4th International Symposium of ICOMOS Slovenia

Balancing investments in energy efficiency measures with conservation of cultural heritage buildings in the light of global warming – A Slovenian case study

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LIFE CLIMATE PATH 2050

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Zavod za varstvo kulturne dediščine Slovenije

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je financiran iz finančnega mehanizma LIFE, ki ga upravlja Evropska komisija, in iz Sklada za podnebne spremembe Ministrstva za okolje in prostor RS.

To preserve or not to preserve… climate and cultural heritage buildings

- In their fight against climate change, many countries have already committed to reduction of greenhouse gas emissions, increasing the share of renewable energy and improving energy efficiency.
- In the building sector, a substantial contribution to these efforts will be made through extensive energy renovation of buildings.
- Cultural heritage buildings represent an important part of the building stock.
- Energy efficiency (EE) related measures can cover up deeper problems of the building’s condition. Hence, in the long run, building renovation is going to have to be implemented in more holistic manner.

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To preserve or not to preserve… climate and cultural heritage buildings

- In order to preserve cultural heritage (CH) buildings, more holistic renovation require a more extensive and detailed planning as well as investments.
- CH buildings cannot be demolished and replaced, holistic renovation of this building cohort will require substantial investments.
- Additional aspect will also have to be addressed, such as seismic strenghtening.
- The presentation and its following paper will offer:
  - an insight into required knowledge of current condition of buildings and their required extent of renovation in the future;
  - comparison of investments for improving energy efficiency in cultural heritage buildings with other buildings;
  - typical measures for seismic strengthening of CH buildings;
  - case study.

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Modelling of CH buildings‘ decarbonization

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Why do we model?

- For the purpose of National Energy and Climate action plan, scenarios for the reduction of GHG emissions were prepared, which included CH buildings.
- Modelling results made in the scope of LIFE ClimatePath2050 served as expert basis for the acceptance of:
  - National Energy and Climate Action Plan
  - Long term building energy renovation strategy to 2050
  - Climate strategy
- Stock of cultural heritage (CH) buildings was analyzed separately, due to limited options of building renovation measures that can be applied.
- Central govermental buildings were modeled separetely since:
  - They should present an example case study for all other buildings
  - An analysis on holistic renovation possibilites was possible.

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Why do we renovate?

- The main issue was lack of information on current condition of public buildings. Country has to annualy renovate 3 % of its buildings, but has troubles to sistematically provide sufficient resources with appropriate financial instruments.
- Priority list of buildings for renovation was prepared, that gives the government an insight into required extent of renovation works as well as investments & savings.
- Aspect of cultural heritage for the possible energy as well as seismic renovation was analyzed for each buildings with joint cooperation with Ministry for culture.

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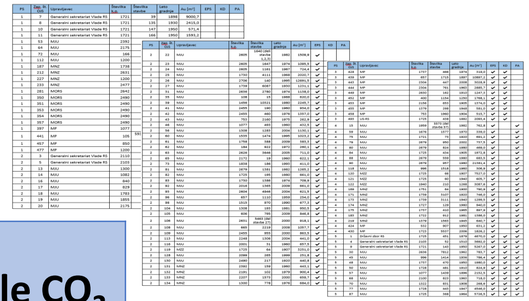
Potential for holistic renovation of central governmental buildings



Group	Achieved minimal energy efficiency	Required compliance of CH	Required compliance of seismic streghtening	Number of buildings	A_u [m²]	Possible energy savings [GWh/a]	Possible CO_2 savings [kt/a]
1	yes	-	-	22	55.250		
2	no	no	no	166	263.986	20,85	5,85
3	no	yes	no	59	121.982	9,64	2,70
4	no	ne	yes	21	47.723	3,77	1,06
5	no	yes	yes	34	81.539	6,44	1,81
6	no	yes	-	10	33.889	2,68	0,75
7	no	no	-	179	286.531	22,64	6,35
Sum				491	890.899	66,02	18,52

