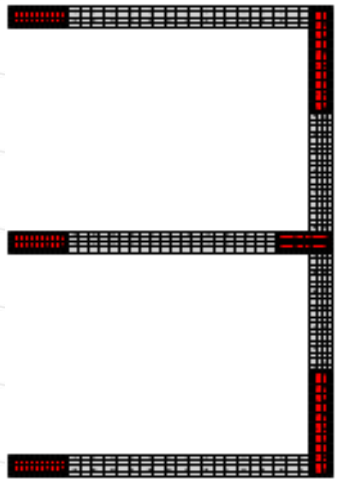
The Case Study Structure:An Archetype Tunnel-Form Building

- An existing 14-storey residential building representsing a common design that has been used in many tunnel-form buildings with the same structural properties.
- The total height of the building is 39.2 m, and each story, including the basement enclosed by continuous shear walls, has a height of 2.8 m.
- Concrete with compressive strength of 30 MPa and steel reinforcement with yield strength equal to 500 MPa and 420 Mpa were used.
- The provisions of the Turkish Building Seismic Code (TBSC) 2007 for the high-ductility class were followed for the seismic design of all structural members.

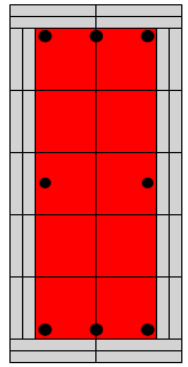


Finite Element Modelling of the Case Study Structure





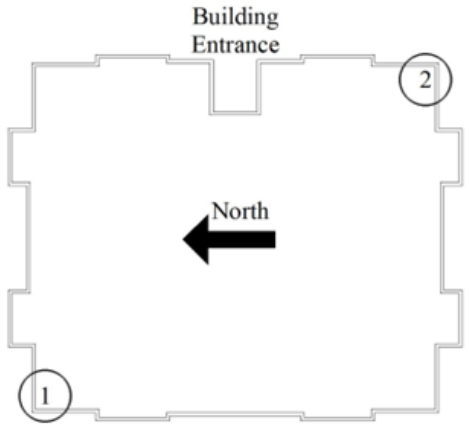
- Line elements employing the fiber-based distributed plasticity model [1]
- Detailed fiber sections to capture progression of damage
- Modified material models to capture brittle flexural failures
- Material regularisation to achieve post-peak objectivity
- Shear response through trilinear backbone curves

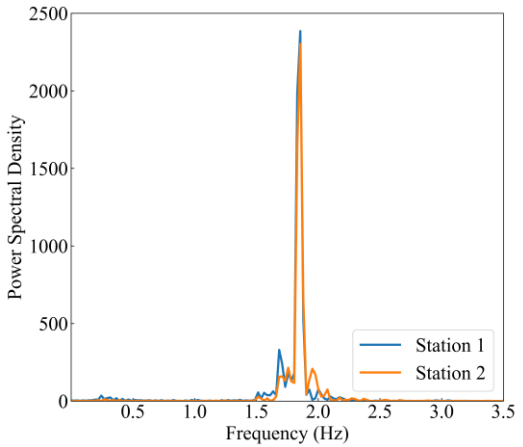


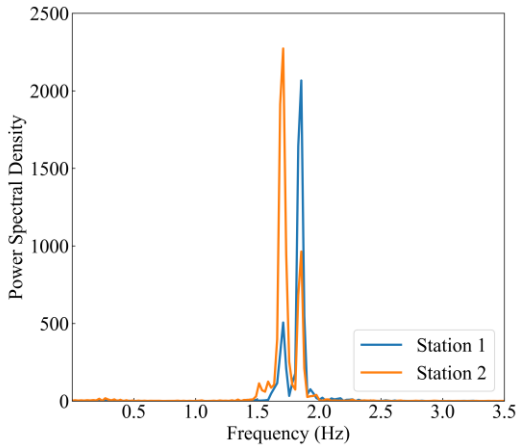
- Line elements employing the fiber-based distributed plasticity model
- Detailed fiber sections to capture progression of damage
- Explicit representation of shear sliding response at the wall-beam interfaces and shear distortion response along the beam length [2]

