SUSTAINABILITY CHALLENGES OF RESIDENTIAL REINFORCED - CONCRETE PANEL BUILDINGS

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Abstract.
Quite similar large-panel prefabrication technologies were used for residential buildings in East-Europe and some countries in Northern-Europe, e.g. Finland. Even if technologically similar, the fate of the building stocks is different in the two regions, with buildings functioning sustainably in Finland. Hence, one could adapt the maintenance and renovation experiences to the building stock in other countries, creating opportunities for communities and business. The paper presents technological, economical, and institutional/policy aspects in the two environments, and discusses them in the larger framework of European sustainability targets. For major renovation, as targeted in the paper, methods of change management should be applied, entailing thoughtful planning and sensitive implementation and above all, consultation/involvement of the people affected. If the presented interventions would be used in a systematic and planned way, improvements can be achieved for social sustainability targets like e.g. adaptability and visual comfort, while maintaining the safety and security. Finally, the limitations of the approach in light of the institutional setting and ownership structure are discussed, highlighting how different ownership models are favoring or hindering major retrofit interventions. The paper offers ways on strengthening the role of key stakeholders to support major renovation interventions on the panel building stock.

Key words: social sustainability, major renovation, structural interventions, prefabricated concrete residential building stock

1. Introduction to the context

The paper summarizes some outcomes of the authors work on *Case studies on Sustainable Renovation in Eastern and Northern Europe* (RESPIRE), within a collaborative project *Integrated strategies and policy instruments for retrofitting buildings to reduce primary energy use and GHG emissions* financed by the EracoBuild Sustainable Renovation Program. The paper highlights some findings related to the broader perspective on renovation, without developing the details which can be found in individual papers and reports (Botici *et al.*, 2012; Nagy *et al.*, 2012; Ungureanu *et al*, 2013; Riihimäki *et al.*, 2012; Talja, 2011), but also in a collection of papers summarizing the work and findings of the project (Ungureanu and Fülöp, 2014). A short non-technical summary on the ideas developed in the project is also available in the magazine International Innovation (International Innovation, 2013).

The starting idea of RESPIRE was the similarity of prefabrication technologies used in East-Europe in the past (Niculescu, 1961; Demeter, 2006), and in Finland even today. Large-panel concrete buildings are an accepted form of construction in Finland, while most East European countries reduced the use of this building system after 1990's.

The performance of the buildings realized with the panel technology is strongly dependent on the maintenance, which in turn depends on the institutional/ economical setting.

Consequently, the intention of the paper is to report, besides the technology, on the institutional settings that function successfully and may be further adapted at a wider scale.

2. Drivers for sustainability

2.1. Owner expectation

Client expectations are strong drivers of the building market. Studies conducted on emerging markets show that consumers do not value environmental sustainability; but they are interested in size and amenities, so comfort and convenience (Bomee, 2007). These are aspects related to social sustainability, and can usually be improved only by major renovations with a cost over 25% of the buildings value (EP2010/31, 2010).

In order to understand the balance in expectation of a potential occupant/owner of large panel building apartment in Romania, an online survey was conducted. The number of responses (about 25 fully filled responses) cannot lead to general conclusions, especially because the typical responder is far from average citizen. Most responders are below 40 years highly educated urbanites, from the biggest 5 cities of Romania (but not Bucharest). However, the data collection is continuing online (VTT/RESPIRE, 2012), with a full response session in the range of about 30 minutes.

In the survey, a slightly modified version of VTT-ProP, also implemented in ECOPROP (VTT/ECOPROP, 2013) hierarchy was the basis of the multi-criteria decision making (MCDM) model. The survey focuses on distinguishing responder priorities on "Conformity", "Performance" and "Cost".

The three main focus areas were subdivided in: (1) vicinity, (2) location/access to services, (3) spatial system of the apartments, (4) internal comfort, (5) state of deterioration, (6) adaptability of the apartment's internal space, (7) safety to natural/man made hazards, (8) accessibility to the apartment, (9) price and (10) maintenance costs or long term costs.

The 1000Minds (1000MINDS, 2013) decision-support software was used for prioritizing alternatives base on responder's choices from pairs of hypothetical configurations. Since most of the criteria listed above can only be interpreted in context of the responder's life situation (e.g. wealth, health etc.), three generic levels for each criterion have been used:

- Above the basic expectation;
- Just fulfilling the expectation;
- Below the expectation (representing a compromise on the criteria).

