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Assessment of today's condition of Modernist architecture in Skopje in terms of energy efficiency and authentic architectural appearance using actor network theory

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Abstract. The identity of the city of Skopje was completely lost after the earthquake in 1963. The buildings from the post – earthquake period were built in Modernist architectural style and they play a major role in creating the new identity of the city. On the other hand, in terms of energy efficiency, these buildings have very poor thermal properties. In order to improve the energy efficiency, retrofit interventions have been constantly implemented and their authentic appearance has been significantly compromised. Many buildings have already been changed to an unrecognizable state, which degrades the architectural identity of Skopje. In order to explore the connection and implication between the reconstruction of the city and the current condition of the buildings in terms of materials, thermal properties, authenticity, degradation and retrofit measures, the methodology of actor network theory (ANT) has been used. The results showed that certain type of buildings are the most vulnerable ones in terms of their energy efficiency issues, sustainability, authentic appearance and in process of significant degradation.

1. Introduction

Skopje's earthquake in 1963 changed the image of the city forever. The earthquake caused more than 1000 human losses, irreversible degradation of the cultural heritage and 80% destruction of the building stock [1]. The buildings of the post-earthquake period, were built in the time when the international modernist architectural style was very popular. This style became a main characteristic of Skopje's architecture. Although this architecture dates from the "recent" past and often its historical values are not recognized, it undoubtedly represents an important cultural heritage [2]. Modernist architecture introduces a new ideology not only in the cultural and architectural sense, but also in the structural sense, especially in the use of new types of construction and building materials. In that time, the buildings were built in lack of energy efficiency standards, without thermal insulation materials.[5] Knowing than modernist buildings represent over 60% of building stock [3], Skopje is facing serious issues in terms of energy efficiency, sustainability, energy consumption and emissions [4].

This paper aims to look at and analyze the current situation of post-earthquake modernist buildings in terms of their structural systems, building materials, energy efficiency, sustainability, authentic appearance and degradation. In order to analyze all this aspects in relation to one another, the research will employ the actor-network theory (ANT). The goal of the research is to map out the relevant actors and the network that was formed during the reconstruction process and identify the buildings connected to it. By using the ANT methodology, this paper detects and defines the most common types of

buildings, which are in same time the most problematic ones especially in terms of energy efficiency, degradation and compromised authenticity.

Actor-network theory (ANT) is a theoretical and methodological approach to social theory where everything in the social and natural worlds exists in constantly shifting networks of relationships. Although ANT contains 'theory' in its name, it can be defined as a research method that focuses on the connections between entities that have agency, both human and non-human, and the networks they form. In ANT the connections between actors can lead to the creation of new entities that are not simply the sum of characteristics of the constituent entities. An example of such fusion of entities into another entity is a gunman, an actor-network formed from two separate entities, a man and a gun, which are connected in a third entity: the gunman [6]. A gunman is different from both a man and a gun in the sense that a gunman is able to shoot someone whereas both the man and the gun cannot do this separately. It is important to underline that the term actor is, everything that in some way affects the network, not only human beings, but also, for instance, technology, methodologies, techniques, social rules and institutions, knowledge, and last but not least, external objects. In the example, the actor gun is part of the actor-network gunman.

An actor-network can be defined as a heterogeneous network of actors with aligned interests [7]. In a sense, actor-network is similar to actor, and whether or not an entity will be observed as a singular actor or an actor-network depends on the desired detail and complexity of the network. Actor-networks are thus constructed and reconstructed through interaction between actors. As long as the actors keep interacting the actor-network will look stable from the outside and can be treated as a monolith actor. Punctualisation is the term used to describe treating a heterogeneous network as an individual actor in order to reduce network complexity [8]. In ANT, the formation and stabilization of networks are the results of translations [9]. Translation is the process of alignment of the interests of a diverse set of actors with the interests of the focal actor around which the network is formed [9][10]. Problematisation is the first moment of translation, during which a focal actor defines the identities and interests of other actors that are consistent with its own interests [9]. Further transformations of the network over time are a result of different types of translations.