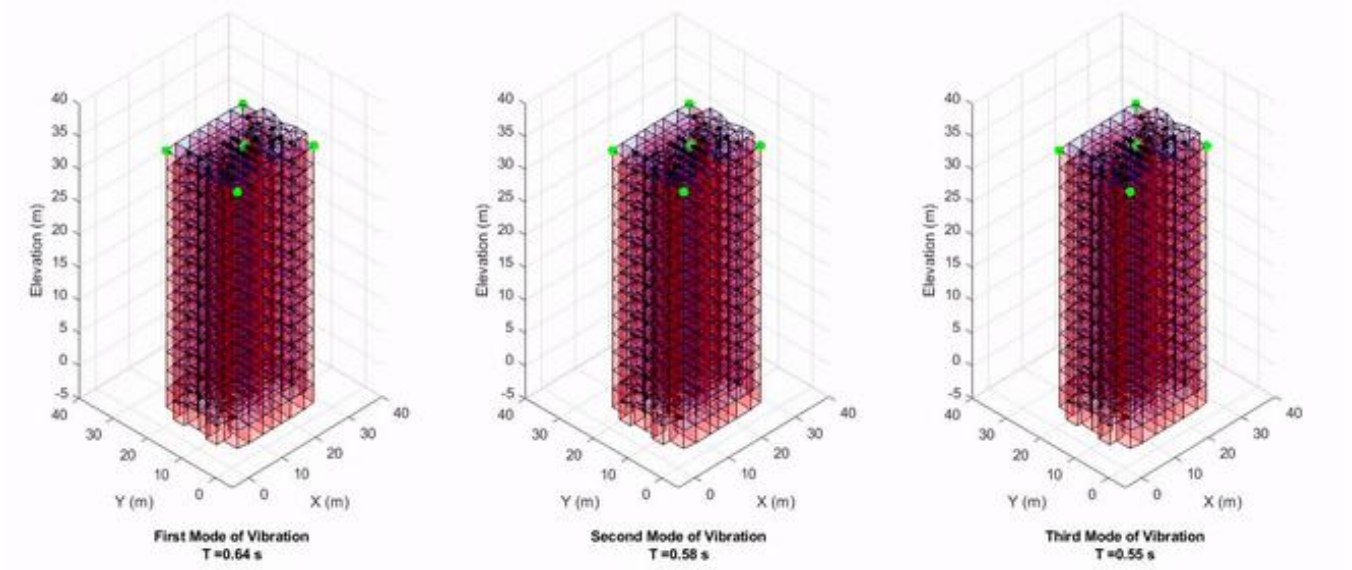
1. *Beyer K, Dazio A, Priestley MJ. Inelastic wide-column models for U-shaped reinforced concrete walls. Journal of Earthquake Engineering. 2008 Apr 11;12(S1):1-33.*
2. *Ding R, Tao MX, Nie JG, Mo YL. Shear deformation and sliding-based fiber beam-column model for seismic analysis of reinforced concrete coupling beams. Journal of Structural Engineering. 2016 Jul 1;142(7):04016032.*

Validation of the Finite Element Model: Stage I



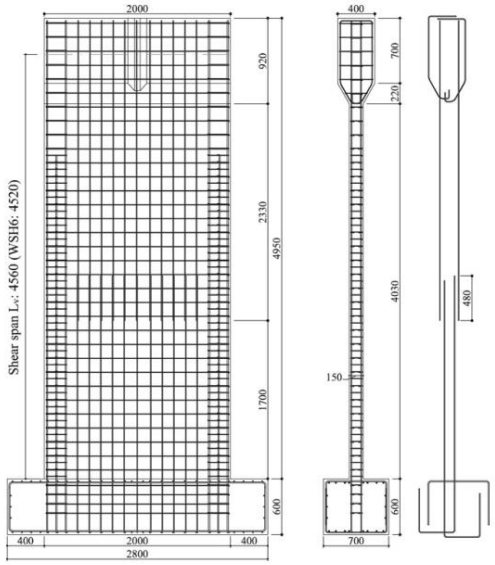


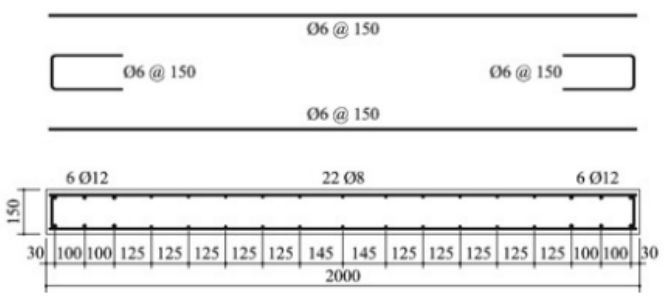


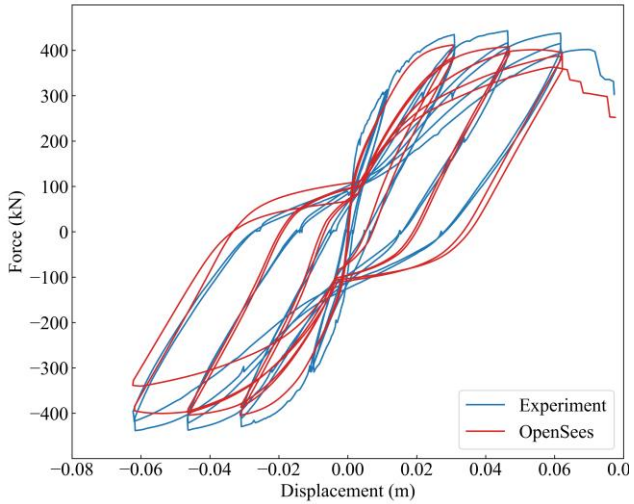


Validation of the Finite Element Model: Stage II

- Line elements employing the fiber-based distributed plasticity model [1]
- Detailed fiber sections to capture progression of damage
- Modified material models to capture brittle flexural failures
- Material regularisation to achieve post-peak objectivity [2]
- Shear response through trilinear backbone curves