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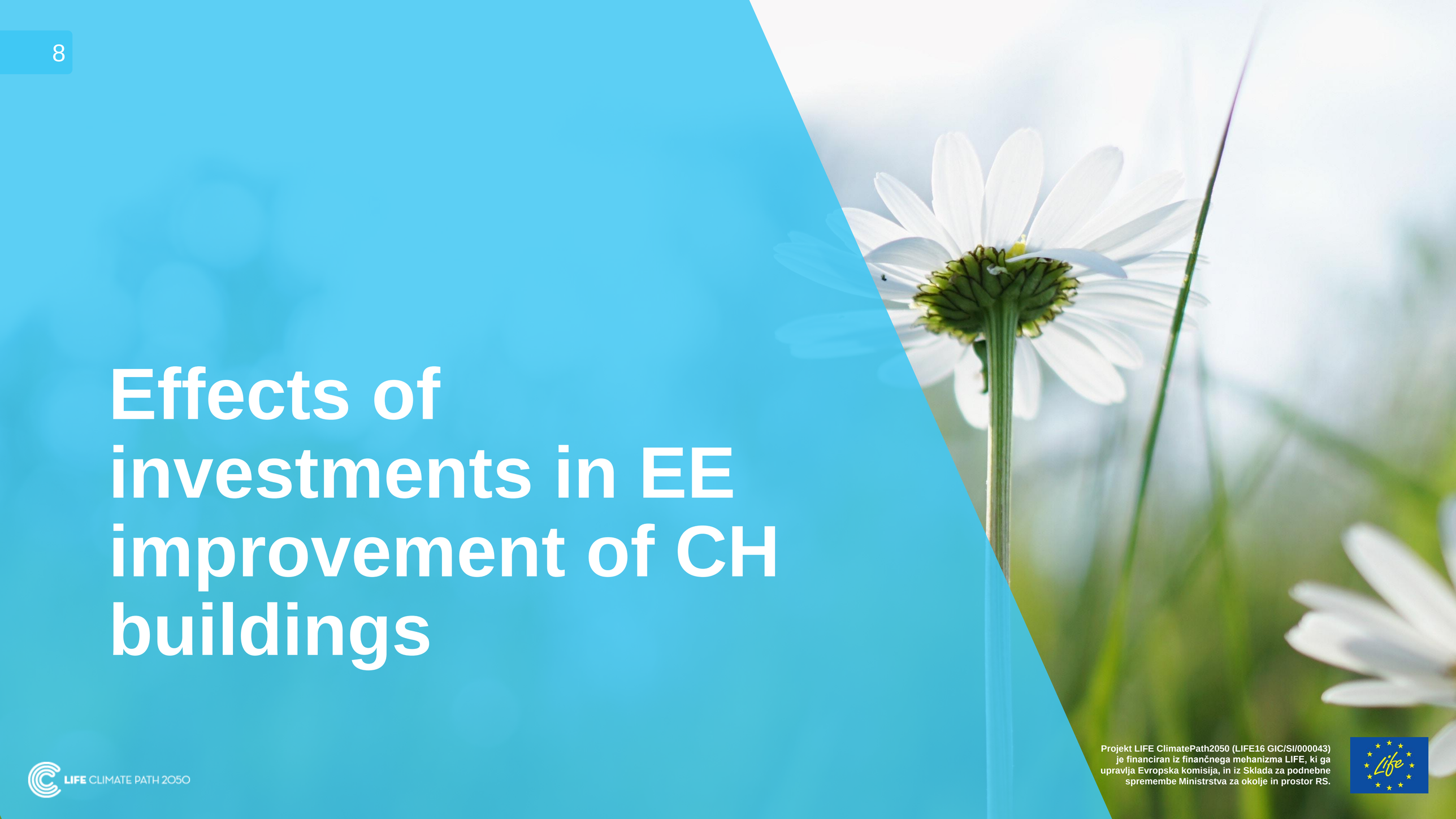
Effects of investments in EE improvement of CH buildings



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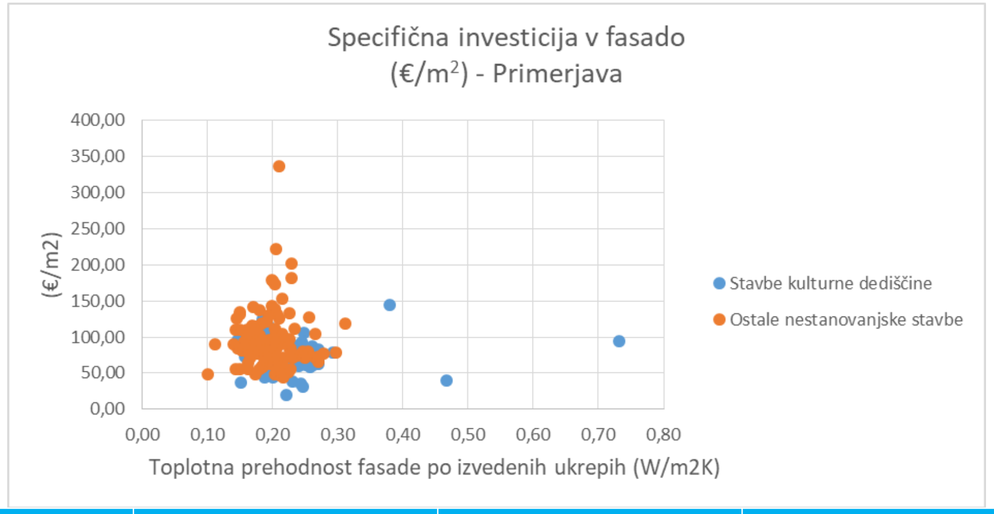
Building energy renovation – facade