ANT proved as a suitable method for this research for a number of reasons. First of all, unlike other social network analysis methods, it allows for the inclusion of non-human actors in the network and gives them agency. This was especially important because one of the central actors of this research is the earthquake, a non-human actor. The second important reason is the focus ANT has on the connections between the actors. It does not just establish that there is a connection but looks at what type of connection it is, and how it changes the actors. Further, the network in Skopje is fairly complex; so the interchangeability of the terms actor and actor-network was important because, through punctualisation, it allowed us to examine the network on a suitable level of complexity while maintaining the big picture. Lastly, the different types of translations [11] gave us a method to examine the changes of the network as the reconstruction of Skopje progressed and resulted in today's energy efficiency and city authencity issues.

The data analyzed by ANT has been conducted through the following methodological procedures:

- Collecting and documenting data, which includes: Insight of the project's documentation; "In situ" visits and photo documentation; Use of graphic sources and literature; Interviews with architects - authors of buildings.
- Analysing the collected data, which includes: identifying the structural, architectural, thermal and cultural properties of the buildings; adding additional actors related to these aspects and grouping the buildings according to their relation to them. The new relations are established according to the structural system, building materials, degradation degree, and energy efficiency and reconstruction measures.
- And finally analysing the network to identify the energy efficiency problems and their effect on the buildings

2. Establishing the actor-network

Since ANT is primarily concerned with relations, we will look at the case of Skopje by analysing the translations that helped form and transform the network's connections. The complete network can be divided into two main sections (Figure 1). The first section is formed by analyzing the reconstruction of the city in the aftermath of the earthquake, and by following the translations of this network through time. The second section is formed around a group of actors that establish themselves as obligatory passage points during the transformations of the first section.

