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The importance of the criteria of residential buildings from the perspective of future users

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Abstract
The developers need to know what is important to their customers in preparation of new construction of residential buildings. The paper deals with finding the importance of structure, material, cost, time and environmental criteria of residential buildings from the perspective of the future owners. The research methodology that provided the information was questionnaire survey. Research was conducted in two lines. The first line is dedicated to the research of main construction domains of residential building. The second line of the research deals with the specific criteria of main construction domains. The order of importance of the main areas and the specific criteria is determined by analyzing of data through descriptive characteristics: median, modus, variance, average value and by weigh of importance.

Key words: residential building, structure criteria, user perception

1 Introduction

Currently, this time is trend of projecting and realization residential buildings, which would be attractive in architecture, with low purchasing and operating cost, which are also energy efficient. It is necessary to build fast, quality and environmental friendly buildings. Environmental and climate changes, as well as events in security of electricity and gas have brought new impulses that affect throughout the European Union strategy.

The residential houses should meet one of the basic human needs – the need of housing. This fact raises the question for investors or developers, what the future owner expecting from his new housing. Is the speed of realization important for him? How much? And what about the type of building materials or technology they preferred for realization? How important is the total price of his new apartment? This information is for the developer very important. The researches in this regard claim that today's buildings are becoming less able to meet the needs of their residents through changing demographics and lifestyles.

Tkáč writes [1] that number of cities in Slovakia (and also increasing housing needs) in the past, grew unnaturally fast. Each citizen needs to have its place that meets his requirements for relaxation, privacy and other. Study in New Zealand [2] dealt with demonstration how to

retrofit existing residential buildings, and also how to create smart and sustainable residential buildings, suitable for New Zealanders' future lifestyles. Project consisted of three parts: the creation of a 'Now residential house' - which establishes a benchmark for further houses, and demonstrates best use of today's technologies in the pathway to creating these types of buildings; the creation of a 'Then residential house' - which demonstrates how to retrofit an existing house to turn it into the required and desired building and the creation of a 'Future residential house' - which is a Now house set by the year 2015. This has been built from new systems, technologies and materials that are currently not yet commercialized.

Social sustainability focuses on the people using the building. Their current and future needs influence the design, which aims to create a highly-flexible plan that allows the building to be easily re-purposed as needs change by the design. A flexible design means the structure can be used longer, preventing the negative impact involved in tearing down an old building and rebuilding a new one [3]. Study from South Korea [4] was focused on the idea to ensure the high energy efficiency of new residential buildings. Operational evaluation should be accurately estimated in the early design phase. The study developed a methodology for the measurement of dynamic service rating of new residential buildings using advanced assessments methods and stochastic methods.

In Poland was made an historical analysis [5] of the development of the prefabricated housing construction market as well as an attempt to answer questions concerning the future of prefabrication in housing construction based on conducted studies. An analysis of the development of the housing takes into account the implemented technologies and the requirements of sustainable development in the construction industry which may bring undoubted benefits in numerous areas of investment activity in many countries. The perception and understanding of prefabricated housing is undoubtedly starting to change, which for foreign investors and entrepreneurs constitutes an opportunity to undertake investment activity.

The issue of residential buildings in the context of the implementation modern methods of construction (MMC) is also the subject of research in Slovakia. MMC potential in this segment of construction was studied for comparison on selected 8 types of buildings [6]. Five buildings were built through MMC. Three buildings have been built through traditional buildings technologies. The result was that MMC can be the way how to build energy efficiency buildings per lower building costs. Also Urbán [7] in his paper writes that one of the best ways to achieve a reduction in construction costs, improving quality and speeding up the construction process is the using of modern off-site technologies. Buildings must not have only the unified construction, but these objects can have attractively architecture. These modern technologies can bring buildings with high quality, cost-effective and highly efficient construction solution that is environmentally friendly and reduces construction time.