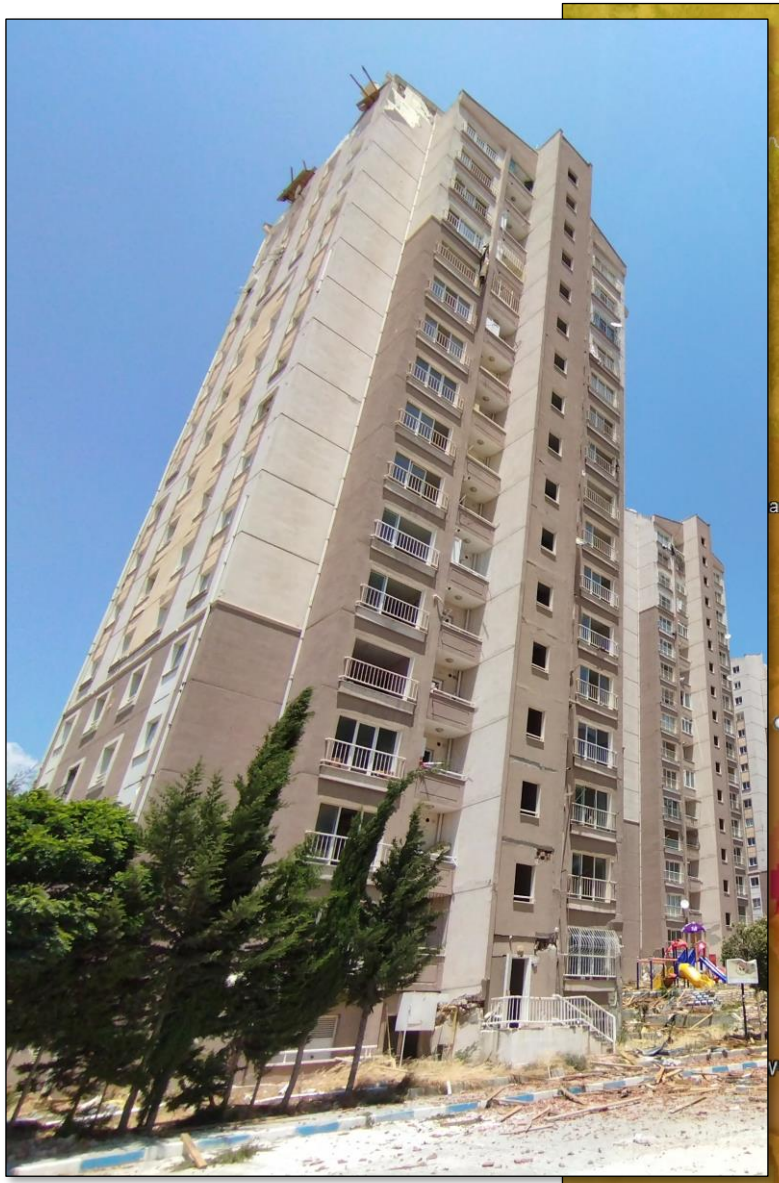


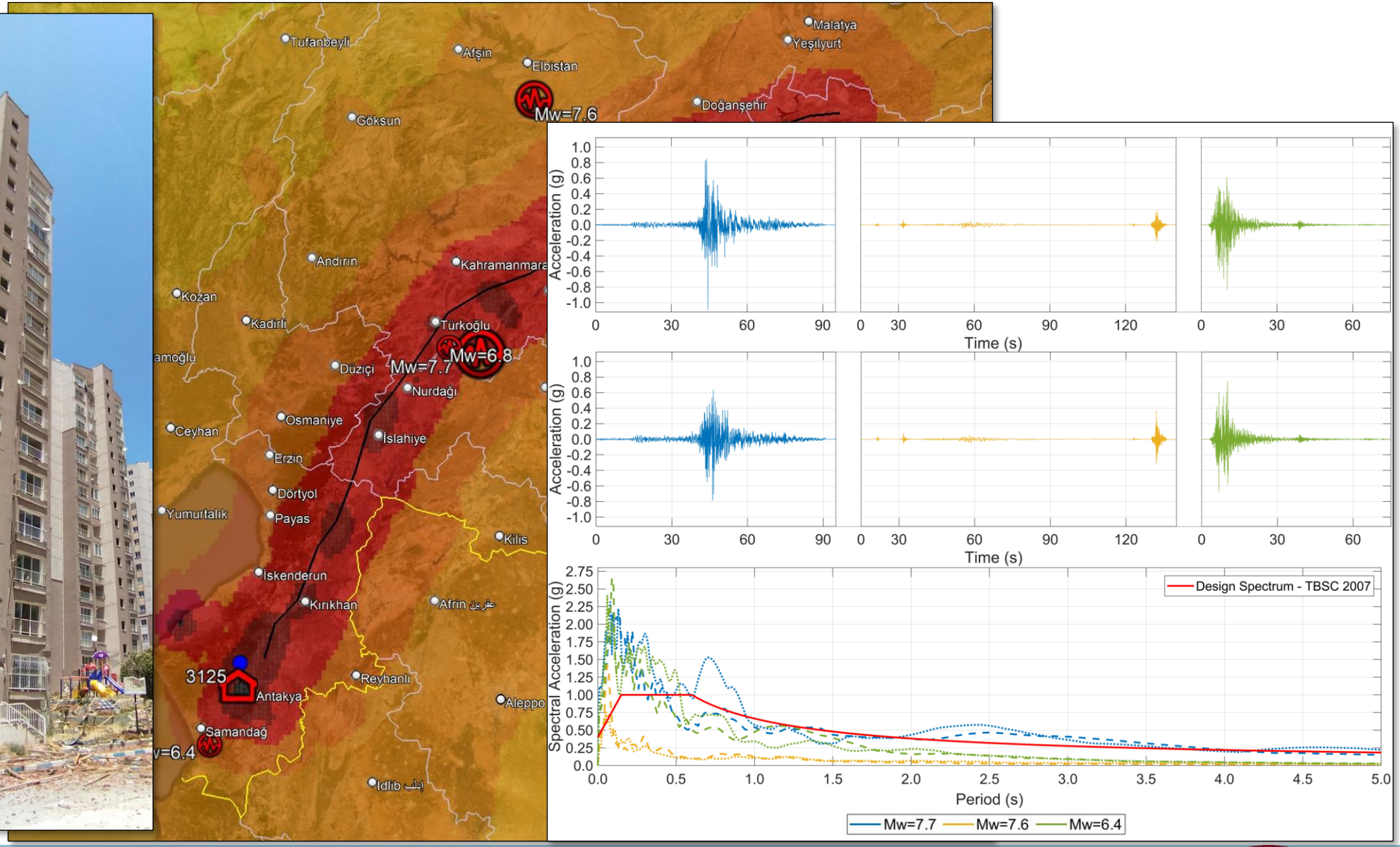




1. *Dazio A, Beyer K, Bachmann H. Quasi-static cyclic tests and plastic hinge analysis of RC structural walls. Engineering Structures. 2009 Jul 1;31(7):1556-71.*