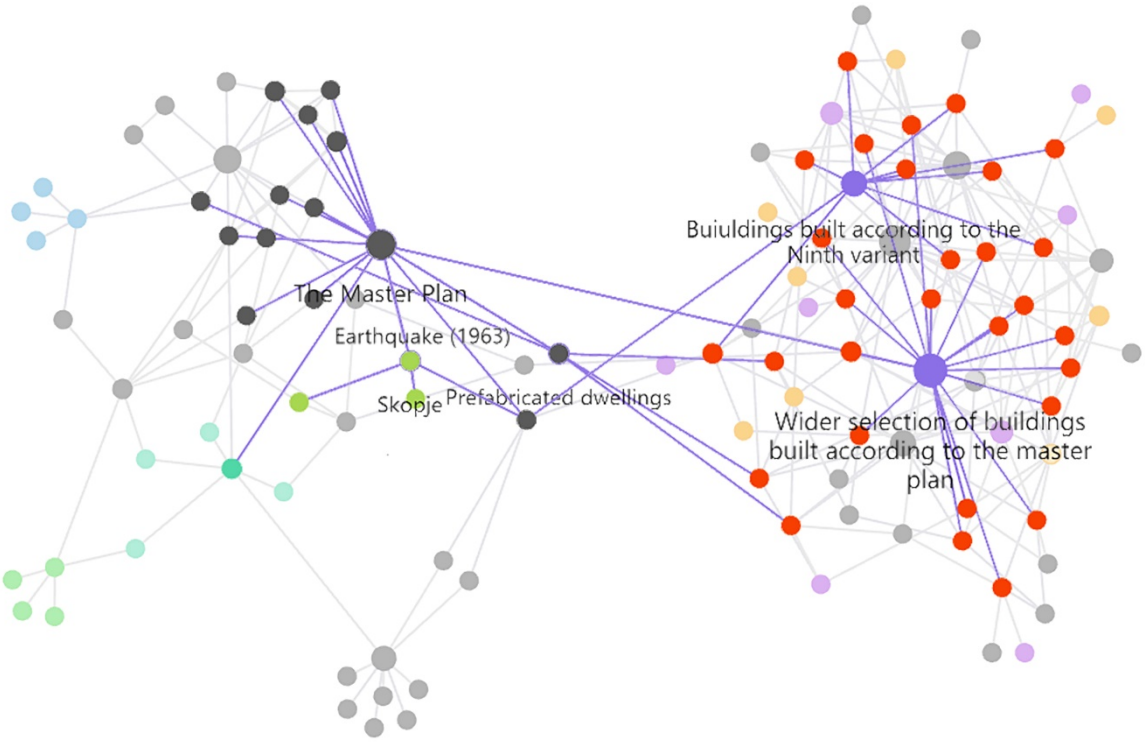

Figure 1. Diagram of the complete actor network; red nodes represent the constructed buildings form the Master plan

Four distinct translations of the first section of the network can be identified. The first translation or the problematisation follows the formation of the network immediately after the disaster and the international outpour of aid. The second translation, or the detour, maps out the long term reconstruction of the city and the making of the new Master plan for the city. The city administration saw its shortcomings in its ability to pursue the reconstruction of Skopje only with material and monetary aid and reached out to the UN for help. In terms of ANT, this means the main road of pursuing the interest was cut off. This created conditions for a type of translation that can be called a *detour* to take place [11]. A detour happens when an actor-network is no longer capable of pursuing its interest independently on the trajectory it was headed on. In order to achieve its goal the network now engages with new actors that can provide an alternate route to the original goal. The new actors involved in Skopje were a large group of international experts that were involved in the making of the Master plan of the city and the plan for the city center, also known as the Ninth variant.

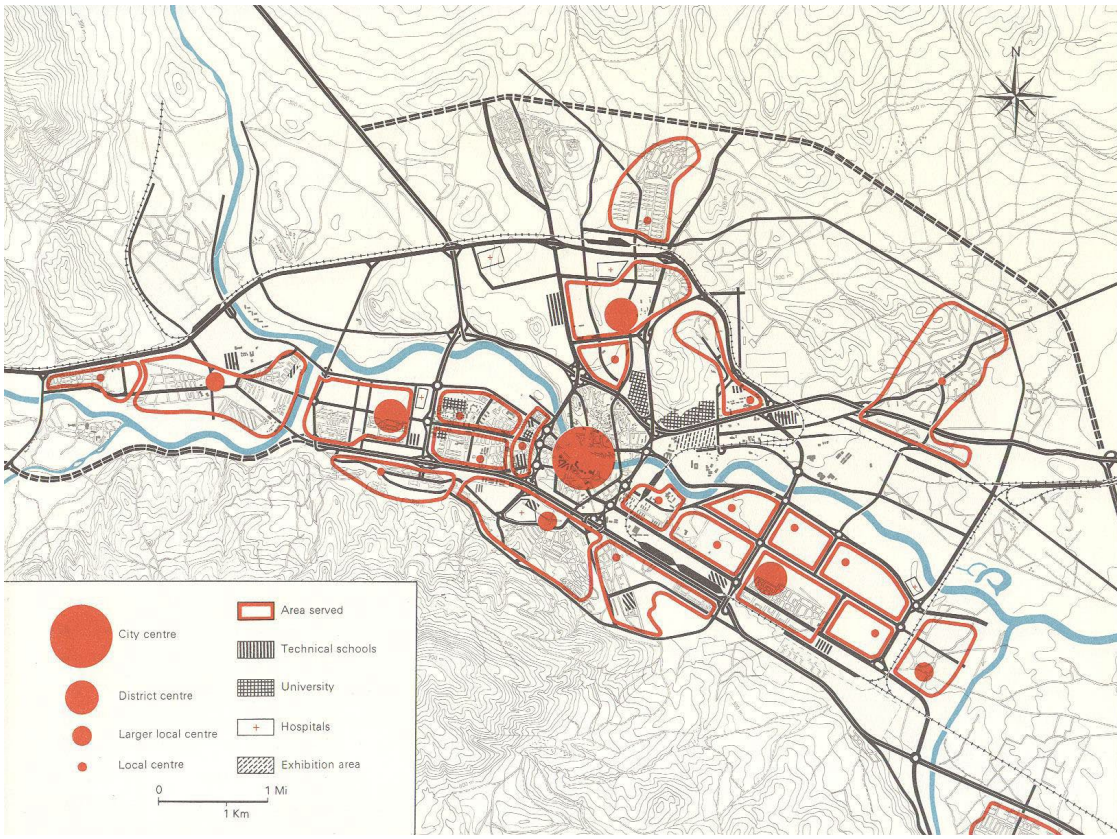

Figure 2. Master plan for Skopje (1965)

