Numerical analysis and retrofitting of an historical masonry buildings

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Outline

- Motivation

- Aim of thesis

- Study case

- Analysis results

- Conclusion
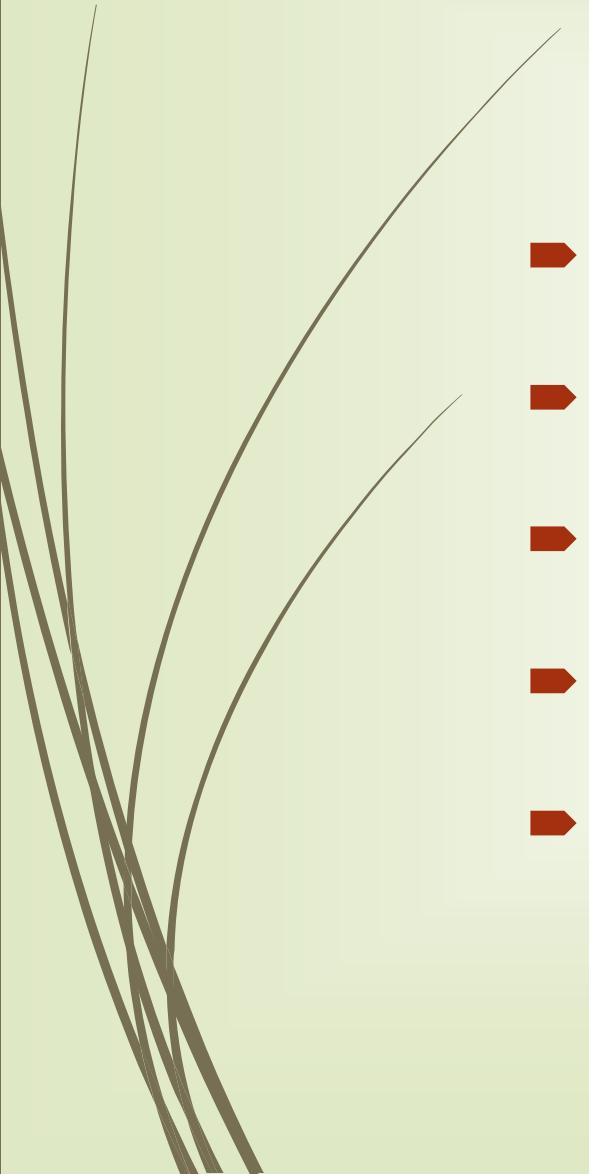
Motivation

- Hot topic

- Not so well known in Czech Republic

- Passion for architectural heritage

- Cooperation on real project

Aim of thesis

- The aim of this bachelor thesis is to perform a seismic analysis of an historical masonry building located in seismic zone based on Italian code NTC 2008 and investigate the possible retrofitting techniques in order to preserve the building in case of earthquake. Elective method will be applied on chosen structure and in case of unsatisfactory results would be the structure retrofitted.

