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Potential Results of Using Current Thermal Rehabilitation Techniques on a City Block of Timisoara and their Structural Strengthening Opportunities

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Abstract. City blocks developed in settlements part of the Austro-Hungarian Empire and in Timisoara in particular, are still standing today and pose common rehabilitation problems related to energy efficiency and structural reinforcement. Moreover, many of the buildings are classified as monuments and are not compatible with current energy rehabilitation techniques. The paper explores possibilities of using techniques that would allow structural and thermal rehabilitation adapted to particularities of buildings external surfaces built during the 1800s. These techniques are in use today but have to be used and combined in a fashion that doesn't alter the characteristics of monuments and get maximum results. Using only one set of procedures would lead to losses in efficiency or would be damaging to the heritage aspect of the buildings. The analysis is done on a city block within the old walls of the fortress of Timisoara and ponders energy efficiency gains and structural reinforcement potential that could be derived from the intervention on buildings envelopes. The block is situated between the streets Janos Bolyai, Lucian Blaga, Carol Telbisz and the Ion C. Bratianu boulevard. It includes a church, two education buildings, a hotel as well as residential ones. Potential analysed interventions would be limited to surfaces situated on the thermal skins of the buildings (facades, windows, horizontal surfaces towards attic and underground cellar storage spaces). They would take advantage of the characteristics and levels of decoration used during the 1800s and 1900s to minimize the heat transfer while preserving the external look of the buildings towards streets and internal courtyards. Conclusions would be compared with results from a basic intervention with minimal or no energy efficiency goals.

1. Introduction

Due to the changing environment and energy-efficiency regulation, exiting buildings have to be thermally renovated. While this action may not be a problem for buildings with no aesthetical or ornamental feature, the thermal rehabilitation of historic building, with highly decorated facades that are part of heritage urban areas, represent a more complex problem and are not compatible with current energy rehabilitation techniques.

Starting from this problem, the study is aiming to evaluate thermal insulation techniques suitable for the thermal rehabilitation of historic buildings built at the end of the 19th century. The analysis was done on a block from within the old fortress of Timisoara and ponders energy efficiency gains that could be derived from the intervention on buildings envelopes.



Evaluated solutions take advantage of the characteristics and levels of decoration used during the 1800s and 1900s to minimize the heat transfer while preserving the external look of the buildings towards streets and internal courtyards.

2. Historic context

Timisoara is a city located in the western part of Romania. In the 18th century, the former Ottoman fortress was conquered by the Austrian Empire and a new Vauban style fortress was built. The new fortress was organised after a rectangular grid of streets. In time buildings were placed on the exterior part of the rectangular blocks, generating continuous exterior facades and complex interior courtyards [1].

While blocks placed in the central part of the fortress suffered minor changes over time, the situation for those placed closer to the city walls was completely different. After the fortress walls were demolished at the beginning of the 20th century, in order to ensure the connection between the old city and the suburbs developed nearby, the importance of these blocks changed completely. From blocks placed on the outer part of the city, they became highly visible and could ensure the connection between old and new. This new function brought significant changes for the buildings of these blocks, which had to be adapted (figure 1).



Figure 1. The analysed block

One of these city blocks was evaluated during the thermal rehabilitation and energy efficiency study. The block is placed on the southern side of the old city, having a significant urban value due to its position close to one of the main squares of the city and the historic medieval castle.

In the 18th century, the first building was built in the northern part block, the St. Kathrine church. Subsequently, 2 other buildings were developed in a close connection to the church, a boy's school and Sisters of Notre Dame School. The block continued to grow, buildings filling in time all its sides. Ultimately, at the end of the 19th century, the most significant changes occurred: the church was rebuilt, the schools were torn down and new buildings were developed in their place (figure 2, figure 3).

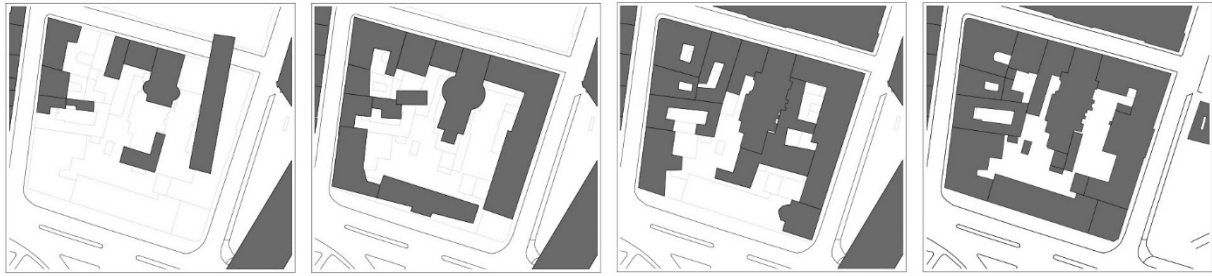


Figure 2. Urban evolution of the block [2]