The third translation follows the implementation for the master plan and its establishment as an obligatory passage point (OPP). In the geometric sense of translation an OPP is an actor with a unique position in the network, other actors have to pass thorough their position and help them further their interests. During this translation, the network remains largely functional and its primary interest is intact. The network surrounding the master plan as an OPP starts to recruit new actors to further the interest of the actor-network, the reconstruction of the city through the implementation of the plan. The fourth translation of the network represents the disintegration of the original network connected to the renewal of the city. During the fourth translation, the original actor-network rapidly loses the interest of the actors, the Master plan is replaced with new plans and is soon reduced to a few isolated actors. The buildings that can be tied back to the Master plan together with the reconstructed buildings and prefabricated dwellings become OPPs in their own right because they became fixed points and the city developed in accordance with them. These actors are a product of the earthquake network, but they cannot be viewed as a network because no connections remain, the actors are now parts of the new actor-network and develop new interests different from the original, the reconstruction of the disaster-stricken Skopje.

However the buildings that were constructed as a result of the renewal share certain characteristics in terms of the materials and technology that was used to build them which showed potential for the problematisation of a new section of the network. In order to establish the second section a group of new actors is introduced and their connection to the OPPs from the first section is mapped. This lead to the creation of four sub networks whose relation to the OPPs was further explored. The first two help us introduce certain physical characteristics of the buildings and underline them as separate actors. One of these subnetworks adds the different structural systems of the buildings as actors and the second one does the same with the building materials used. The final two subnetworks introduce a series of actors whose relation to the OPPs help us define two main common characteristics of these buildings: their

lack of thermal insulation that results in large energy consumption and their value as modernist architectural heritage for the city. One of the network maps out the interventions that were made to remedy the energy efficiency problem (if any) and the other one explores the degree of authentic preservation of the buildings.

2.1. Selection and categorization of the buildings

The buildings that were identified as OPPs and used to establish the second section of the network are shown in Table 1. The five subnetworks that are used to further explore them are comprised of the following actors:

- Structural system subnetwork: Massive reinforced concrete structural system; Skeleton reinforced concrete structural system; Prefabricated reinforced concrete structural system; Combined (skeleton-massive) reinforced concrete systems; Steel skeleton structural system; Hanging construction (steel and concrete); Shell structural system; Prestressed concrete structural system.
- Building materials subnetwork: Masonry wall of ceramic blocks or bricks with façade finishing render; No-finish concrete walls, known as *"concrete brut*" [12] with specific “in situ” made façade design; Masonry or concrete walls with stone or ceramic facade elements, combined with large glass surfaces; Curtain wall panels with steel substructure or sandwich panels with insulation usually combined with structural glass; Combined concrete walls and façade brick masonry visible on facade without finishing layer; Combined no-finish concrete walls or masonry with stone, ceramic or other finishing layers; Masonry ceramic block walls with ceramic or aluminium panels on steel substructure with stone or glass wool insulation;
- Improvement of thermal characteristic subnetwork: Significant improvement of thermal characteristics (major interventions); Slight improvement in thermal properties (minor interventions); Very low thermal properties (original condition)
- Authentic appearance condition subnetwork: Unchanged authenticity; Partially impaired authenticity; Endangered authentic appearance; Imitation of authentic appearance; Complete changed authentic appearance (unrecognizable outlook); Important cultural monuments demolished.