2. *Pugh JS, Lowes LN, Lehman DE. Nonlinear line-element modeling of flexural reinforced concrete walls. Engineering Structures. 2015 Dec 1;104:174-92.*

Validation of the Finite Element Model: Stage III





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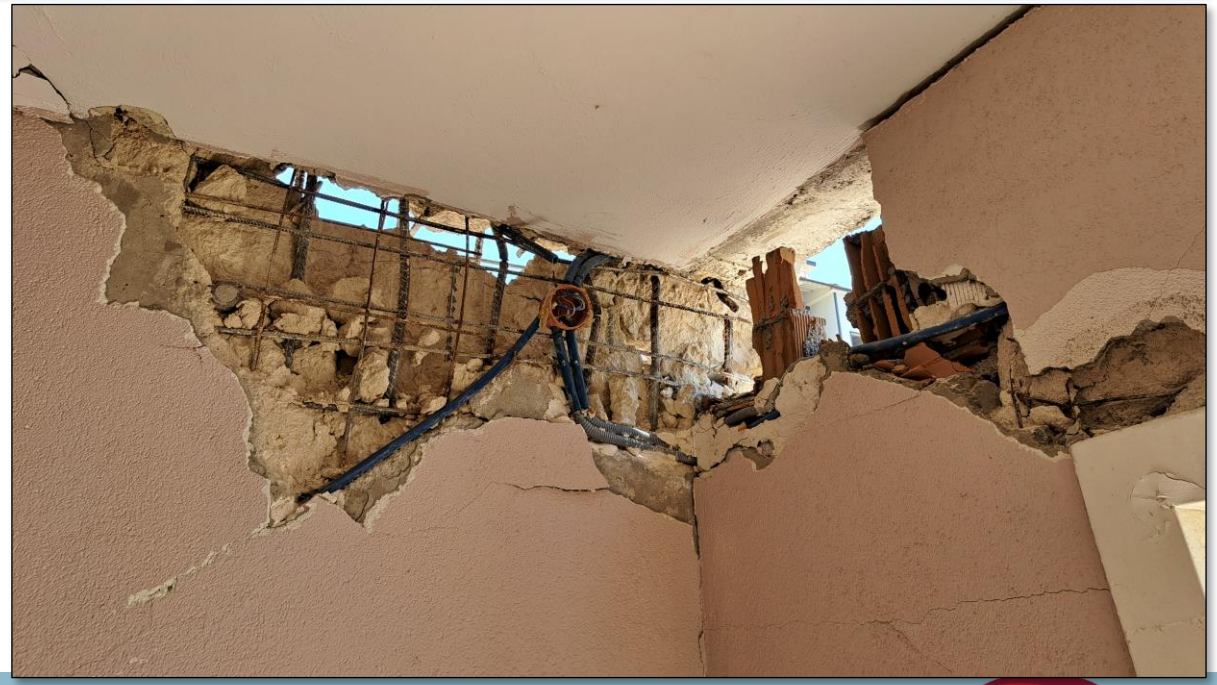