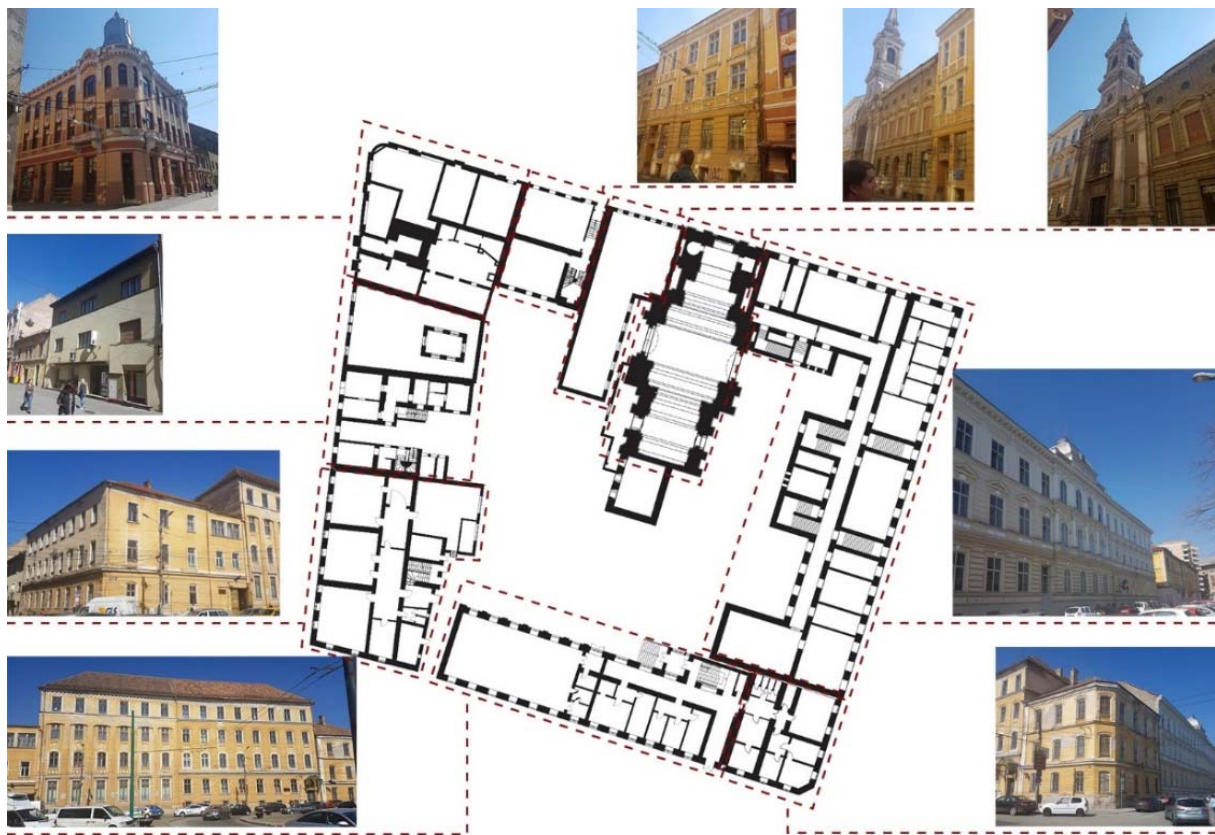


Figure 3. The analysed block – ground floor plan and buildings

On the north-western corner of the block, an inn was built in the 18th century. The inn was demolished during the refurbishing of the block, a new, 1900 Secession style, building was built instead. Today this building is a hotel. On its both sides residential constructions can be found, with two upper stories for the buildings from the northern side of the block and one single story for the two residential building from the west. A high school can be found on the southern side of the block, composed from 3 buildings. The two corner buildings didn't suffer major changes at the beginning of the 20th century. The middle building on the other hand was transformed in a 4 storey eclectic building, since it is the most visible building of the block. The whole eastern side of the block is occupied by one eclectic building, today the Faculty of Chemistry.