2 Research methodology

In the segment of building construction is observed permanent demand for projects of residential buildings (RB). For developers it is therefore necessary to know expectations of future use. It is necessary to define the specific criteria and their order of importance, which respects the requirements of the future user to procure their living in residential buildings. For

the research methodology was selected a questionnaire survey among the potential customers. The survey was carried out in two lines. In the first line are defined the main domains of living in residential construction. The second line of research is devoted to specific criteria of each domain (Table 1.). Through the questionnaire were collected the responses from the future users. There was used an indirect method based on subjective assessment of respondents' answers.

Table 1: Two lines of research by analyzing the answers from responses

First line of research		**Second line of research**	
Label	**Construction domains of RB**	**Label**	**Specific criteria of residential buildings (RB)**
A	Material	A1	Material base of the load-bearing structures
		A2	Use of natural materials
B	Structure	B1	Construction system
		B2	Internal disposition of the apartment
		B3	Apartment orientation to the cardinal points
		B4	Number of floors
		B5	Number of apartments per floor
		B6	Number of habitable rooms
		B7	Floor area
C	Time	C1	Construction time
		C2	Speed of moving into an apartment
D	Costs	D1	Operating costs
		D2	Total cost of apartment
		D3	Price per m^2 of floor area
E	Energy	E1	Energy certificate
		E2	Status of green building

The responses in both line of the research were analyzed through descriptive characteristics – median, modus, variance, mean value and by scheduling wages of importance.

Median is defined as the number in the middle of a given set of numbers arranged in order of increasing magnitude. When given a set of numbers, the median is the number positioned in the exact middle of the list when you arrange the numbers from the lowest to the highest. The median is also a measure of average. In higher level statistics, median is used as a measure of dispersion. The median is important because it describes the behavior of the entire set of numbers [8].

$$\tilde{x} = a_{me} + h * \frac{r_2^{(4)} + 0{,}5 - \sum_{i=1}^{r-1} n_i}{n_x} \quad (1)$$

$\tilde{x}$ – median
a_{me} – bottom limit of the median interval
h – range of median interval
$r_2^{(4)}$ – order of the statistical units which will be for the median
n_x – frequency of the median interval
$\sum_{i=1}^{r-1} n_i$ –sum of the absolute frequency into the median interval

Modus is defined as the element that appears most frequently in a given set of elements. Using the definition of frequency given above, mode can also be defined as the element with the largest frequency in a given data set. For a given data set, there can be more than one

mode. As long as those elements all have the same frequency and that frequency is the highest, they are all the modal elements of the data set [8].

$$\hat{x} = a_{mo} + h * \frac{d_0}{d_0 + d_1} \quad (2)$$

$\hat{x}$ – modus
a_{mo} – bottom limit of the modus interval
h – range of modus interval
d_0 – the difference in absolute numbers and modus previous range
d_1 – the difference in absolute frequency and of the next modus interval

The **variance** measures how far each number in the set is from the mean. Variance is calculated by taking the differences between each number in the set and the mean, squaring the differences (to make them positive) and dividing the sum of the squares by the number of values in the set [8].

$$\sigma^2 = \frac{1}{N} * \sum_{j=1}^{m} (x_j - \bar{x})^2 * n_j \quad (3)$$

σ^2 – variance
N – file range
m – the number of classes in the file
n_j – the absolute frequency of the class-j (j = 1,2, ..., m)
x_j – the character value X, which represents the j-class

Mean value represents the degree of centrality probability distribution. It indicates the kind of center of the entire distribution around which values fluctuate randomly variable with repeated observations [3].

$$E = \sum_{i=1} x_i * p_i \quad (4)$$

E – mean value
x_i – value of character X
p_i – the relative frequency of the i-th class

Analysis by **weighing the importance** of the answers from respondents is based on the following weigth distribution:

- answers with "5" has been assigned a negative weight (-2)
- answers with "4" has been assigned a negative weight (-1)
- answers with value "3" has been assigned a zero weight (0)
- answers with "2" has been assigned a positive weight (+1)
- answers with "1" has been assigned a positive weight (+2).