The data collected so far show a few clear trends. The most consistent response set is obtained concerning the importance to the responder of "Internal comfort", with coefficient of variation (COV=0.39), followed by "Maintenance costs" and "Spatial system" (0.44). Responders most agree on the importance of these three criteria. Most varying responses are obtained for "Accessibility" and "Adaptability" (0.74) and "Location" (0.60). Responders agree the least on the importance of these three criteria.

As mean value, the responses prioritise the following criteria to be important for them when they consider moving to/buying an apartment (see Fig. 1.): spatial system and safety (~13% each); neighbourhood (~12%); location, indoor comfort and price (~11% each); state of deterioration (~9%); maintenance costs (~8%); adaptability and accessibility (~7%).

It can be noted that, like seed in other studies (Jakob, 2004; Boome, 2007; Banfi *et al.*, 2008), energy efficiency interest responders mostly in connection with co-benefits like thermal comfort, indoor air quality and noise protection. It is also interesting that social sustainability targets, tackled at the level of the building are important to the responders in over 38%. In fact, responders value social qualities on par with environmental/energy and economic qualities.

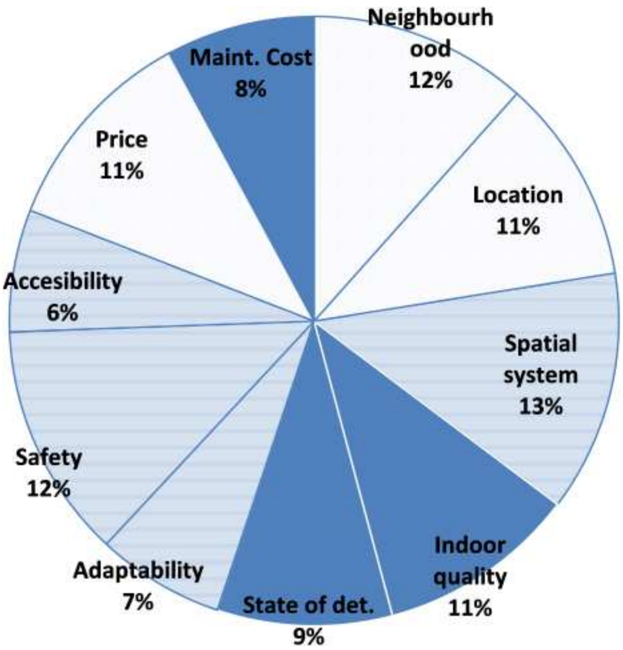

Fig. 1. Interest of responders of social performance related qualities (accessibility, safety, adaptability and spatial system) accounts for 38% of their focus

Based on the above result, and the general knowledge that large-panel buildings are inflexible systems when it comes to deep renovation, it is warranted to assess how the large-panel building stock fares in relation with social sustainability targets.

2.2. Social sustainability standardization

The European framework for assessing social sustainability is given in the standard EN 15643-3 (2012), while the methodology of assessment is described in more details in prEN 16309 (2013). The European standardization process is at the start concerning social sustainability, and only some categories of social performance aspect have an agreed basis for standardization. As aspects and indicators of social performance are difficult to quantify (FOBRP, 2001; TISSUE, 2005; Häkkinen, 2007; SuPerBuidings, 2012), as it has been seen already when designing the survey, a checklist approach is promoted by the standards without specifying assessment schemes or valuation methods.

In this section, an attempt is made to estimate the social performance of a typical panel building. The aim is to support early stages decision making on retrofit measures, and to help policy development target complex portfolios of intervention tailored to the panel building typology. Locally tailored retrofit portfolios, supported by compliance and enforcement measures are known to be very effective in achieving environmental sustainability targets (Ürge-Vorsatz *et al.*, 2007). On the other hand, the management measures of the building stock need to be tailored to the demographic development and local population migration trends (Kohler and Yang, 2007; Vâlceanu, 2013; Petre, 2014).

The case-study is made on a unit of T744R-IPCT standardized building, having 1188.9m² of useful area per year. The building is residential, and the number of apartments is 20. The system boundaries are set strictly to the perimeter of the building superstructure, its foundations system and exclude the building site.

For social performance, the only life cycle stage covered is the use stage, with focus on module B1 of EN 15804 (2012), or use scenario. For further simplicity, only the impacts on the users of the building are discussed here, as shown in Annex B of EN 15643-32012), neglecting the temporary impacts when carrying out the renovation work.

Also the impacts on the neighbourhood and involvement of society are also defocused. However, broader impacts on society, primarily the local community, may be significant in the use stage, as the retrofit proposed in the following section of the paper can change the number and type of the occupants of the buildings, e.g. reducing the population density in neighborhoods.