- Cultural heritage buildings achieve on average higher (poorer) thermal transmittance of external walls than other buildings.
- The price of energy renovation of facades in cultural heritage buildings is lower than the price in other buildings (lower final thermal transmittance of external walls, less complex facade systems).



Stavbe	NUMBER OF ANALSED BUILDINGS(n)	SPECIFIC INVESTMENT (€/m²)	ACHIEVED U – value AFTER RENOVATION (W/m²K)
CULTURAL HERITAGE BUILDINGS	46	71,37	0,25
OTHER BUILDINGS	123	93,86	0,20

Data processing: Luka Zupančič, GI ZRMK

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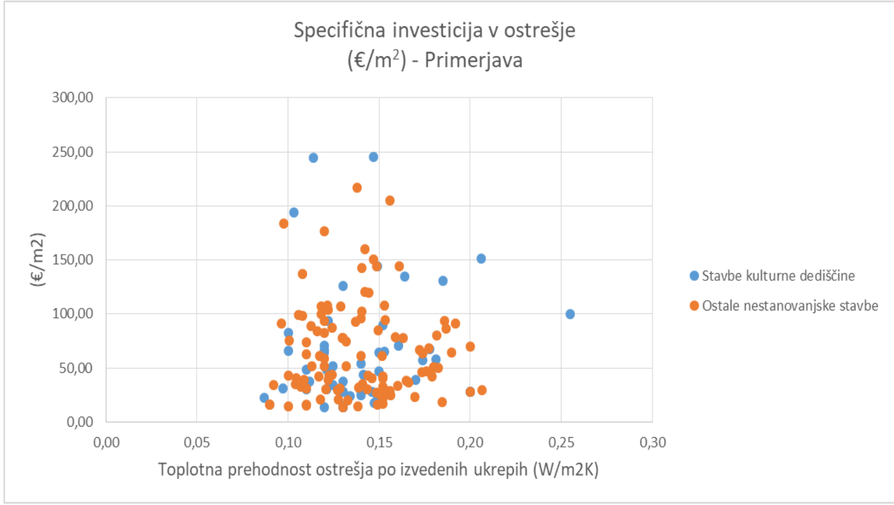
Building energy renovation – roof

- The comparison of cultural heritage buildings and other buildings did not show a significant discrepancy both in the prices of the investment and in the achieved thermal transmittance of the renovated roof.



Stavbe	NUMBER OF ANALSED BUILDINGS(n)	SPECIFIC INVESTMENT (€/m²)	ACHIEVED U – value AFTER RENOVATION (W/m²K)
CULTURAL HERITAGE BUILDINGS	51	64,33	0,14
OTHER BUILDINGS	108	66,14	0,14

Data processing: Luka Zupančič, GI ZRMK

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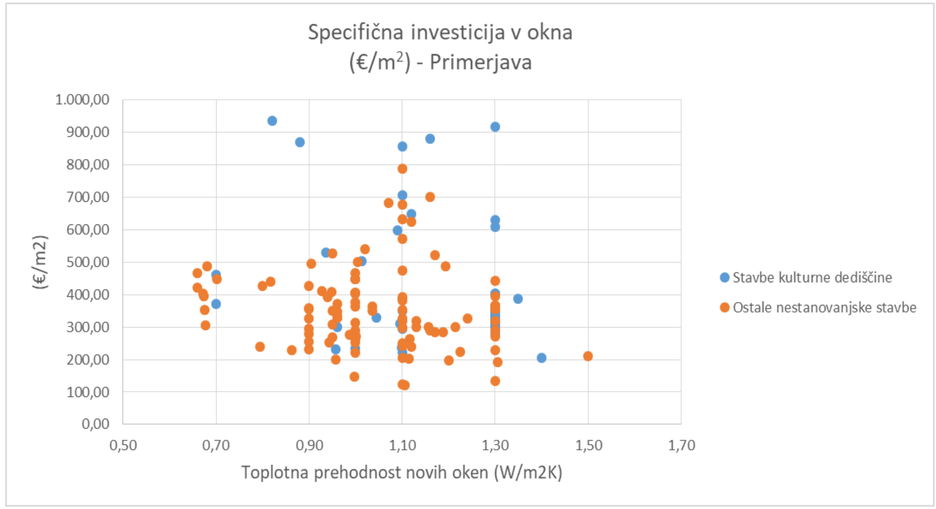
Building energy renovation – windows