# Study case – „Palizzi" castle

- Adress: Via Sant´Angelo, 14 Regio Calabria (RC) Palizzi, 89038, Italy

- Name of building: „Palizzi" castle

- Permanent parcel: st. 113, 114

- Building use: Historical monument

- Owner: Municipality of Palizzi

Study case – „Palizzi" castle
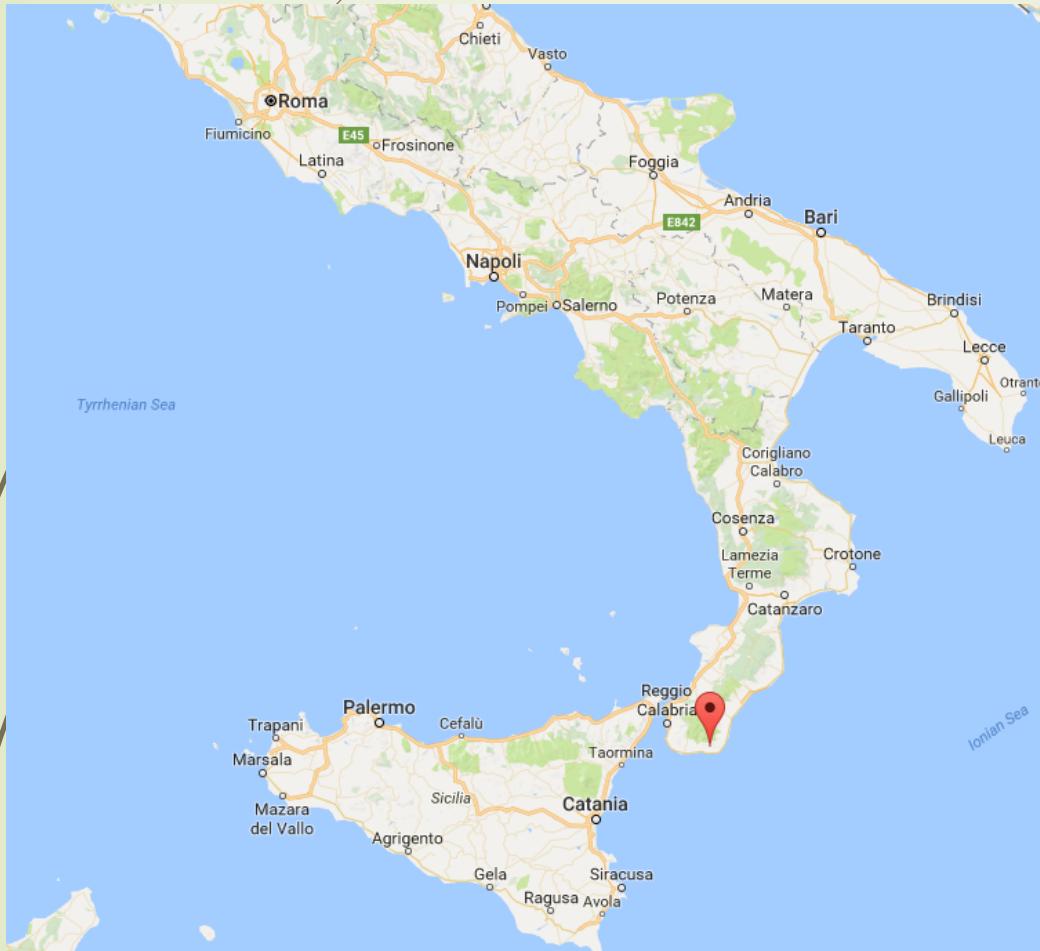
Map of Italy with location of Palizzi town (https://www.google.cz/maps/)
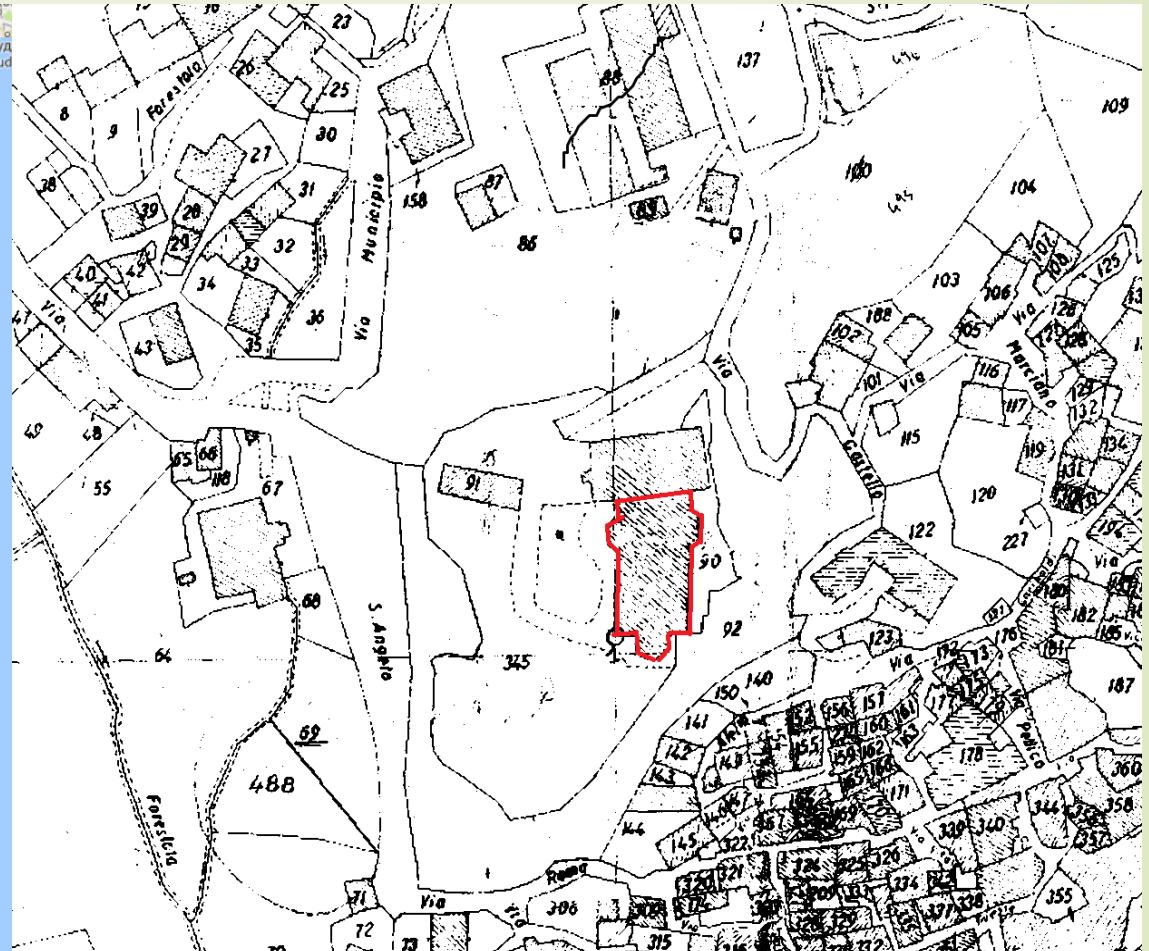
Cadastral map of Palizzi municipality showing the location of the castle