Given these limitations, the list of aspect related to social performance, and a few possible measures to improve performance are given in Table 1, based on the upcoming standard prEN 16309 (2011).

It can be noted from Table 1 that not all means of improving social sustainability are available at the building level. For instance the approach to the building is something that is in the responsibility of municipalities in the Romanian context.

Synthetizing the finding of the survey, and the targets set by the design standards it can be noted that, quite a few qualities can be improved by the city authority. These are partly the aspects of "Safety", "Neighbourhood" and "Location" (in the sense of improving access to services and transport options). They add up to 31% of the priorities of the responders (see Fig. 2.)

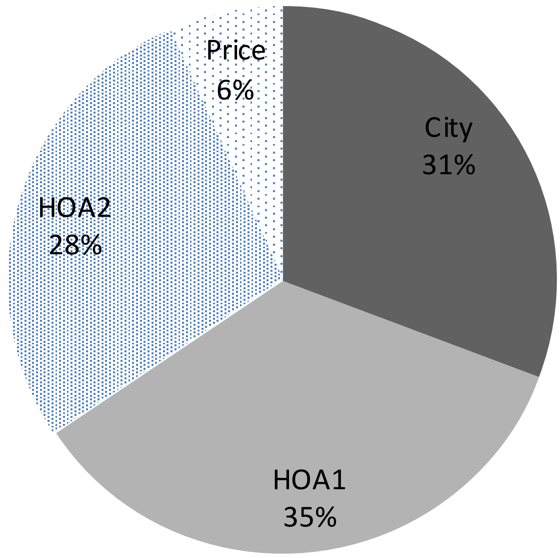

Fig. 2. Stakeholders responsible for improving social performance aspects interesting for owner and outlined in European standards.

A second set of qualities can be improved by the home owner association (HOA) with moderate effort: indoor quality, state of deterioration, part of safety and reducing the maintenance cost. These represent together about 35% of the priorities stated. Only "Indoor quality" and "Maintenance cost" may be improved by renovation undertaken by a single apartment owner, emphasizing that HOA's do need to act together to respond to expectations of their members.

Table 1. Aspects related to social performance prEN 16309 (2011)

Aspect related to social performance	**Sub-aspect and section number in prEN 16309:2011**	**Relevant? (yes/no)**	**Applicable national or European requirement (as in 2013)**	**Possible measures to improve performance for the social aspect**	**Measure ensured by the initial design?**
Accessibility for people with special needs	Approach to the building (7.2.2)	no	NP051/2012	Not relevant because it is outside of system boundary	no
	Entrance and movement inside the building (7.2.2)	yes	NP051/2012	Access ramps for ground floor apartments. Ensure accessibility ensured for 20% of the floor area	no
			NP051/2012	External elevator systems. Accessibility to 100% of the floor area	no
			NP051/2012	Width of door openings upgraded for accessibility	no
			NP051/2012	Minimum width of corridors and room spaces upgraded	no
	Access to building services (7.2.3)	yes	NP051/2012	Minimum width of bathroom spaces upgraded to include manoeuvring space	no
Adaptability	Adaptability (7.3)	yes		Minimization of internal load-bearing elements	no
		yes		Ease of demolition/demountability of internal elements	partly
		yes		Provisions for possible future equipment e.g. elevators	no
Health and comfort	Visual comfort (7.4.5)	yes		Increased daylight contribution	yes
				Improve visual connection with exterior by modifying window heights, aspect ratios etc.	yes
	Spatial characteristics (7.4.6)	yes		Modify number and floor area of rooms.	yes
				Number and floor areas of toilets, bathrooms, volumes of storage rooms	yes
				Outdoor area and balconies	yes
Maintenance	Maintenance (7.6.)	yes		Ease of access. Accessibility without dismantling/removal of building components.	no
Safety and security	Resistance to climate change (7.7.2)	yes		Zoning of apartments to create buffer spaces (e.g. south facing facades in hot climate)	no
	Accidental actions (7.7.3)	yes		Maintain structural stability for earthquake and explosion	yes
				Optimization of size of smoke and fire compartments	no
				Improved design for the means of escape in case of fire (including people with disabilities. Improved access of fire fighters.	yes

A third set of qualities (28%) are also within the reach of the HOA to improve, but with substantially more effort and expense. These are deep-renovations targeting aspects of social sustainability of the building stock "Spatial system", "Adaptability" and "Accessibility". "Spatial system" is a strong driver of choices, so it will impact on the price of the building. It is also strongly linked with "Adaptability" of the internal spaces. On the other hand, "Accessibility" should be a wider societal concern, given the aging population in Europe.