- The analysis of the investment in windows showed a significant difference in price.
- New windows installed in cultural heritage buildings are generally more expensive, but also have slightly poorer thermal characteristics compared to windows in other buildings.



Stavbe	NUMBER OF ANALSED BUILDINGS(n)	SPECIFIC INVESTMENT (€/m²)	ACHIEVED U – value AFTER RENOVATION (W/m²K)
CULTURAL HERITAGE BUILDINGS	54	412,01	1,19
OTHER BUILDINGS	108	349,98	1,04

Data processing: Luka Zupančič, GI ZRMK

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Final energy use after renovation (as planned)

	Total heated floor area of renovated buildings (m^2)	Sum of the final energy use after energy renovation (kWh/a)	Specific energy use after energy renovation (kWh/m^2a)
CULTURAL HERITAGE BUILDINGS	127.249,70	15.317.098,83	120,37
OTHER BUILDINGS	245.963,40	27.309.127,84	111,03

Data processing: Luka Zupančič, GI ZRMK

- 8 %

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Final energy savings and use of renewable energy sources (as planned)

	Total heated floor area of renovated buildings (m^2)	Sum of the final energy use (kWh/a)	Specific energy use (kWh/m^2a)	Total use of renewable energy sources (kWh/a)	Specific use of renewable energy sources (kWh/m^2a)
CULTURAL HERITAGE BUILDINGS	127.249,70	6.767.654,99	53,18	2.519.442,70	19,80
OTHER BUILDINGS	245.963,40	18.064.569,93	73,44	6.995.179,43	28,44

Data processing: Luka Zupančič, GI ZRMK

+ 28 %

+ 30 %

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Seismic strenghtening of CH buildings

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Seismic strenghtening for CH buildings

Similar methods of strengthening as for ordinary buildings, but due to earthquake resistance problematic geometry, unknowns and limitations on measures invasiveness and appearance **more complicated and expensive** (some standard methods cannot be applied)

1. Connection of load bearing elements
    1. horizontal steel ties or perfo ties (inside wall)
    2. anchoring roofing
    3. exchange/stiffen wooden floors with RC/planking
2. Strengthening load bearing structure
    1. cement grout injections of stone masonry
    2. refill of cracks or rebuilding in brick masonry
    3. RC coating of brick masonry walls
3. Reinforcement of foundations
4. Remove or anchor ‘loose’ elements (ornaments, chimneys)
5. Other restoration works (frescos, altars, stone ornaments…)