Table 1. Selected buildings list [13]

	Name of building	Period	Function
1	Russian residential buildings "Karposh"	1963-1965	Housing
2	Historical Archive of the City of Skopje	1966-1968	Administration
3	Primary School Johannes Heinrich Pestalozzi	1967-1969	Education
4	National library,,St. Clement of Ohrid"	1967-1972	Culture
5	"City Wall" residential buildings	1967-1976	Housing
6	Government building	1968-1970	Administration
7	High School "Nikola Karev"	1968-1970	Education
8	Residential buildings "Block B1-B7"	1968	Housing
9	Museum of Contemporary Art	1969-1970	Culture
10	Military Hospital	1969-1971	Health
11	High School "Orce Nikolov"	1969-1971	Education
12	Medical School "Pance Karagjozov"	1969-1973	Education
13	Student dormitory "Goce Delchev"	1969-1977	Housing
14	City Shopping Center (GTC)	1969-1973	Trade

15	High School "Josip Broz Tito"	1970-1971	Education
16	Skopje Fair	1970-1972	Trade
17	University Campus "Ss.Cyril and Methodius"	1970-1974	Education
18	Museum of Macedonia	1971-1976	Culture
19	Transport Center	1971-1981	Transport
20	National Hydrometeorological Institute	1972-1975	Administration
21	National Bank of the R.Macedonia	1974	Administration
22	Telecommunication Center and Counter Hall	1979-1981	Administration
23	Macedonian National Theater (today MOB)	1972-1980	Culture
24	Church of St. Clement of Ohrid	1972	Religion
25	Macedonian Academy of Sciences and Arts	1973-1976	Administration
26	Radio Television Skopje (MRTV)	1974-1983	Administration
27	Institute of Earthquake & Seismology	1978-1980	Education
28	Residential Towers Karposh IV	1979-1981	Housing
29	Office building "Vardar Import - Export"	1978-1980	Business
30	Ministry of Education and Science of R. M.	1982	Administration

3. Analysis of the actor-network and results

In this section different portions of the network are analyzed by looking at the relationships established between the actors. Some sections of the networks are separated in order to give a clearer graphical representation of the discussed relations.

Figure 3 and 4 show the connection between the improvement of thermal characteristic subnetwork and the authentic appearance subnetwork in relation to the buildings (OPPs). Paring the buildings with the actors from the authentic appearance subnetwork defines new actors which are distinct from the original buildings, such as partially impaired buildings or authentic buildings. By analyzing the new actors it can be concluded that 40% of the buildings have partially impaired authenticity while, 46.7% have unchanged authenticity. The rest of the buildings represent isolated instances of either buildings with completely changed appearance or demolished buildings.

Figure 3 (a) shows the relations between the subnetwork of buildings and one specific actor form the authentic appearance subnetwork: partially impaired authenticity. The new actors that are derived form that relation are further layered with the improvement of thermal characteristic subnetwork. It can be seen that in 41.7% from the partially impaired buildings the changes did not result in improvement of thermal characteristics and huge percent of those buildings are dealing with extremely low thermal properties. Also, 41.7% have only slightly improved thermal characteristics. A significant improvement of the thermal characteristics is noted in only 16.6% of the analyzed buildings. Figure 3 (b) shows the network of buildings related to the actor unchanged authenticity and the connections to the improvement of thermal characteristic subnetwork. A slight improvement of the building's energy efficiency can be seen in only 14.3%, while 85.7% have no improvement in their thermal characteristics. However, since there are buildings that have been renovated but do not have energy efficiency improvements, it is often a case where, due to the preservation of authenticity, energy efficiency is neglected. These buildings

have a participation of 6%. From the analysis it can be concluded that 80% of the buildings have very low thermal properties, not corresponding to nowadays standards.