3. Energy efficiency analysis

In order to analyse the energy efficiency of the buildings of the block and the possible thermal rehabilitation solutions, EcoDesigner for Archicad [3] was used. The software allows the evaluation of the energy efficiency evaluation based on the architectural model, made after the geometric survey of the buildings. It is based on VIP-Core Dynamic Simulation Engine (Energy Evaluation) by Structural Design Software in Europe AB and validated with through following tests: EN-15265, IEA-BESTEST, ASHRAE-BESTEST (ANSI/ASHRAE Standard 140-2001), StruSoft-BESTEST.

EcoDesigner offers results based on room zones, defined by walls and slabs with a composite structure, but also based on environmental related feature (climatic data, shading, wind direction and used systems). The software provides therefore a way to evaluate the energy performance of a building based on its design features and context (table 1).

Table 1. Geometric characteristics of the block

External Envelope Area:	12241.97 m ²
Ventilated Volume:	50476.72 m ³
Glazing Ratio:	8 %

4. Insulation materials

Since almost all the buildings of the block are historic buildings with highly decorated facades and aesthetical features that should be kept intact, the choice of proper insulation materials is more difficult to make. Therefore, two different solutions were tested, and the energy efficiency was tested for each of them.

Taking the value of the historic facades into consideration for the outer walls the use of insulating plaster, developed by Kerakoll was considered [4]. According to the data sheet of the insulating plaster [4], it contains only natural materials and has a low thermal conductivity (0,075 W/mK). Due to its high porosity it also ensures a proper ventilation of the historic walls (table 2).

Table 2. Physical properties of the used materials

	Density (ρ) kg/m ³	Thermal conductivity (λ) W/(mK)	Heat capacity J/(kgK)
Historic brick	1800	0.81	870
Insulating plaster	370	0.075	1080

Following scenarios were taken therefore into consideration:

- Existing buildings with no thermal rehabilitation, usage and heating scenarios according to reality
- Buildings with insulating plaster, usage and heating scenarios unchanged
 - facades insulated on both sides with insulating plaster, 2.5cm on the inside, 4cm on the outside walls between buildings insulated only on internal side, church wall insulated only on the outside because of the decoration
 - 20cm mineral wool on the floor towards attic space
 - 10cm mineral wool boards on the floor towards the cellar
 - rehabilitated windows with double glazing, low-e glass on the inside, 4 Seasons external glass, argon in the cavity, existing frames with new sealing, $U_{\text{glass}} = 1.3 \text{ W/m}^2 \cdot \text{K}$, U frame unchanged
- Buildings with insulating plaster towards the street (4cm), 10cm mineral wool based ETICS towards the courtyard, where the facades were traditionally not decorated, heating and usage scenario unchanged
 - facades insulated with insulating plaster 2.5cm on the inside, 4cm on the outside towards the street, 10cm mineral wool based ETICS towards the courtyard, except for

the church wall which kept the insulating plaster solution on the walls between buildings insulated only on internal side, church wall insulated only on the outside because of the decoration

- 20cm mineral wool on the floor towards attic space, including over the church vaults
- 10cm mineral wool boards on the floor towards the cellar
- rehabilitated windows with double glazing, low-e glass on the inside, 4Seasons external glass, argon in the cavity, existing frames with new sealing, $U_{\text{glass}} = 1.3 \text{ W/m}^2\text{K}$

5. Results and discussions

The differences between the three scenarios are extremely visible (table 3). The insulation applied for the second scenario would reduce by half (48.4% reduction) the heat transfer coefficients for the shell (figure 4) and the heating energy needs (figure 5, figure 6) and cost (figure 7) for the whole block, which would quickly absorb the investment costs. Retrofitting existing wooden windows with modern panes of glass and using new seals to make them air-tight would also contribute to internal comfort reducing street noise. The need to preserve the external look of the windows, eliminates the possibility of triple-glazing, but the gains are significant even with double glazing. Combining usage of the insulating plaster with reinforcement meshes would allow at the same time to structurally strengthen the walls and vaulted elements, especially against out of plane deformation while conserving the general look and not covering readymade original decoration elements.

Table 3. Result analysis

	Building Shell Average W/m ² K	Net Heating Energy kWh/m ² a	Primary Energy kWh/m ² a	Fuel Cost RON/m ² a
Scenario 1 - existing	1.19	140.73	272.39	81.75
Scenario 2	0.75	72.62	204.28	59.95
Scenario 3	0.67	62.38	194.04	56.68