Since targets of renovation group HOA1 are quite well covered by current renovation programs, in the following section we discuss the technical measures possibly tackling deep-renovation; both the opportunities they offer and the limitations they have. The functional unit of the interventions is the same T744R-IPCT building.

3. Technological options

3.1. Measures for improving social sustainability in the large panel system

Two possible interventions on the standard project IPCT type T744R will be discussed. They involve reconfiguration of the interior partition in order to increase the comfort of living by merging flats, with corresponding increased living space. The necessity of making large openings in diaphragms is highlighted from the architectural point of view that allows the re-design of the interior rigid partitions and also provides multiple options in terms of interior furnishing. Cutting large openings in structural diaphragms is the technical challenge to these proposals, as the intervention must be done in a coherent way, so as not to affect the safety of the building.

The purpose of the study is the analysis of different types of apartment repartitioning, in order to obtain structural and functional solutions that could be integrated into a reliable 3D building matrix (see Fig. 3.).

The technique has the potential to be used for horizontal or vertical reconfiguration of the spaces by coupling two apartments as shown in in a few potential examples of Fig. 3, but also for reconfiguration and optimization of usable spaces within a single apartment.

It can also be employed to improve social aspects like accessibility or access to building services by e.g. reconfiguring corridors or adding access routes for the disabled, in the spirit of barrier-free design targets (Heiss *et al.*, 2010).

Added difficulty for deep-renovation interventions comes when the buildings are located in changing areas e.g. affected by high earthquake risk, like in Romania.

Given the example case in Fig. 3. the new apartment configuration insures a large liveable area in a semi open space interior configuration, an apartment configuration nowadays frequently used in practice. But more generally, adaptability of the internal spaces is improved.