# Study case – „Palizzi" castle
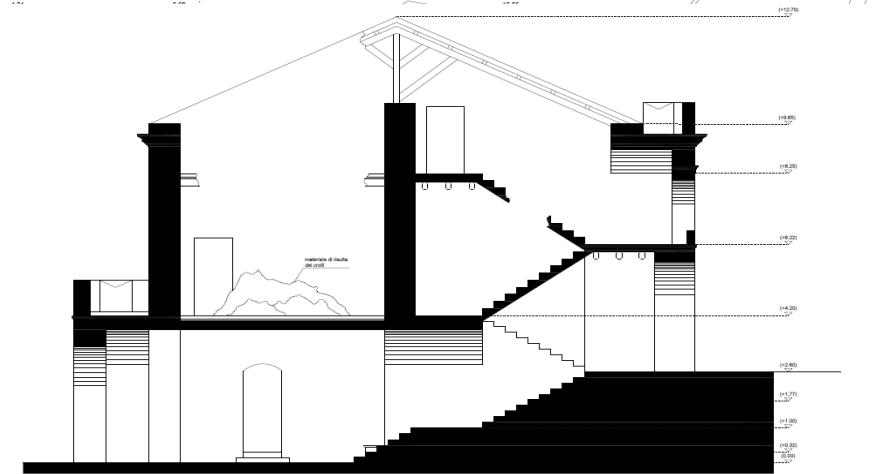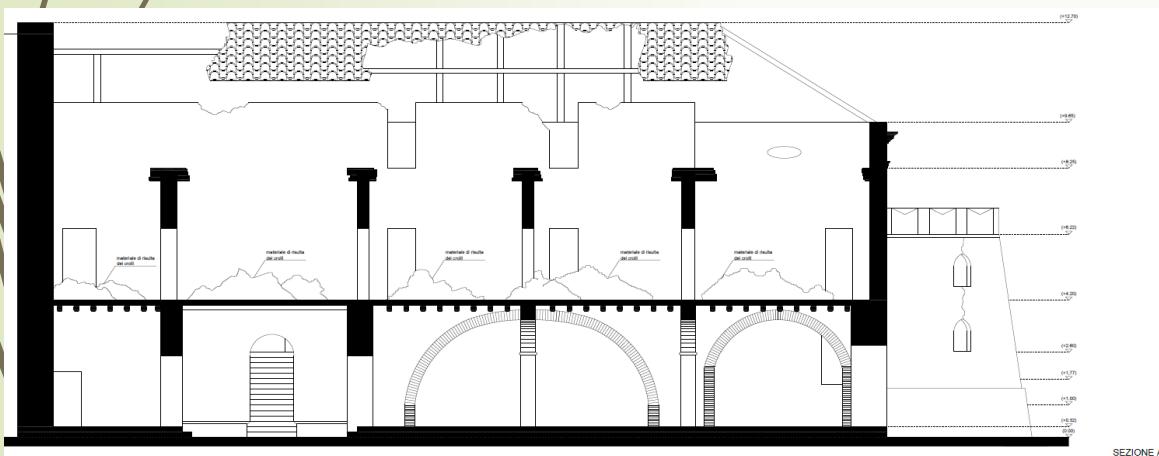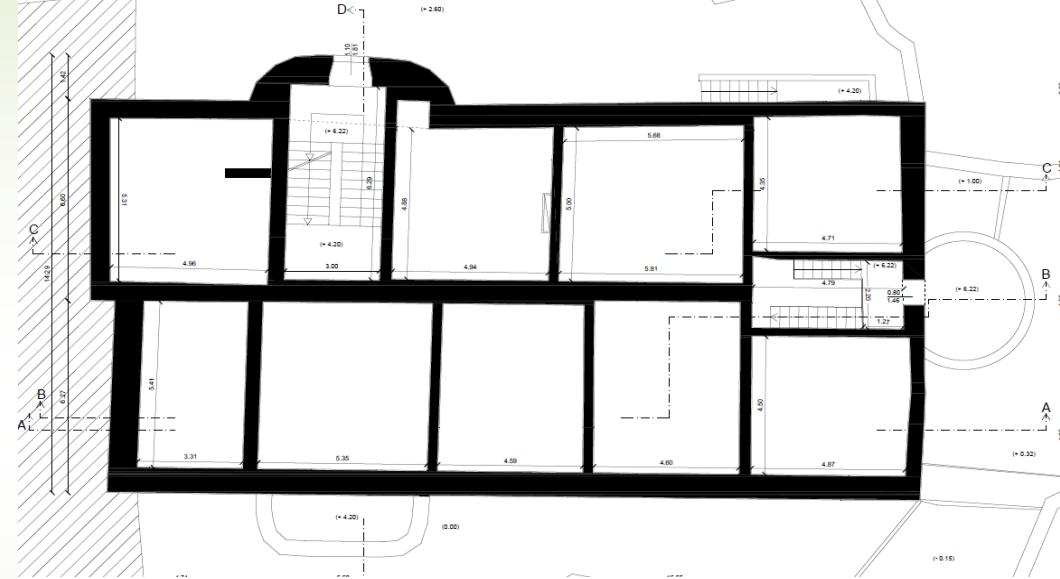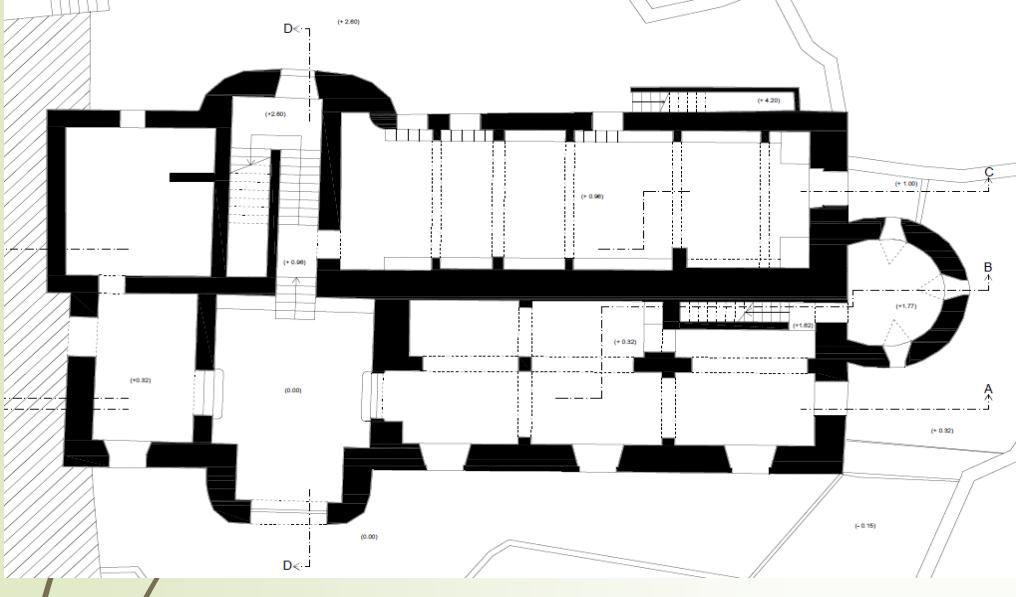
Study case – „Palizzi" castle
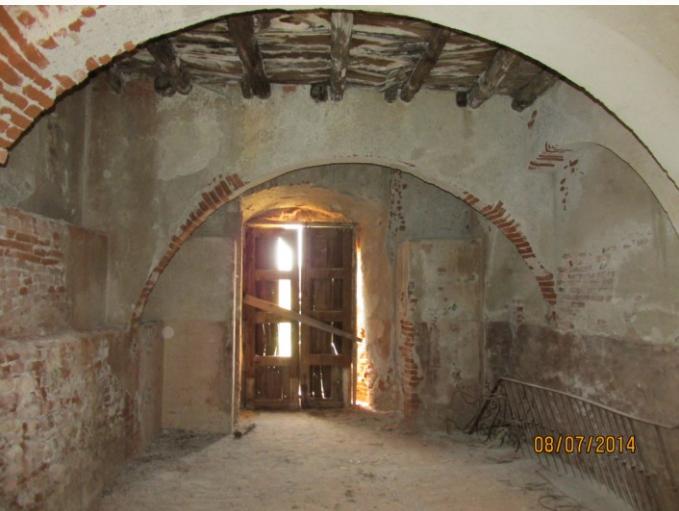
Study case – „Palizzi" castle
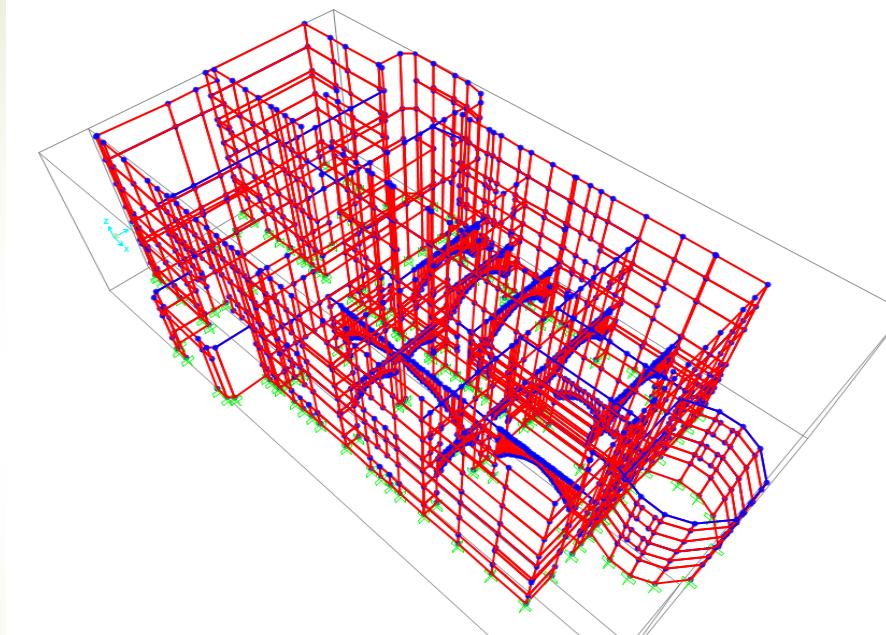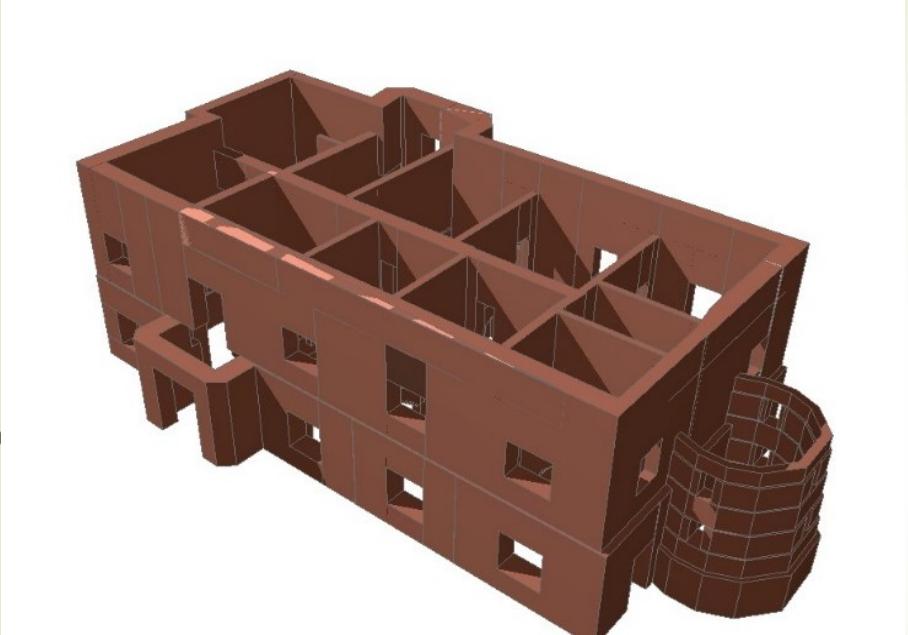
Masonry typology	(N/mm²)	(N/mm²)	E (N/mm²)	G (N/mm²)	W (kN/m³)
Brick masonry and mortar	2,52	0,60	1654	394	18
Masonry of brick and mortar (retrofitted)	4.91	1.16	3225	768	18