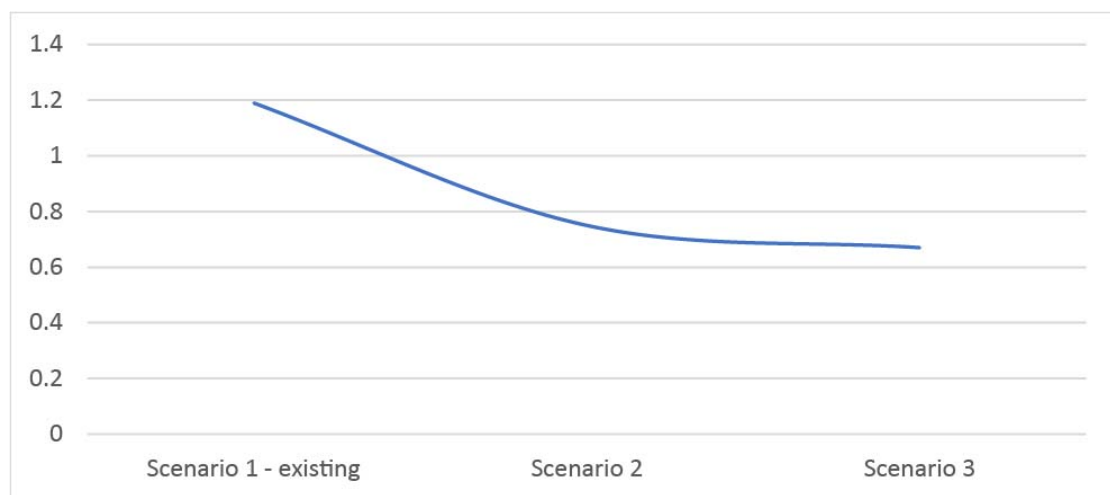


Figure 4. Building shell average for all 3 scenarios

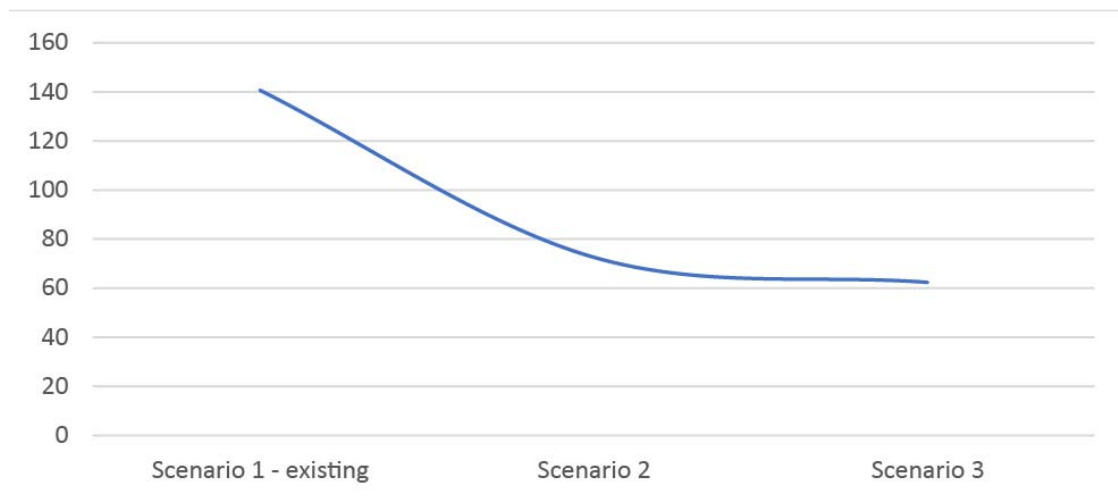


Figure 5. Net Heating Energy for all 3 scenarios

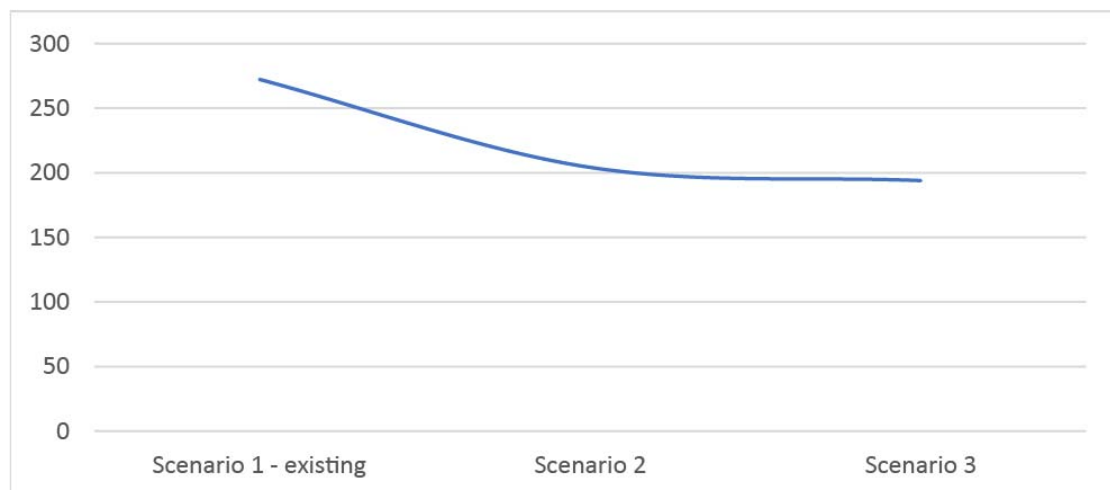


Figure 6. Primary Energy for all 3 scenarios

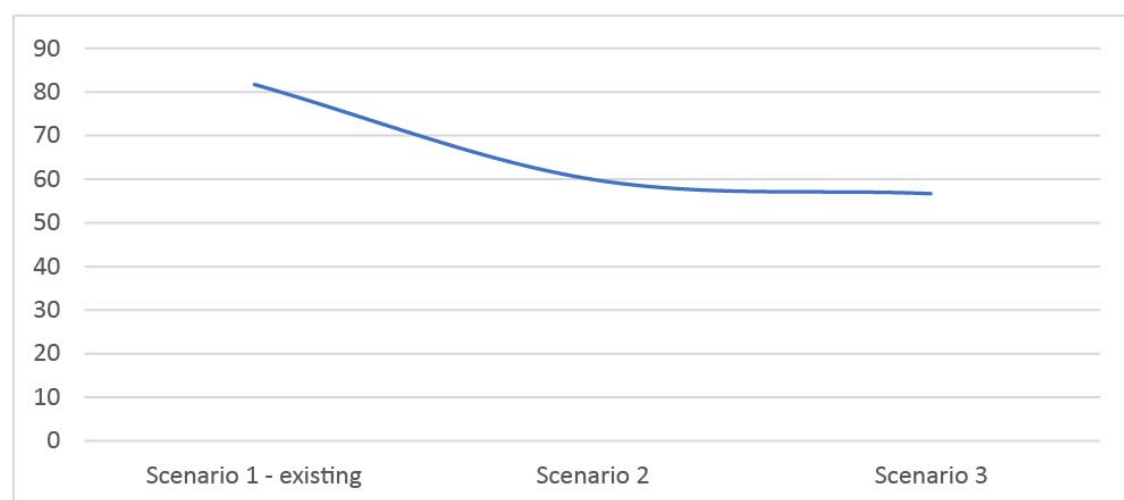


Figure 7. Fuel cost for all 3 scenarios

The gains brought by taking advantage of the decoration strategy from the building period, when internal courtyard facades were not receiving the same attention as the ones towards the street are more subtle. The ETICS that could be applied towards the courtyards would not significantly alter the facade geometry, as there are no decoration elements that could get covered, and smart detailing around windows could avoid compromising their size and proportions. The energy gain is around 14%, and the cost difference brought by it, would prompt for another amortization strategy would need to be thought on the long term, and be driven by environmental reasons rather than economic ones.

6. Conclusions

The conclusion would be that a rehabilitation intervention on historic buildings at city block scale would be beneficial with existing means, would not significantly alter the external appearance and decoration, but the means used should be assessed and adapted for each surface balancing the gains and their effects. The lack of decoration towards the inner facades of the city block could be exploited for gaining more insulation without compromising facade elements. The use of these systems on facades towards the streets would destroy original decoration elements, and thus cannot be allowed.

The other conclusion, regards the tools that can be used during the design process. The architectural BIM platforms in use today have incorporated energy assessment tools that have reached a degree of maturity which allows for quick iterations in energy evaluation during the designed phase once a 3d model has been produced. Different solutions can be assessed in a matter of hours. Of course, these results need to be double-checked by dedicated personnel and software, but the feedback of changing design elements is real and can contribute to better solutions. These tools should not be left standing, as they largely are in our country, but should be used to support decisions by architects. Teaching curricula should incorporate them.

References

- [1] M. Opris, "Timisoara: small urban monography," Editura Tehnica, Bucurest, 1987 (in Romanian).
- [2] M. Mosoarca, A. Keller, "A complex assessment methodology and procedure for historic roof structures," *Int J Archit Herit.*, vol. 12(4), pp. 578-598, 2018, <https://www.tandfonline.com/doi/abs/10.1080/15583058.2018.1442519>.
- [3] GRAPHISOFT, "ARCHICAD 20 Help", 2016.
- [4] KERAKOLL, "Biocalce® Termointonaco product data sheet," 2015 (in Romanian).