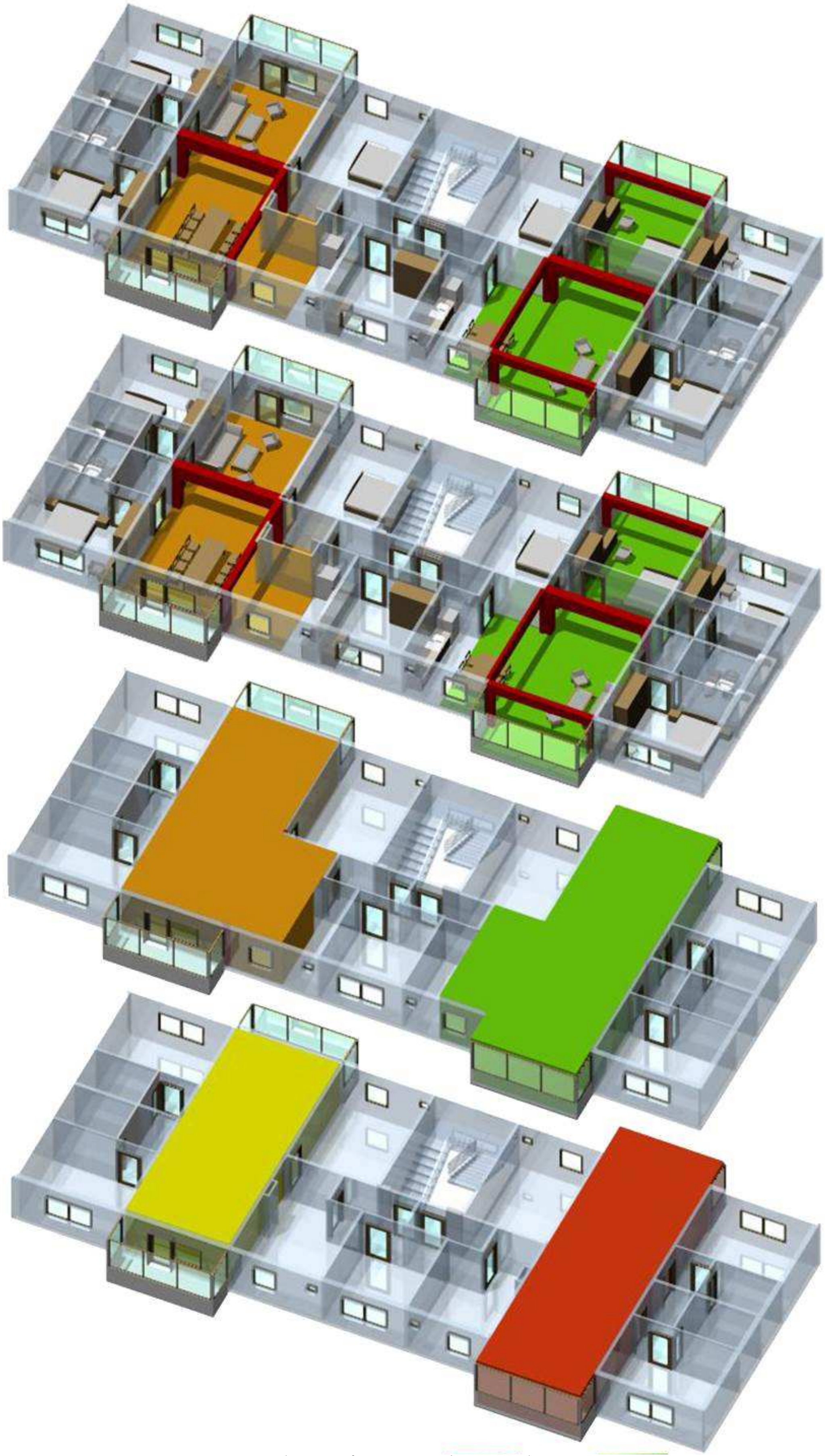

Fig. 3. Horizontal reconfiguration by coupling two apartments

The new opening in the panels should be used in a fashion of a flexible matrix allowing the apartment owners to realize different configurations, with the use of light partitioning, and should not impose obligation. For these cases of deep retrofit intervention, structural solutions and regulations must be formulated, in order to accommodate a diversity of possibilities regarding the "open space".

In urban areas this type of intervention can rebalance certain areas in terms of density, green zones for residents and can also decongest some traffic routes, contributing solutions to challenges in the urban context (Radoslav *et al.*, 2010, 2012). From a social perspective this type of intervention involves a release on the public area allocated to parking areas. At the same time it implies an urban density decrease (see Fig. 4).

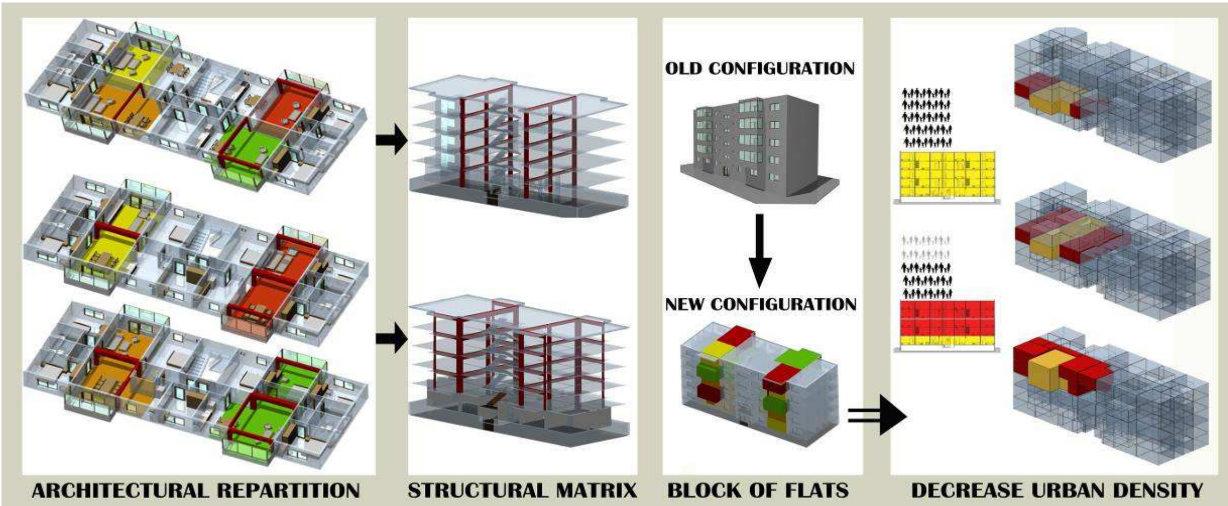

Fig. 4. Possibilities of regulating population density in relation to building stock and used areas

3.2. Feasibility of deep-renovation solutions for large panel buildings

Within the RESPIRE project the technical feasibility of such, very ambitious interventions was shown. The design of the retrofitted structure was separated in two stages:

- Verification of the current state of the original structure, accounting for the accumulated degradations and
- Verification of the structure after intervention (retrofitted structural system.

It is important to underline here that from the period 1965-1975 until now, several changes appear in what concerns the actions, especially seismic action, and in the design codes. Deep intervention would offer the opportunity to review and upgrade the buildings to account for these changes in loads.