Study case – „Palizzi" castle
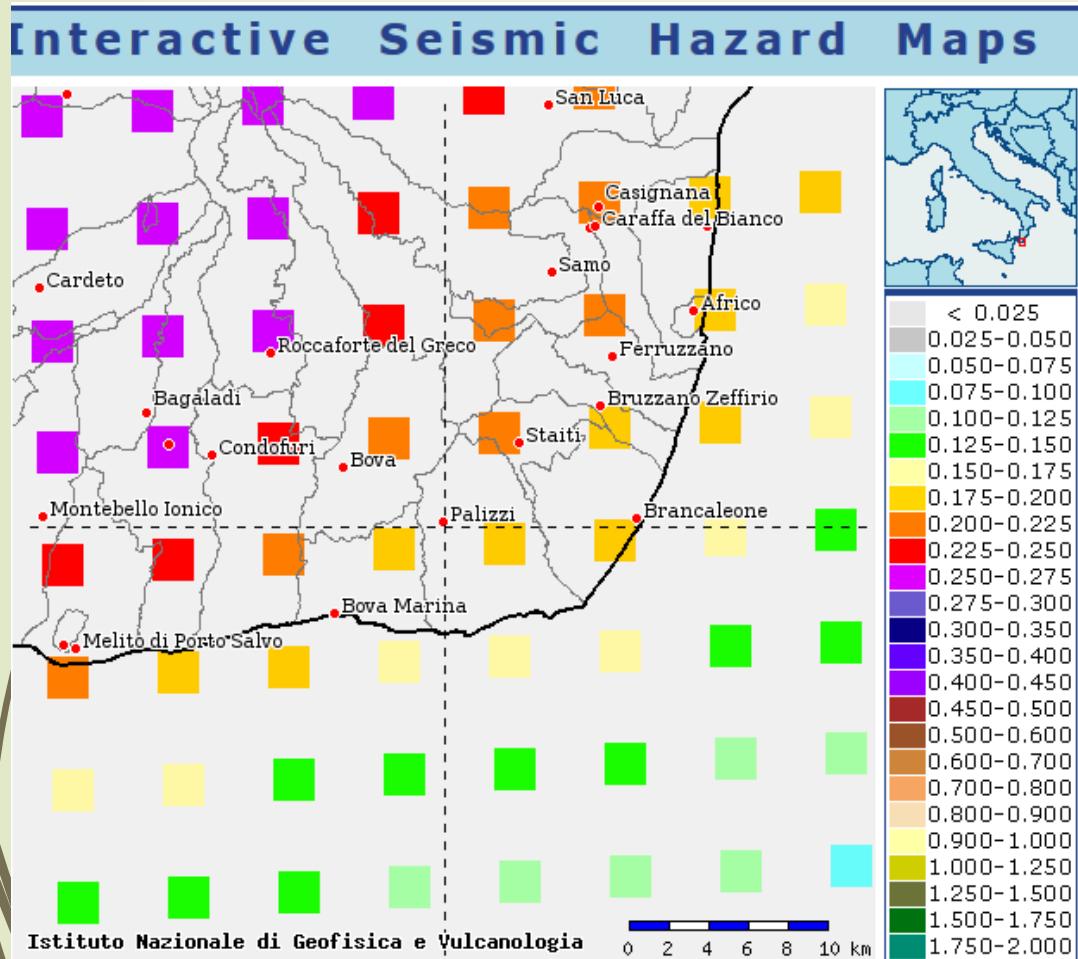
- Actual PGA is 0,175 – 0,200
- Region of Calabria – 1. zone – PGA is 0,301