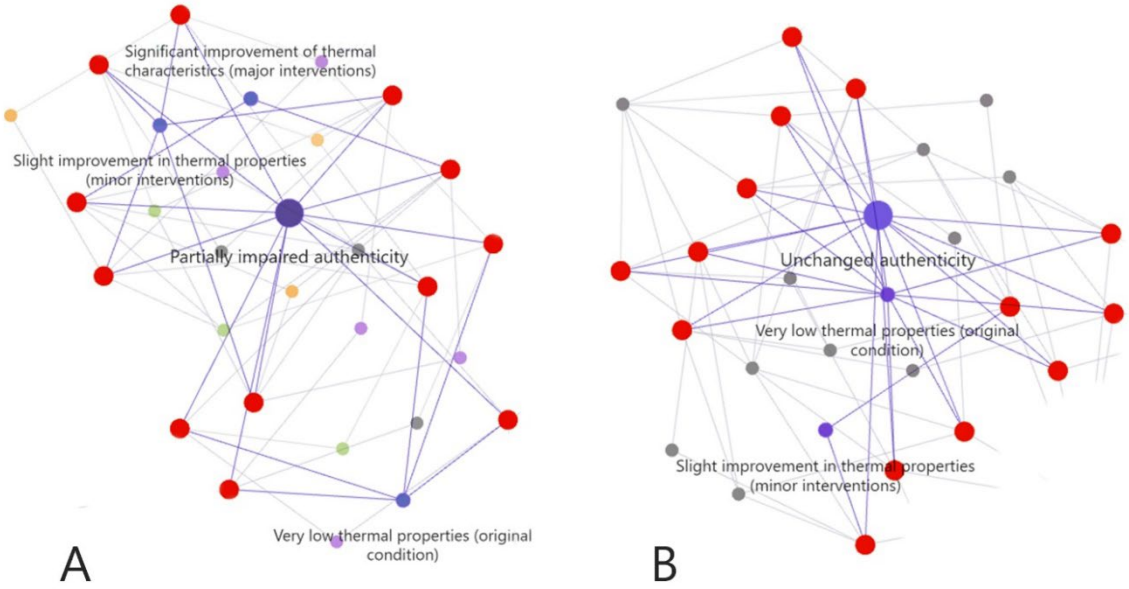

Figure 3. Sections of the network that represent the relations between the buildings and the subnetwork of authentic appearance condition: (a) Partially impaired buildings (b) Authentic buildings

In the Figure 4 (a), only buildings with significant improvement are analyzed, which represent 10% of all buildings, 66.7% of those buildings have partially impaired authenticity, and only 33.3% have completely changed authentic appearance to unrecognizable condition. Figure 4 (b) shows the slightly improvement of the thermal properties, which represents 23% of total selected buildings, 71.4% of the buildings with slight improvement, have partially impaired authenticity, while 28.6% have unchanged authentic appearance.