The state of the structures was assessed through 3D analyses using ETABS computer code, by using shell finite elements. The thickness of the vertical and horizontal modelled diaphragms was equal to the thickness of the resistance layer. The seismic load was accounted through a loading scenario corresponding to the building being located in Timisoara, i.e. spectral analysis using ground acceleration a_g=0.16g and a control period T_c=0.7s.

The first mode shapes of the translational, longitudinal, torsional vibration modes are shown in Fig. 5. The corresponding periods of vibration are $T_1=T_y=0.1s$, $T_2=T_x=0.08s$, $T_3=T_\theta=0.078s$.

The structure was studied with hypothetical scenarios of reconfiguring spaces horizontally and vertically, by executing large openings in the existing structural diaphragms. The evaluation of the structural performance after retrofitting was performed according to CR2 1-1.1:2011 (2011).

For the case of executing large openings in the longitudinal walls of the building, 3D modal analyses on the retrofitted structure show that it preserves the first mode of vibration (transversal $T_1=0.1106s$), but the second mode of vibration (longitudinal $T_2=0.0965s$) is affected by the openings that were performed in the diaphragms.

However, the structure remains extremely stiff, even after the intervention. Static analyses shows that internal forces remain unchanged, except for the near vicinity of the newly cut openings. Structural checks revealed that local level reinforcing of the walls affected by the must be carried out. Fortunately, adequate solutions for this local strengthening are available (Botici *et al.*, 2012; Demeter, 2011).

For the case of reconfiguring spaces between floors, implying the execution of large openings in existing panel floors, results show that this is also technically feasible. The structural analyses showed that the vertical concrete diaphragm walls are practically unaffected by the new opening performed in the slab. However, the void created in the slab changes the internal force distribution in that particular slab. For reference evaluation in the project, the slab panel P42-21 was verified by considering a cut of 1200x1200mm. Results show that the slab needs strengthening in one spacing direction, and technical solutions were worked out to carry out the required consolidation (Botici *et al.*, 2012; Demeter, 2011).

It is clear conclusion of this study that technical solutions exist for the kind of deep retrofit needed to socially upgrade the large panel building stock. In broader term, the economic suitability of some of the solutions can be further studied, but generally intervention techniques can be found for major reconfiguration tasks.

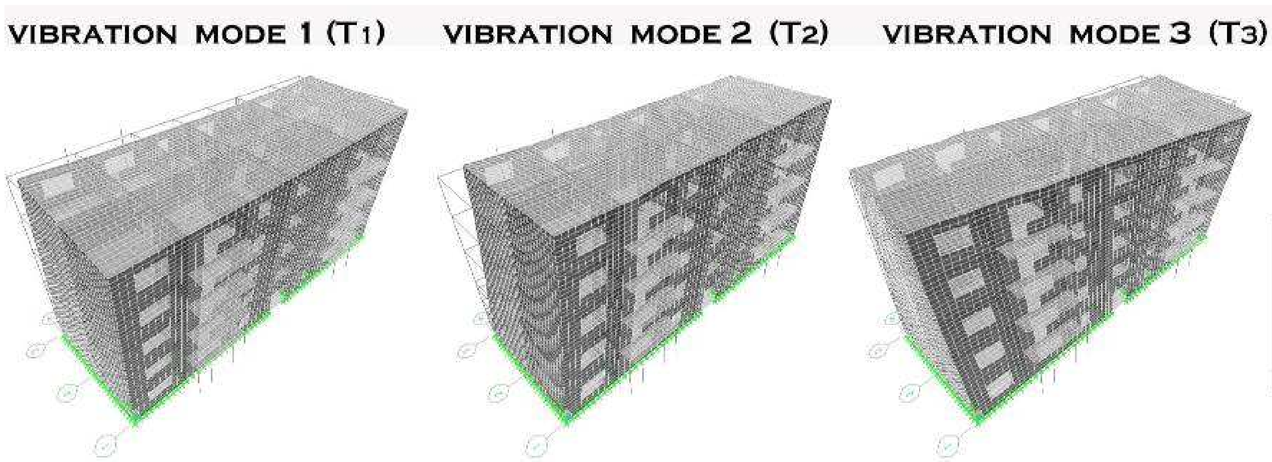

Fig. 5. Vibration modes and periods of original structure

4. Socio-economic factor

4.1. Market environment for carrying out deep retrofit

As shown earlier, deep renovation would need to be employed on the large panel building stock of concrete in order to upgrade it from the social sustainability point of view. This is both desired by the occupants, required by European and national legislation and it is technically feasible.