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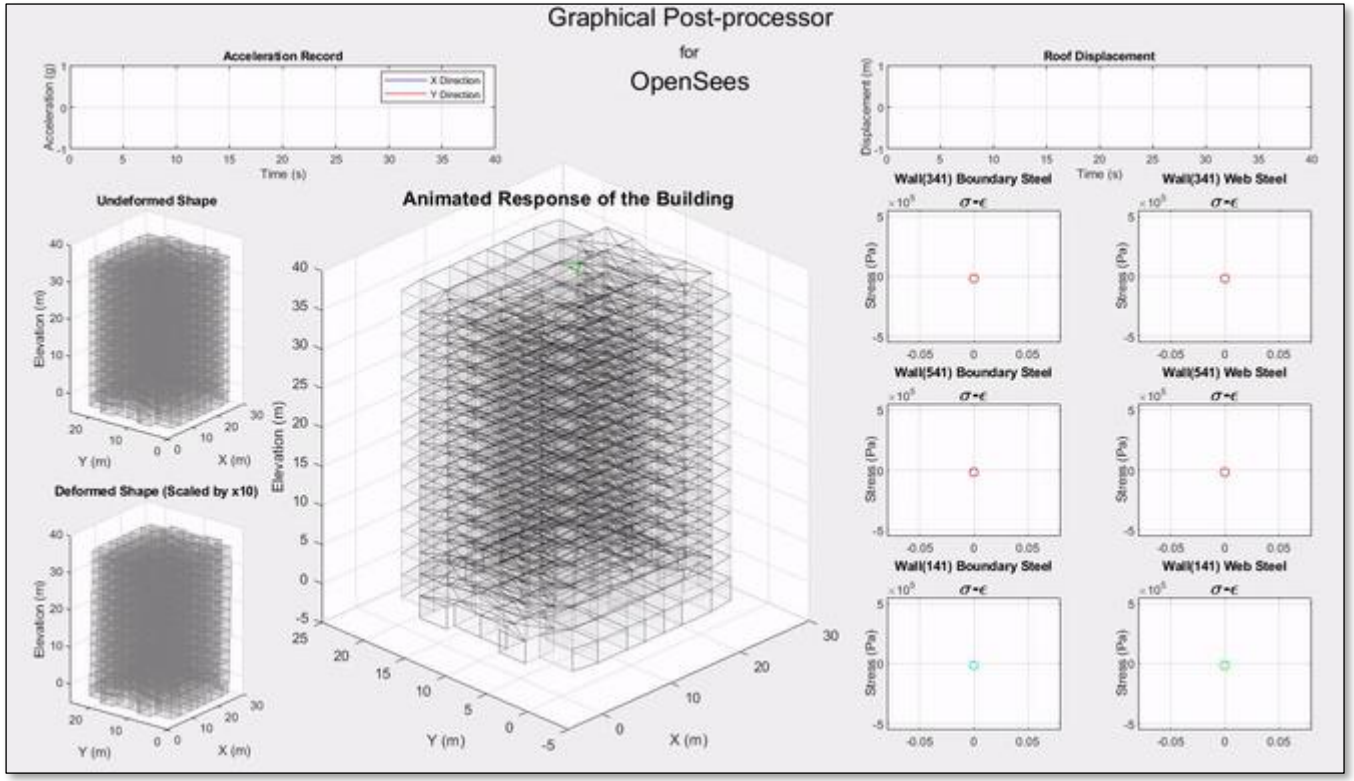
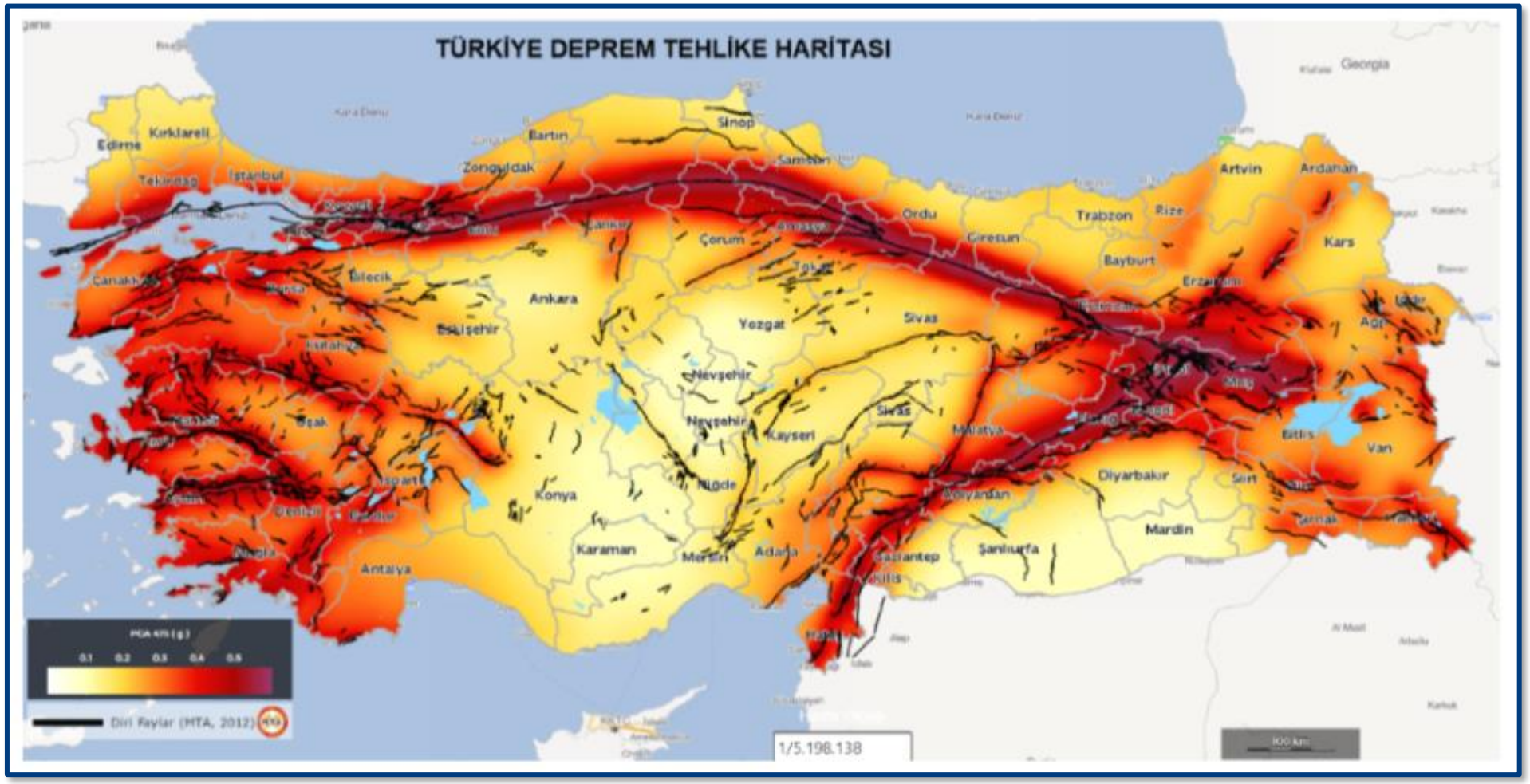