Weighs of importance for domains and specific criteria were calculated as [3]:

$$\bar{x} = \frac{\sum_{j=1}^{5} W_j * f_{ij}}{\sum_{j=1}^{5} f_{ij}} \quad (5)$$

$\bar{x}$ – weigh of importance
W_j – weight the importance of examined factors (-2, -1, 0, +1, +2)
f_{ij} – corresponding the frequency of levels of importance j or i
$\sum_{j=1}^{5} f_{ij}$ – total numbers of responses.

3 Results and Discussion

Analysis of the criteria importance of residential buildings from the perspective of future users was carried out in two lines. The first line of research dealt with the main construction domains, the second line determined the order of importance by the specific criteria of construction domains. Through the results of the descriptive characteristics was determined the order of importance by main areas and by specific criteria. Result of the analysis is selection the descriptive characteristic which accurately determined the order of importance.

3.1 First line of the research according to the main construction domains

Respondents were asked to assign the importance to five main domains of residential construction - material, structure, time, cost and energy (used scale 1 – 5). In table 2 are elaborated response rate and descriptive characteristics of the results of responses.

Table 2: Response rate and descriptive characteristics of the results of responses in the main construction domains of residential building

Domain	Frequency of response*					Descriptive characteristic for determining the order of importance				
	1	2	3	4	5	median	modus	variance	mean value	weighs of importance
Material	21	21	9	6	9	2	2	1,91	2,41	0,59
Structure	9	27	18	12	0	2	2	0,90	2,5	0,50
Time	21	24	9	6	6	2	2	1,59	2,27	0,73
Costs	24	21	12	0	9	2	1	1,75	2,22	0,77
Energy	24	30	9	3	0	2	2	0,67	1,86	1,14
**1 – very important, 2 – important, 3 – neither important, 4 – not important, 5 - unimportant*										

The lowest value according to the median, modus, variance and mean value represents the highest importance. By analysis with weighs of importance the highest value is the best. Table 3 presented orders of importance the main construction domains in relation to the used descriptors characteristics.

Table 3: The orders of importance by construction domains of residential buildings

Order according to median		Order according to modus		Order according to variance		Order according to mean value		Order according to weighs of imp.	
1.	Material	1.	Costs	1.	Energy	1.	Energy	1.	Energy
	Structure	2.	Material	2.	Structure	2.	Costs	2.	Costs
	Time		Structure	3.	Time	3.	Time	3.	Time
	Costs		Time	4.	Costs	4.	Material	4.	Material
	Energy		Energy	5.	Material	5.	Structure	5.	Structure

According to the median the construction domains cannot be ranked because they all have the same value. According to the modus the costs domain is the first and the remaining domains are the second (could not distinguish the order). Order according to variance, mean value and according to the weighs of importance shows that the most important domain for the respondents is the energy area. Second in the order, according to the mean value and weighs of importance is cost domain (by variance is it the construction domain). The third is time

domain. Material domain, according to the mean value and weighs of importance is on the fourth (by variance is it the cost area). At last, fifth, according to the mean value and weighs of importance is the construction domain (by variance is it the material domain).
The above findings show that for further analysis is appropriate to use the order of importance for the main construction domains according to mean value and according to the weighs of importance because the orders of the areas examined in these descriptive characteristics are identical.