Study case – „Palizzi" castle
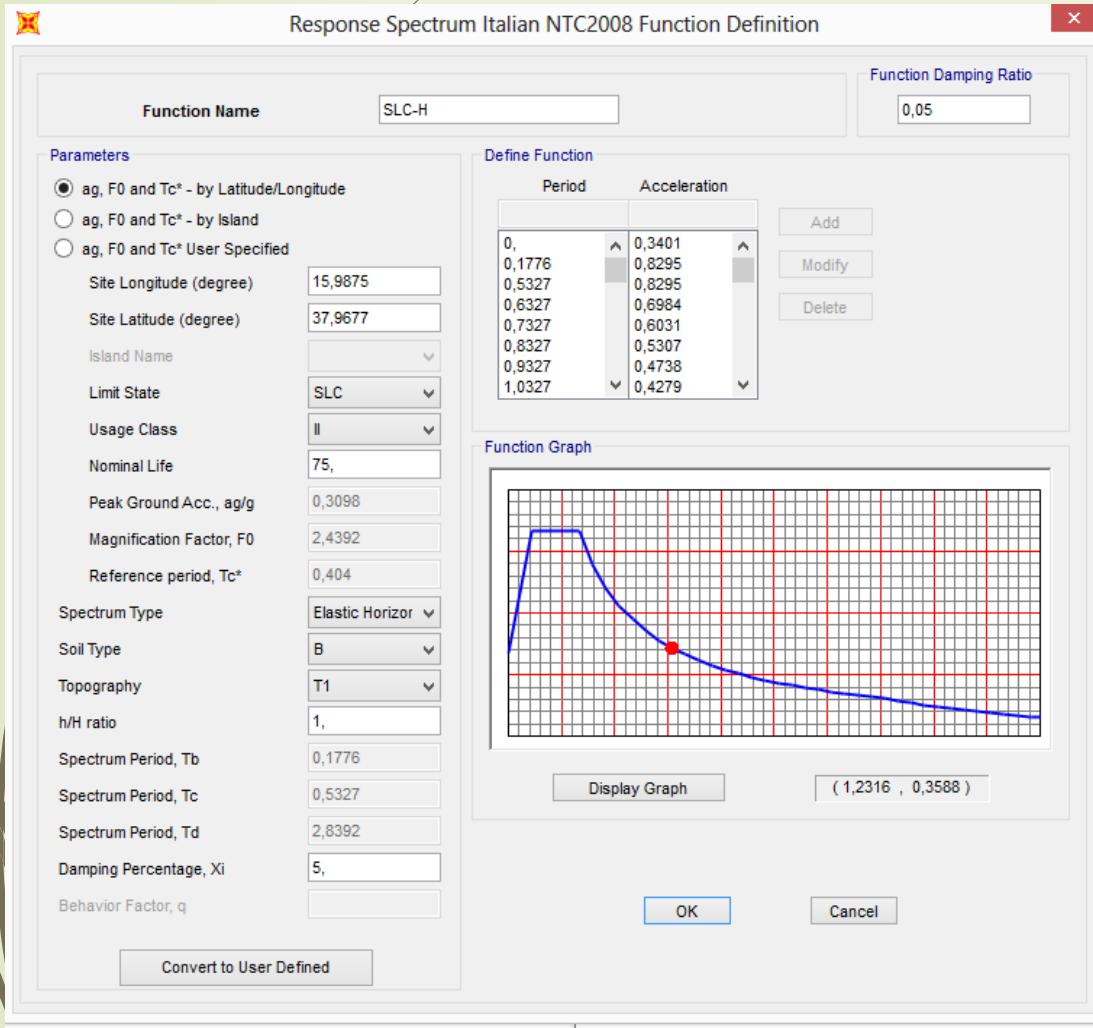
- Collapse prevention Limit State (SLC)
- Damage Limitation State (SLD)
- Operating Limit State (SLO)
- Life-Saving Limit State (SLV)