The next focus of the research was to understand the social and economic environment, where such retrofit may be deployed. Support of the many stakeholders (Riley *et al.*, 2003), and the acceptance and understanding of novel renovation measures is known to be an important aspect of implementation (Kiss and Neij, 2011; Häkkinen and Belloni, 2011; Kiss *et al.* 2012). Removing institutional barriers (Priemus, 2005) and temporary fiscal incentives can also play important role in jump-starting ambitious sustainability solutions (Dewick and Miozzo, 2002; Pitt *et al*, 2009). But most importantly, realistic estimates of upfront capital costs versus the long term benefits need to be communicated correctly (Bon and Hutchinson, 2000; Hydes and Creech, 2000).

In this work we started by studying the structure of ownership and mapping the assumed roles of the main stakeholders. For the model, the external reference of the case of Finland has also been very useful, as the differing practices in maintenance and retrofit could be compared.

The apartments in large panel buildings were built between the 1950's-90's, with well documented technological solutions (Focşa *et al.*, 1957; Niculescu, 1961; Martac *et al*, 1962; Mihaescu 1985), and were owned by the state. The inhabitants were tenants, and due to the political ideologies of the regime, the private property was severely limited.

The situation changed radically after 1990, when the private property became protected and guaranteed by law. The authorities decided to sell the apartments to the tenants, initially at very low prices (the equivalent of 32 monthly salaries). As the inflation was out of control, in 1993 this sum represented only 1-2 monthly salaries. Therefore, one apartment could be bought with low financial effort and as a result, Romania has the highest now owner occupancy rate in Europe (96%). But, other East European economies also have the highest owner occupancy rate in Europe (Rybkowska and Schneider, 2011).

Paradoxically, central European Courtiers have a mid/low-range of property index (PRA, 2013) (Romania 5.3, Slovakia 6.2, Latvia 5.6, Poland 6.2, Hungary 6.4, Czech Republic 6.4), and Nordic Countries, where larger parts of the existing building stock is publicly owned, are scoring high (e.g. Finland 8.6, Sweden 8.5). The property rights index measures the degree to which a countries law protect private property rights, and the degree to which its government enforces those laws. Higher scores mean that the property rights are better protected.

There are also differences in what "*owner occupied*" means in the two contexts, depending on the ownership models of the apartments.

For instance, the ownership model, implemented in Romania after privatizing is a condominium type ownership. In this scheme, the apartment itself is a private property, while shared parts of the building are used under legal right associated with owning the apartment. These rights extend to all commonly used parts of apartment buildings, land, foundations, cellars, stairways, elevators, external walls, roofs, depositing areas, entrances etc. Owners are organized in home owner associations or HOA's, for the purpose of managing the co-owned parts of the property, but also to pay utility bills and other costs.

The Finnish/Nordic alternative for owning apartment buildings is the so called collective ownership model. In such buildings, the right to reside in a particular apartment flat is tied to the ownership of shares in the housing company. In essence, the housing cooperative owns the building/buildings, and the shareholders own the housing company. The ownership of shares associated with an apartment automatically entitles one to live in that apartment.

In Finnish legal terms, the transfer of a home owned by a housing company is seen as the sale of shares in the housing company, not a real estate transaction. However, the perception of the occupant is very strongly that he/she owns the apartment. So much so, that "*owner-occupied*" is most frequently used term for this type of ownership.

Of course there are also strong similarities, as in both cases residents pay a monthly fee to cover maintenance costs, heating costs and the water supply. Housing company/HOA decisions are defined by residents at open meetings, etc.

4.2. Influence of ownership on maintenance and renovation

The main advantage of the collective ownership scheme is that the housing company, as legal entity, is able to enter agreements for maintenance and renovation, or to sign loan agreements with banks for the financing of such renovation by offering the building as guaranty.

One difficulty in HOA's, as organized in Romania and other countries, is the lack of ability to agree on maintenance and renovation, especially deep renovation. Traditionally, it took the full agreement of all owners to contact a bank loan to finance renovation of the building. In case of larger associations there is practically no chance to achieve unanimity, throwing the HOA in impossibility of deciding (Kecskés, 2006). But even with lowering of the required votes from 100% to majority, it will make the group to decide e.g. to renovate, and then force a private individual to pay a bill.

This approach has its limits, as the leverage of the group over the individual is limited. It is not a surprise that current financing schemes for renovation leave only a minor part of the expenses to be paid by owners.

In the collective ownership schemes, the situation is different. Once the decision is taken by the owners meeting, the contracting of the bank loan it is done by the housing company. Apartments, more precisely shares, are freely sold on the market with outstanding renovation loans; the loans are simply deduced from the selling price and transferred to the new shareholder.