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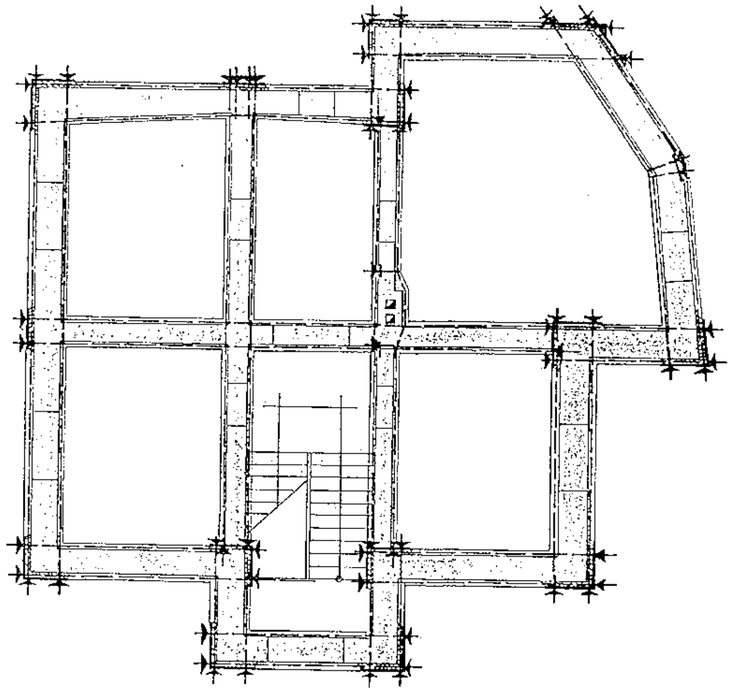
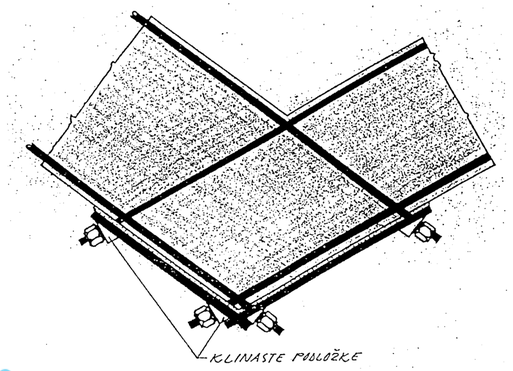
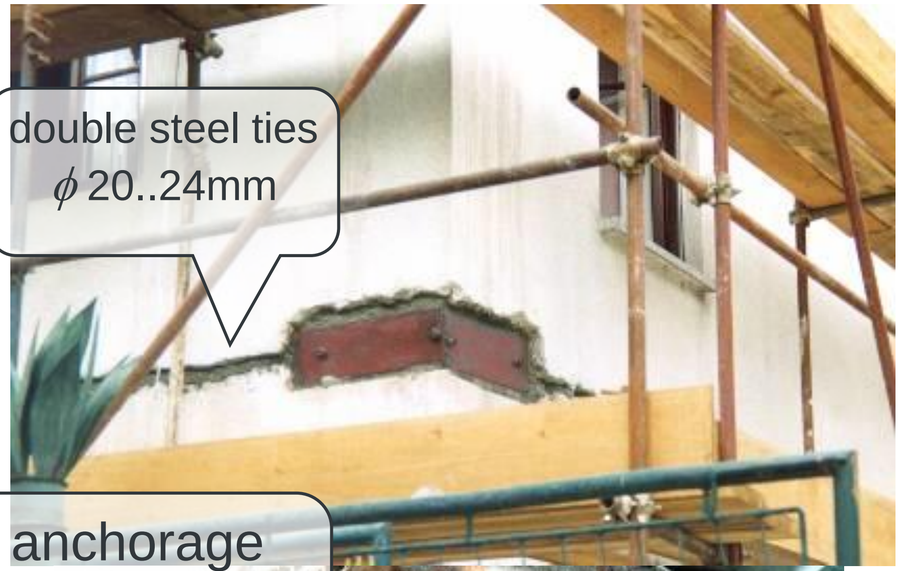
Connection load-bearing walls with steel ties