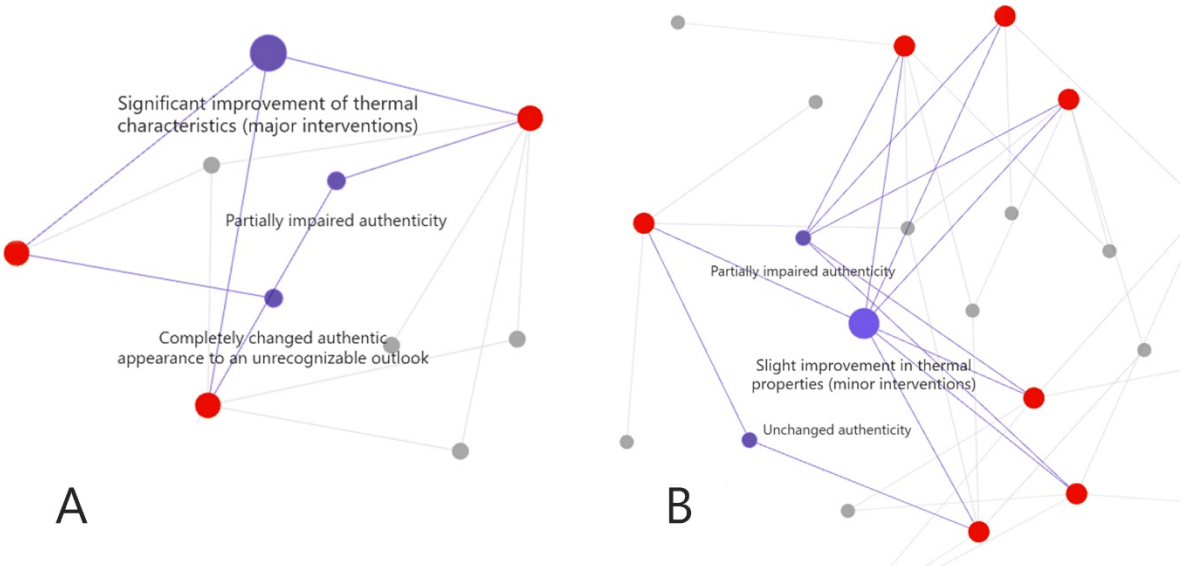

Figure 4. Sections of the network that represent the relations between the buildings and the sub network of improvement of thermal characteristic: (a) Buildings with significant improvement (b) Buildings with slight improvement in thermal characteristics

Figure 5 (a) singles out an actor whose large number of connections to the other actors warranted further analysis. The actor is part of the Building materials subnetwork and it represent a specific material used at the time to build exterior walls made of concrete with no other finish layers, known as "concrete brut". This material ties itself to brutalist architecture and is an important connection that establishes the value of the buildings as architectural heritage. It also has the largest participation of more than 30% compared to the other types of buildings materials. Figure 5 (b) shows the relation with the Improvement of thermal characteristic subnetwork, these buildings are the most vulnerable ones from many aspects, particularly their extremely low thermal properties and exposure of unprotected concrete to atmospheric influences, which leads to carbonization of the concrete and further degradation. Figure 5 (b) also shows the connection of the brutalist buildings with the energy efficiency measures. It can be seen that 70% of the brutalist buildings have no improvement in the thermal characteristic i.e. there are no energy efficiency interventions, and only 30 % have slight improvement in thermal properties (minor interventions). On the other hand, in Figure 5(c) we see the relation with the authentic appearance condition subnetwork and it can be seen that 30% of the buildings have changes in their authenticity i.e. have partially impaired authenticity. These are the same buildings that have slight improvement in their thermal properties, which means that their identity and protection as cultural heritage is compromised because of the necessity for energy efficiency and thermal comfort improvement.