A second benefit of the stronger collective system is that the housing companies usually use external housing service, whose main task is to manage the property in accordance with the housing company's decisions. The building site is also included, because the housing company either owns the land plot or has leased it from the city by a long-term contract. These housing service companies, some of them looking after as many as 8500 apartments and 12000 customers (Matinkylän Huolto, 2013;

FREMF, 2013), are important repositories of know-how on real estate management and salvage/reuse their experience in renovation from one building to another.

Finally the larger picture of neighbourhood maintenance has to be mentioned. This can also be traced back to several factors, one being the inability of many city authorities to provide maintenance services. But another strong factor is the property division of the land around buildings. In the condominium scheme, only the land just under the buildings enters in the co-ownership of the occupants, all land around the buildings is public/city land. This arrangement leads to feeling of estrangement on the side of the occupants, not being common for HOA's to extend maintenance to these areas.

4.3. Change towards models of more sustainable management of the building stock

Change is at the heart of every element of human behavior. Plenty of change management systems and processes are known, but in several situations change processes are suddenly failing.

In organizational context McCarthy (McCarthy, 2004) addresses six common reasons why change fails and suggests an approach that focuses on people within a "before, during and after" timeframe.

McCarthy's 6 reasons why organizational change fails are: People planning comes last (1), the role of managers is disregarded (2), communication fails to win hearts and minds (3), individual agendas are ignored (4), engagement isn't measured (5) and lack of a project manager and/or project management (6).
On the other side, the change spectrum can also influence the rate of failure: as large the spectrum of change, as high the failure rate is.

So, how change management of current building stock can be defined? A first attempt can be defined as a structured approach to transitioning individuals, and HOA's from the current state to a desired future state, defined by described business models (McCarthy, 2004).

HR Magazine suggests that change can fall into the following broad categories:

- Strategic change;
- Leadership change;
- Cultural change;
- Cost-cutting
- Process change

A typical change process involves 6 steps: to create an emergency feeling (1), the steering coalition settlement (2), setting a vision, defining goals and objectives (3), developing a plan, communicating the plan and strategy, managing cultural differences (4); implementing the plan (5) and maintaining the enthusiasm through the process (6). It sounds so simple but success in most of the cases delays: there are of-ten several blockages involving the people affected by the change. The success of the change process highly depends by the stakeholder's management. Once the relevant stakeholder's are identified, they can be arranged on a matrix (Fig. 6.) identifying those which are important and can influence the success of change process. These stakeholders will be necessary to bring and keep in D cell, while identified antagonistic stakeholders will be kept in A cell.

Success or failure of the change process for more sustainable management of building stock finally can be reduced to a "political game" with stakeholders placed in Fig. 7. Since the definition of change process involves a very large spectrum, which falls in most of the broad categories mentioned before, the solution for the problem should be developed for different layers and managed accordingly.

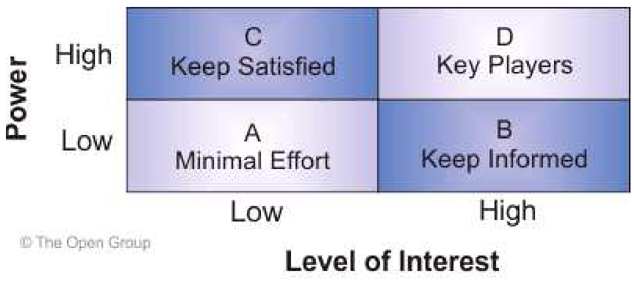

Fig. 6. Stakeholder's management matrix

5. Conclusions

Social sustainability targets should be considered by authorities on par with ecological sustainability. Real estate development programs should include such targets in their financing schemes. These targets are both desired by the prospective owners of the apartments and are required by regulation.

Achieving higher social sustainability standards is technologically possible, but not easy to implement, on the existing large-panel building stock.

The main hindrance to even targeting such ambitious goal is in the inability to promote a broader vision for the community. The individual owner's interest often overrides that of the HOA's, and the HOA's are also unable to become partner of the city authorities, due to their inefficient functioning. The solution is in strengthening the role/power of the HOA's by legislation wherever possible. The introduction of professional management practices, e.g. by promoting housing service, should also by the priority.

With a strengthened HOA system, city authorities can gain a partner in maintaining the building stock and surrounding land. With time even implementing some of the deep intervention measures targeting to improve social sustainability becomes feasible, e.g. installing external elevator systems, converting ground floors to be accessible to the disabled are not too difficult to achieve.

Probably, the ambitious reconversion of privately owned apartment buildings can be realized only in a fully centralized national retrofit program, but pilot implementations for the purpose of benchmarking could be carried out using the buildings currently owned by city authorities.

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