Risk Assessment



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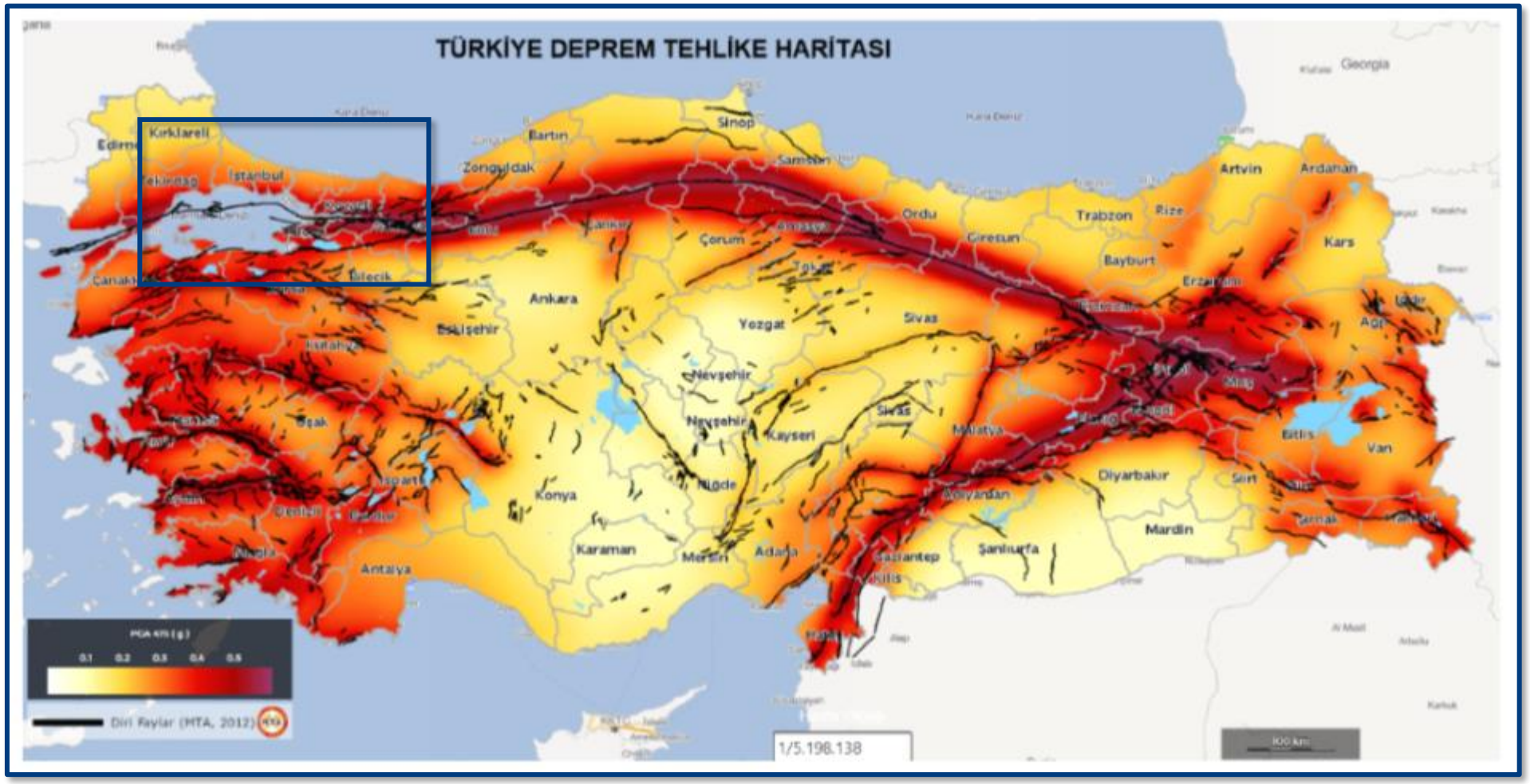