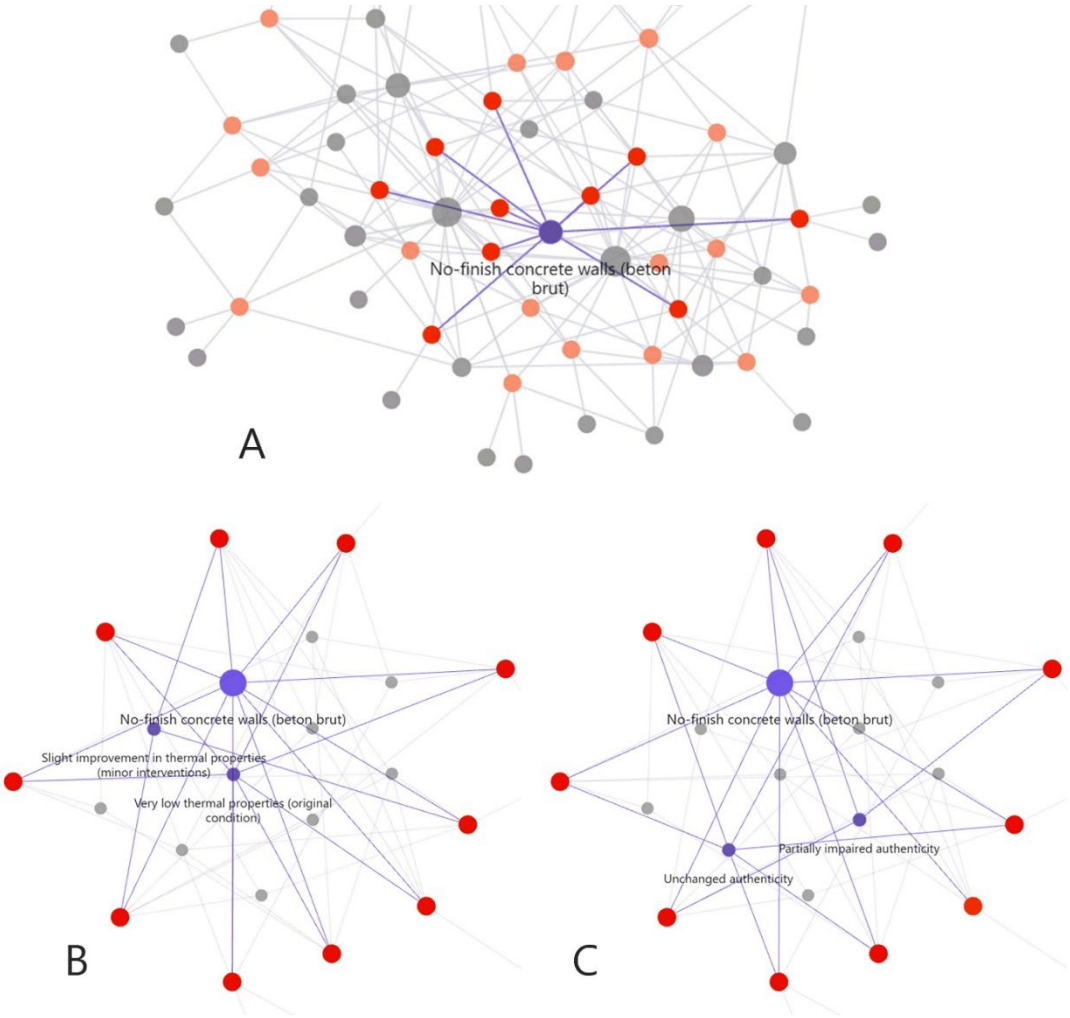

Figure 5. Sections of the network connected to the actor Concrete – Brut

4. Conclusion

The buildings built in the post-earthquake period in Skopje, generally known as buildings of the modern era of the city, undoubtedly represent a significant architectural and cultural heritage, both in terms of quantity and architectural quality, as well as diversity, building materials and building innovation techniques. ANT methodology was used, to detect and define the connection between the most fragile category of these buildings and their structural system features, building materials, function and the most important, the connection between the energy efficiency retrofit measures and authenticity degradation.

From the conducted analysis it can be concluded that the analyzed buildings are generally constructed as skeleton reinforced concrete structural systems. In terms of building materials, more than 30% of analyzed buildings envelope are entirely made of raw exposed concrete, without external finishing layer, known as "brutalist" buildings. They are the most vulnerable in terms of sustainability, environmental changes and energy efficiency. In order to improve their thermal properties and comfort and reduce the energy consumption, numerous of inappropriate renovation innervations have been made which significantly impair the originality of the buildings. That has been identified as key problem in this paper. Using the ANT methodology, brings us to conclusion that there is a direct connection between the thermal properties and the authentic appearance of the buildings. The energy efficiency innervations seriously degrade the authentic appearance, while the authentic appearance is still degraded when there are no energy efficiency interventions at all. This connections lead to the conclusion that there is no good established method for renovation of this type of buildings, where authenticity and the energy efficiency should be implemented together.

Although actor network theory is primarily a social network analysis method, it has shown to be an effective tool for analyzing different aspects and connections in the context of the build environment. This research shows the implementation of the methodology to effectively explore the connection between the different physical aspects of the buildings, such as building materials and thermal properties, while tying them through time to their historical beginning. The flexibility of the actor network methodology allows to map connections both in the physical world, in this case the constructed buildings, and connect them to more abstract social rules and institutions, or historical circumstances. This allows to find correlations between energy efficiency problems and a much wider selection of possible causes form different origins. The study presented in this paper shows only an example of how the actor-network surrounding the earthquake in Skopje, could be used and it illustrates the potential for further research on the topic with this methodology.

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