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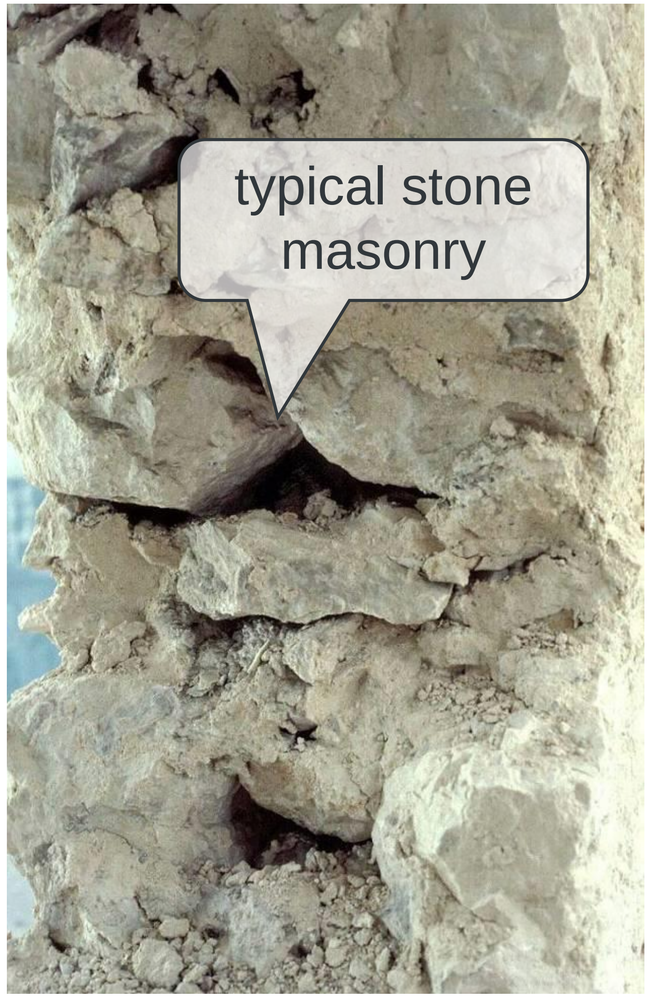
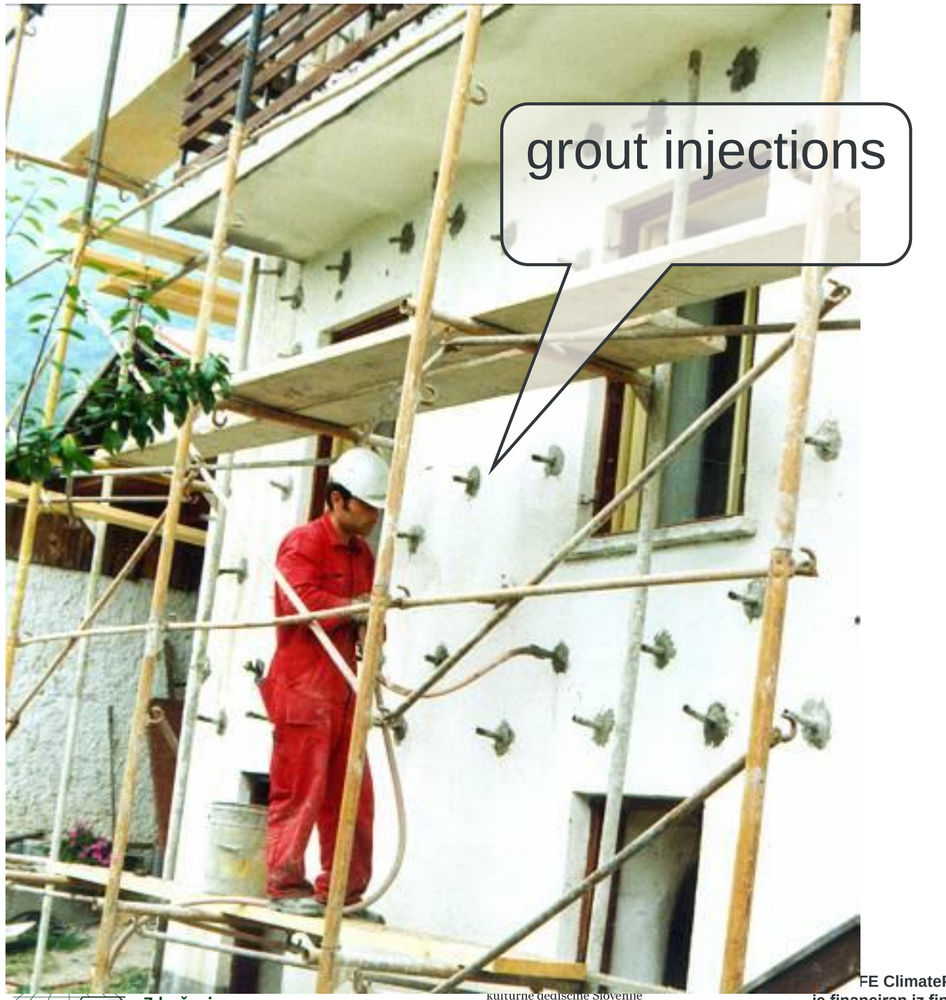
Strengthening stone masonry walls with grout injections





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Conclusions (1)

- There is growing concern that global warming will significantly change the buildings' performance pattern in the future.
- Countries have already committed to reduction of greenhouse gas emissions, increasing the share of renewable energy, and improving energy efficiency.
- Cultural heritage buildings represent an important part of the building stock, especially in historic cities, and improving their energy efficiency can mean significant savings in the overall energy consumption.

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Conclusions (2)

- Measures for the energy renovation of cultural heritage buildings are not evaluated primarily by the achieved energy indicators, but by the extent of their impact on the protected elements and on the building as a whole.
- In principle, priority is always given to those measures which represent the least possible interference with the substance and appearance of a cultural heritage building.
- The energy renovation of a cultural heritage building must therefore seek an appropriate balance between the preservation of protected values and energy efficiency.

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Thank you!

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