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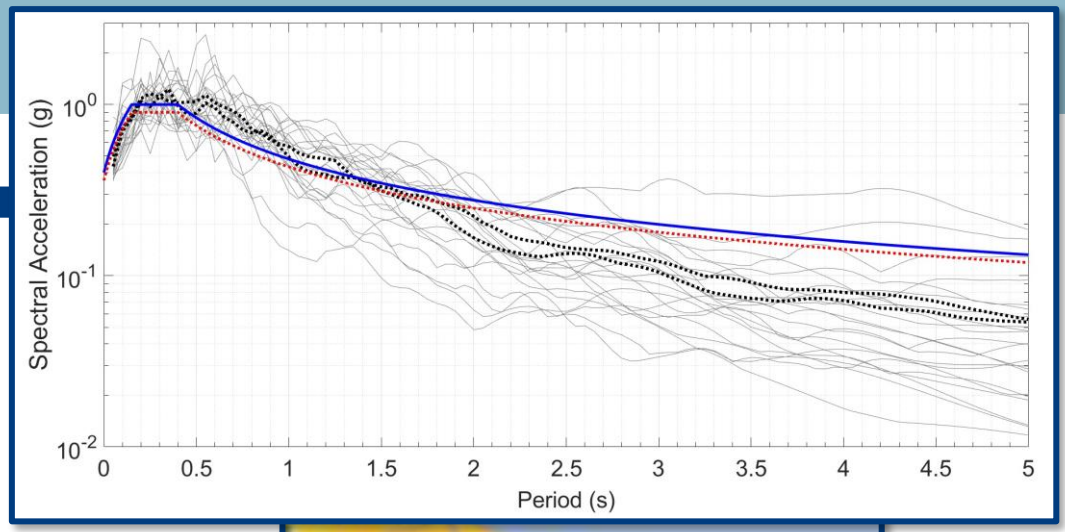