3.2 Second line of the research according to the specific construction criteria

Second line of the research deals with the order of importance of specific criteria describing the residential buildings. If the main domains was marked A, B, C, D, E, the criteria relating to the main domains would be marked A1, A2, B1, B2 and so. The criteria were dealing about:
A1 – Material base of the main load-bearing structures
A2 – Use of natural materials
B1 – Construction system of apartment house
B2 – Internal disposition of the apartment
B3 – Apartment orientation to the cardinal points
B4 – Number of floors
B5 – Number of apartments per floor
B6 – Number of habitable rooms
B7 – Floor area of the apartment
C1 – Construction time
C2 – Speed of moving into an apartment
D1 – Price per m^2 of floor area
D2 – Operating costs
D3 – Total cost of apartment
E1 – Energy certificate
E2 – Status of green building
In table 4 are elaborated response rate and descriptive characteristics of the results of responses.

Table 4: Response rate and descriptive characteristics of the results of responses by specific criteria of residential building

Specific criteria	Frequency of response*					Descriptive characteristic for determining the order of importance				
	1	2	3	4	5	median	modus	variance	mean value	weighs of importance
A1	33	12	9	3	9	1,5	1	2,06	2,14	0,86
A2	12	27	9	9	9	2	2	1,71	2,64	0,36
B1	12	12	9	21	12	3,5	4	1,97	3,14	-0,05
B2	27	21	6	3	9	2	1	1,91	2,18	0,81
B3	42	12	6	6	0	1	1	0,97	1,64	1,36
B4	33	6	6	9	12	1,5	1	2,65	2,41	0,31
B5	18	15	15	6	12	2,5	1	1,98	2,68	0,59
B6	30	21	15	0	0	2	1	0,64	1,77	1,23
B7	30	27	3	3	3	2	1	1,07	1,82	1,18
C1	18	24	15	0	9	2	2	1,62	2,36	0,63
C2	27	18	6	6	9	2	1	2,05	2,27	0,72

D1	36	18	3	3	6	1	1	1,62	1,86	1,14
D2	45	18	0	0	3	1	1	0,81	1,45	1,55
D3	33	24	6	0	3	1,5	1	0,94	1,73	1,27
E1	21	30	6	9	0	2	2	0,97	2,05	0,96
E2	6	27	21	12	0	2,5	2	0,80	2,59	0,41
**1 – very important, 2 – important, 3 – neither important, 4 – not important, 5 - unimportant*										

The lowest value according to the median, modus, variance and mean value represents the highest importance. By analysis with weighs of importance the highest value is the best. In table 5 are presented orders of importance the specific criteria in relation to the used descriptors characteristics.

Table 5: The orders of importance by specific criteria of residential constructions

Order	According to median	According to modus	According to variance	According to mean value	According to weighs of im.
1.	B3,D1,D2	A1,B2,B3,B4,B5,B6, B7,D1,D2,D3,C2	B6	D2	D2
2.	A1,B4,D3	A2,C1,E1,E2	E2	B3	B3
3.	A2,B2,B6,B7,C1,C2,E1	B1	D2	D3	D3
4.	B5, E2	-	D3	B6	B6
5.	-	-	B3,E1	B7	B7
6.	-	-	B7	D1	D1
7.	-	-	C1,D1	E1	E1
8.	-	-	A2	A1	A1
9.	-	-	B2	B2	B2
10.	-	-	B1	C2	C2
11.	-	-	B5	C1	C1
12.	-	-	C2	B4	B4
13.	-	-	A1	E2	E2
14.	-	-	B4	A2	A2
15.	-	-	-	B5	B5
16.	-	-	-	B1	B1

By selection the descriptive characteristic which accurately determined the order of importance ranking by median and modus don't takes into account our requirements to set out prioritization criteria (since in one place are several criteria). Even by the order according to the variance was not reached explicit order (fifth and seventh were placed criteria by which calculation reached the same value). Ranking by main value and weighs of importance sets out the same order of specific criteria of residential buildings. Therefore, this order will be taken as terminative.

3.3 Comparison of the results from the research lines

In previous chapters were determined orders of importance in main domains and specific criteria of residential constructions based on the results of the descriptors characteristics. Now it is necessary to examine the relationship between the orders of importance in main domains and specific criteria (see table 6).