Study case – „Palizzi" castle
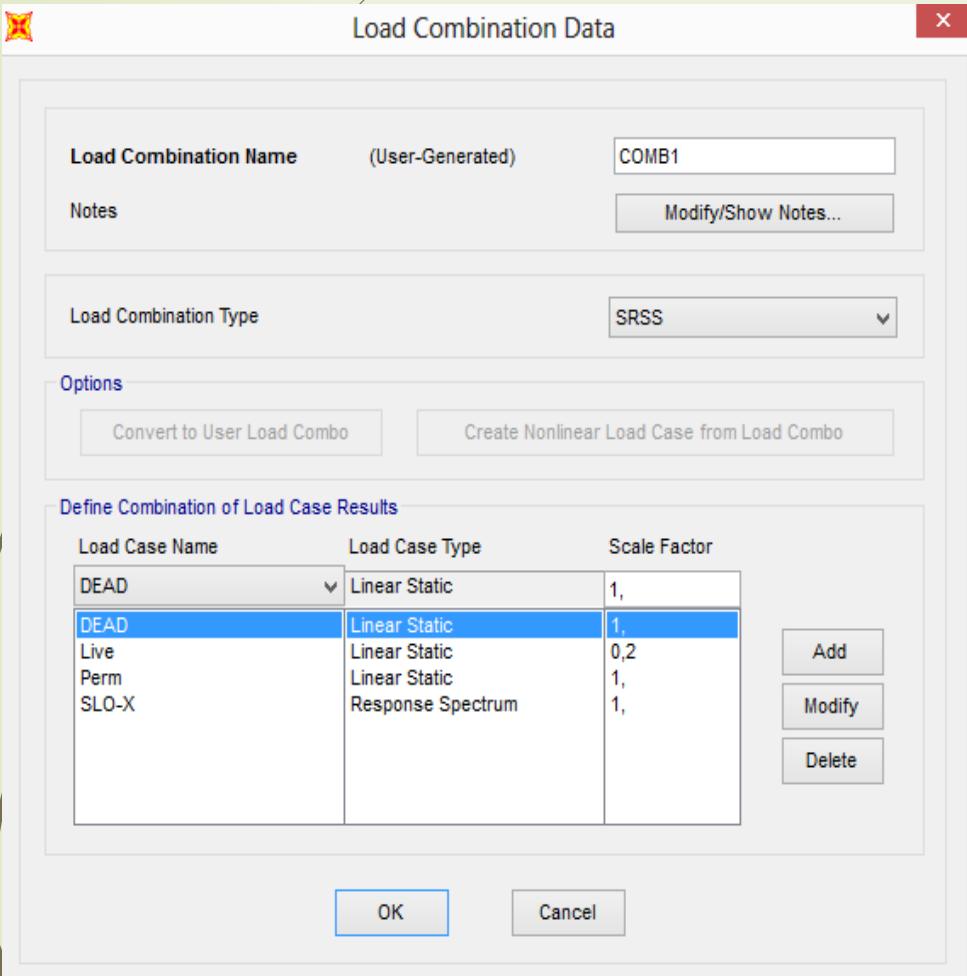
- 12. load combinations
- 1. envelope
- Roof and slabs – with and without
- SRSS - Square Root of Sum of Squares

Study case – „Palizzi" castle

Model without slabs – direct stress

	S22	
Max stress	9,062 N/mm²	2.52 N/mm²
Average stress	0,557642 N/mm²	2.52 N/mm²
Min stress	0,007884 N/mm²	2.52 N/mm²

- **S22:** Direct stress (force per unit area) acting on the positive and negative 2 faces in the 2-axis direction.

- : Tensile strength of masonry (N/mm²)
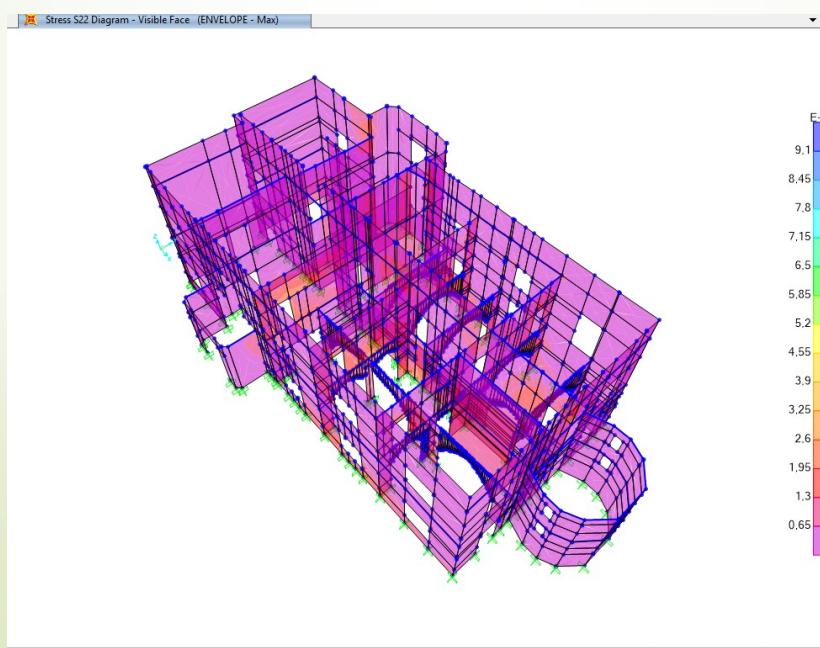
Study case – „Palizzi" castle