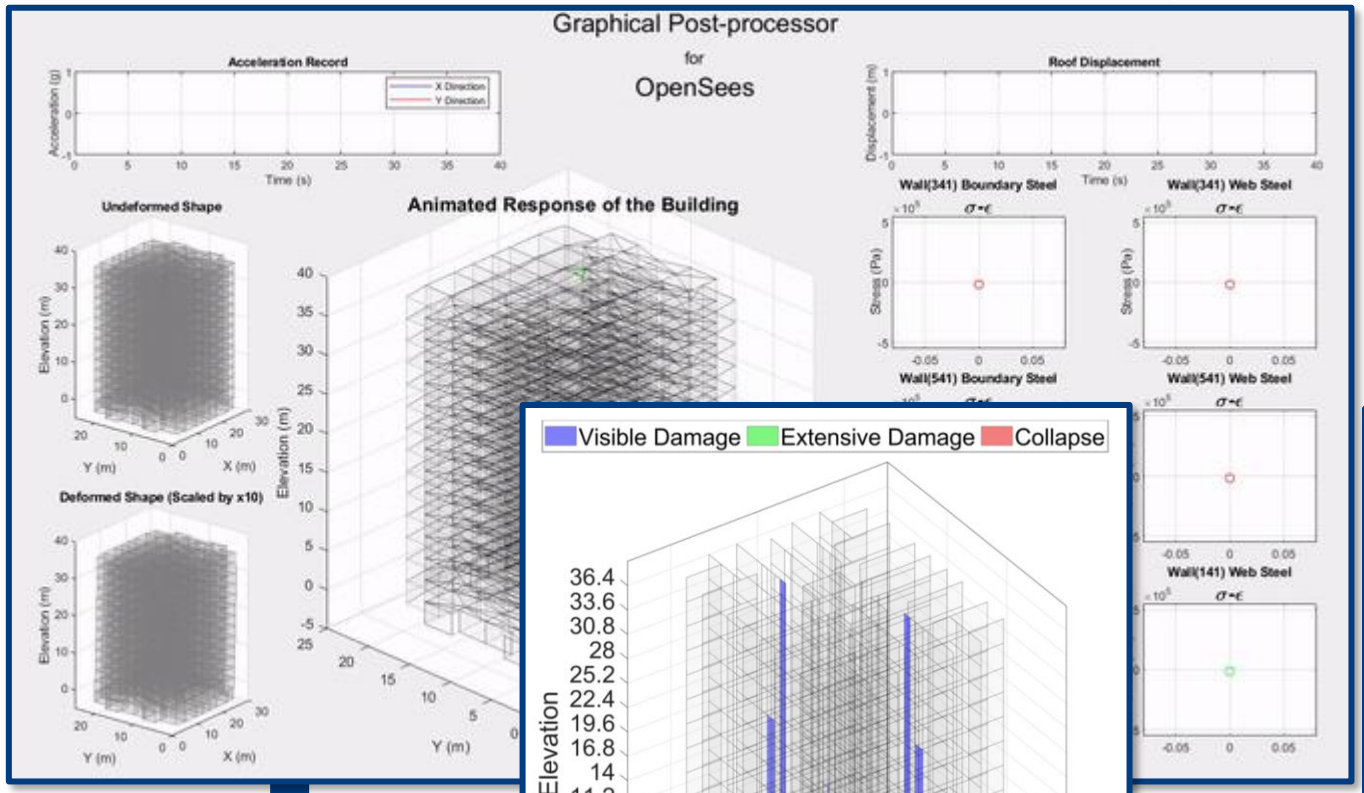

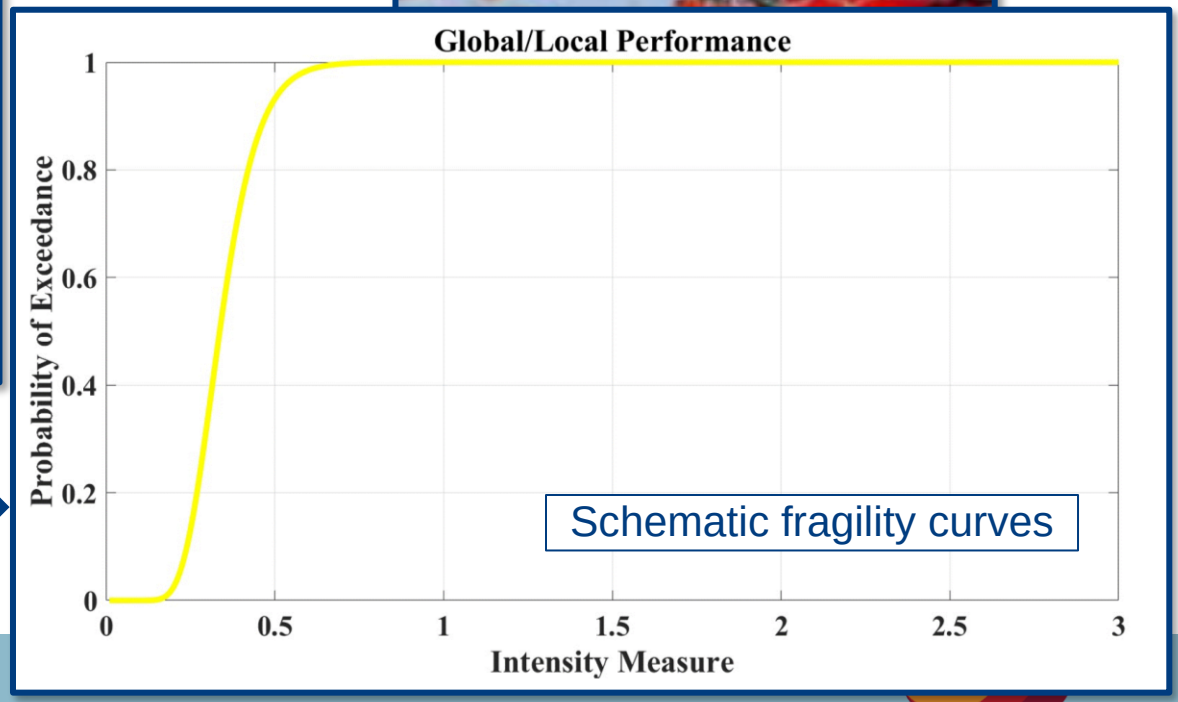

Conclusions

- Performed better compared to nearby reinforced concrete frames and maintained structural integrity
- *Predisposition of shear walls to brittle failure under flexural actions*
- *Brittle failure of coupling beams*
- *Need for advanced finite element modelling techniques to capture prominent failure modes*
- Future steps of this research will provide a clearer insight into their seismic vulnerability and develop engineering solutions to improve their overall performance

THANK YOU FOR YOUR INTEREST!

sahin.dede.21@ucl.ac.uk

linkedin.com/in/sahin-dede/

University College London, Gower Street
London, WC1E 6BT