Model without slabs – shearing stress

	S12	
Max stress	7,516 N/mm²	0.60 N/mm²
Average stress	0,405414 N/mm²	0.60 N/mm²
Min stress	0,0005604 N/mm²	0.60 N/mm²
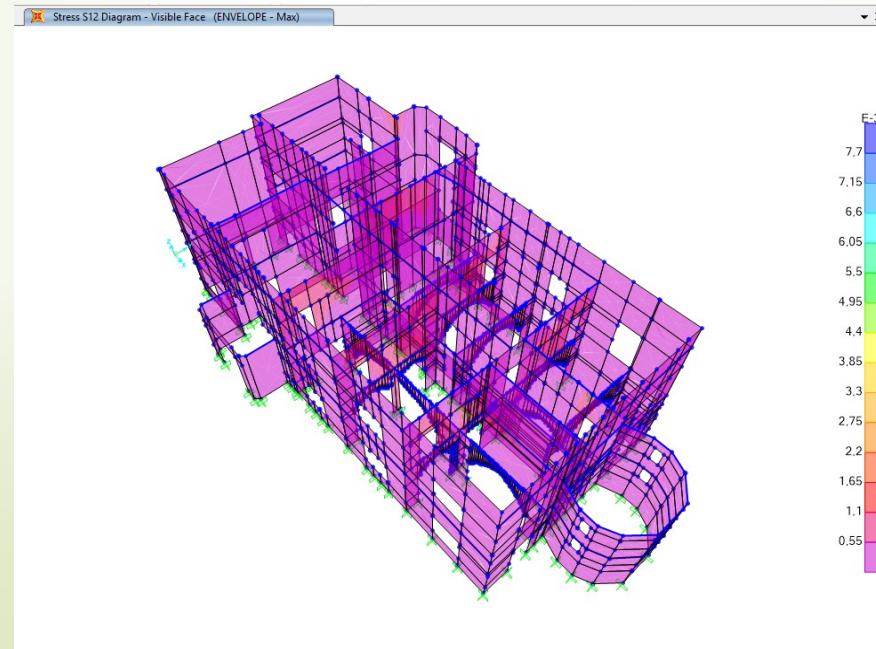
- **S12:** Shearing stress (force per unit area) acting on the positive and negative 1 faces in the 2-axis direction and acting on the positive and negative 2 faces in the 1-axis direction.

- : Shear strength of masonry (N/mm²)

Study case – „Palizzi" castle

Retrofitted model with slabs – direct stress

	S22	
Max stress	11,439 N/mm²	4.91 N/mm²
Average stress	0,433839 N/mm²	4.91 N/mm²
Min stress	0,001775 N/mm²	4.91 N/mm²

- **S22:** Direct stress (force per unit area) acting on the positive and negative 2 faces in the 2-axis direction.

- : Tensile strength of masonry (N/mm²)
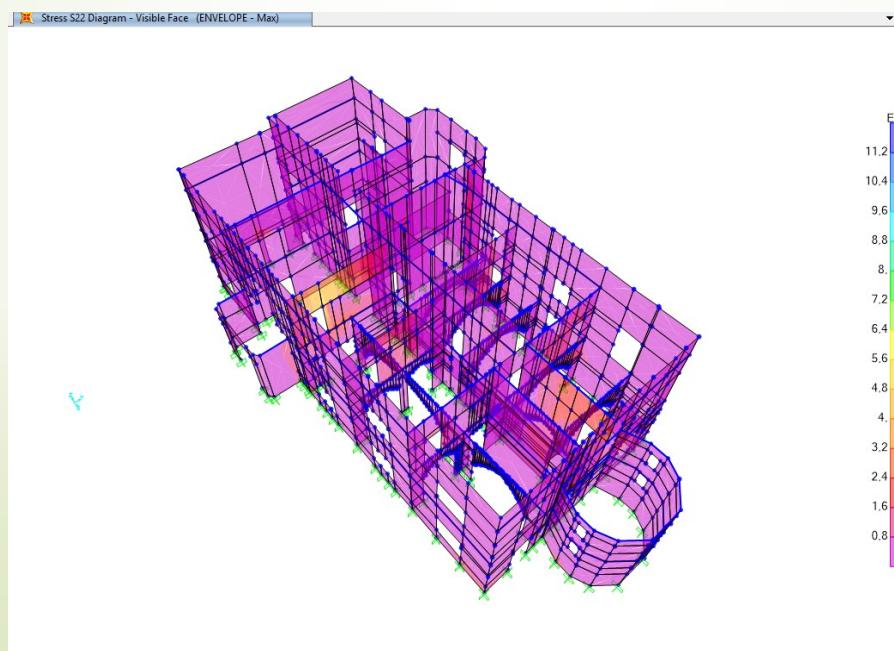
Study case – „Palizzi" castle

Retrofitted model with slabs – shearing stress

	S12	
Max stress	3,557 N/mm²	1.16 N/mm²
Average stress	0,258344 N/mm²	1.16 N/mm²
Min stress	0,002053 N/mm²	1.16 N/mm²
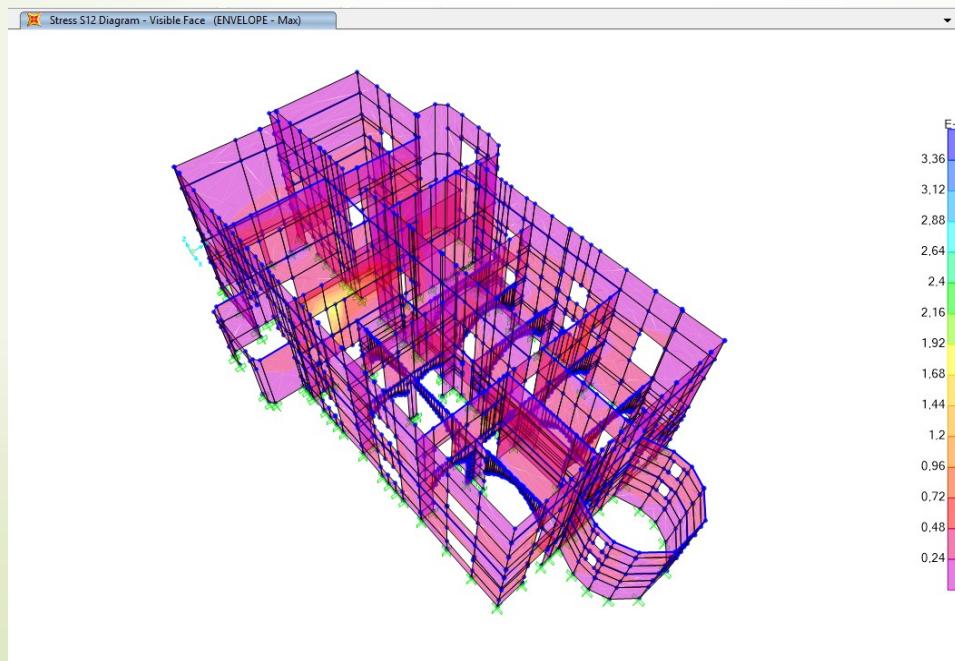
- **S12:** Shearing stress (force per unit area) acting on the positive and negative 1 faces in the 2-axis direction and acting on the positive and negative 2 faces in the 1-axis direction.

- : Shear strength of masonry (N/mm²)

Verification and conclusion

Percentage of verified results

97.11381 — S 22
83.5958 — S 12
99.93443 — S 22 AFTER RETROFITTING
99.19619 — S 12 AFTER RETROFITTING

■ S 22　■ S 12　■ S 22 after retrofitting　■ S 12 after retrofitting
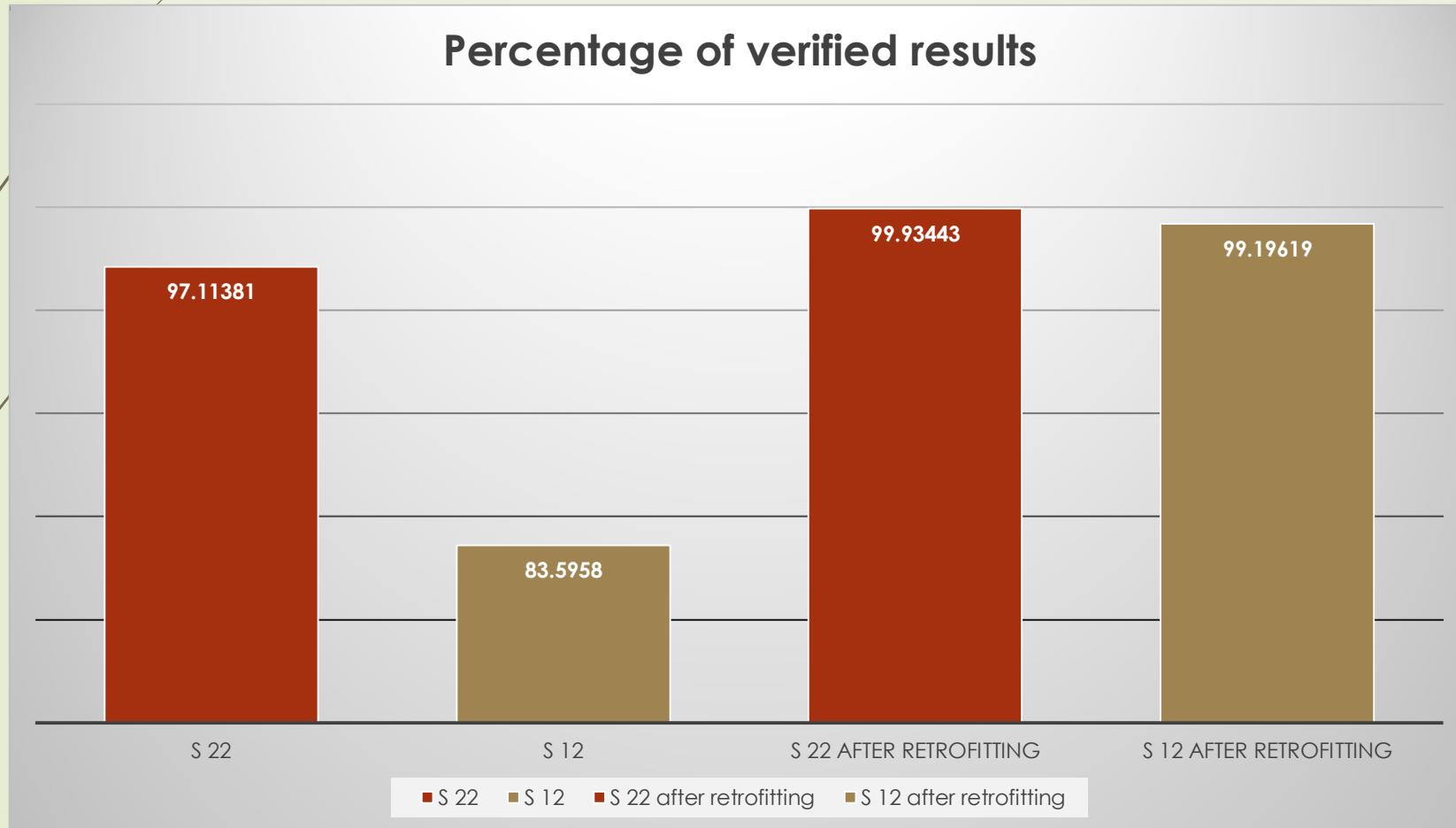
Thank you for your attention!

Questions from supervisor and oponent

- Existují i jiné možnosti úpravy historické konstrukce, tak aby vzdorovala seismickému zatížení? Uveďte příklady které znáte.

Do another retrofitting methods for historical structures exist? Please give examples.

- Jaký máte názor na zpevnění zdiva injektáží? Je vhodná pro zpevnění zdiva při účincích seismického zatížení?

What is your opinion about strengthening masonry by injection method? Can the method be applied for earthquake resistance?

- V jakém zdivu obecně lze injektáž aplikovat a v jakém naopak ne? Co je rozhodující parametr?

In which type of masonry could be possible to apply injection method and in which not? What is the critical parameter?

Retrofitting methods

Surface treatment

- *Bamboo-Band retrofitting technique*

- **Reinforced plaster**

- **Shotcrete**

- *Fiber-Reinforced polymer (FRP)*

- **Post-tensioning**

- *Confinement*

- *Center core*

- *Injection*