Shades in the tab. 6 shown an association of domains to the specific criteria of residential building. The above table shows recognition that if respondents were not directly asked about

specific requirements which affect their decision to buy an apartment in new building, as the most important area was energy area for them. They consider that if they live in residential house with the highest energy standards and the lowest power consumption, advantage for them will by lower operating costs. The least important domain for them was structure domain. However, when respondents were directly asked about specific criterion, we can see in table 6 that at the first five places are criteria from structure domain (3 criteria) and cost domain (2 criteria). Energy criteria are seventh and twelfth (while the energy domain was for respondents the first).

Table 6: Comparison of the importance orders by main domains and specific in residential buildings

First line of research		Second line of research	
Order	**Main domains**	**Order**	**Specific criteria**
1.	E Energy	1.	D2 - Operating costs
		2.	B3 - Orientation of apartment
		3.	D3 - Total cost of apartment
2.	D Costs	4.	B6 - Number of habitable rooms
		5.	B7 - Floor area of the apartment
		6.	D1 - Price per m^2 of floor area
3.	C Time	7.	E1 - Energy certificate
		8.	A1 - Material base
		9.	B2 - Internal disposition of the apartment
		10.	C2 - Speed of moving into an apartment
		11.	C1 - Construction time
4.	A Material	12.	B4 - Number of floors
		13.	E2 - Status of green building
		14.	A2 - Use of natural materials
5.	B Structure	15.	B5 - Number of apartments per floor
		16.	B1 - Construction system of apartment house

We can conclude that the order of importance of the claims of future users of housing clearly indicates the ranking according to specific criteria of residential building.
The questionnaire survey has also monitored the corresponding age of respondents. They were categorized by four age groups. Thus, we can determine the order of importance of the specific construction criteria of residential building with respect to the age of the respondents. Will be used the order according to weighs of importance. From age group 51-60 and above 60 answered just one respondent, that these responses are not applicable for evaluating. We set the order of criteria importance for the age group of 20 to 34 respondents and respondents 35- 50 years old. The results are shown in table 7.

Table 7: Orders of specific construction criteria importance for two different age groups

*1.g.	**D2**	B6	B3	D1	B7	D3	C2	E1	E2	A1	B2	B4	C1	A2	B5	**B1**
**2.g.	**B3**	D2	D3	A1	D1	B7	E1	B6	B5	B2	C1	A2	B4	C2	B1	**E2**

**1.g – group of age 20 – 34*
***2.g. – group of age 35- 50*
D2, B3, D3 ... are explained in 3.2

Younger age group (which usually resolves buying their first apartment and where it is assumed that it will have to deal with a mortgage or loan to buy an apartment) gives highest

importance on monthly operating costs (D2). The second important criterion for them is the number of rooms in the apartment (B6) and the third in order of importance is the flat orientation (B3). This structure criterion is particularly important to them because they do not want to have windows on the cold north side, causing an increase in heating costs in the winter time. Almost irrelevant is for them structural criterion relating to the construction system of the apartment building (B1).
For the older age group the orientation (B3) is even the most important criterion. The second important criterion for them is the amount of monthly operating costs (D2), and the third is the total price of the apartment (D3). This group of respondents can compare their "old" living with "new". Therefore the time criteria are for them generally less substantial than for example structure criteria. Criterion about green building (E2) is for the older age group at last place. Probably they don't know (or they don´t care) about the benefits of green buildings. They are interested only if their new apartment eliminated deficiencies which they have in the old apartment.

4 Conclusion

Paper deals with determining the orders of importance of the criteria on residential buildings from the perspective of future users. Analysis was made in two lines of research with the use of online questionnaire. The first line deals with setting the order of importance by main domains of residential buildings. The second line deals with setting the order of importance by specific criteria of residential building. If we don't take into account the age of the respondents, the most important criterion has become the height of monthly operating costs. But different age groups have different orders of importance of their criteria (which has an impact on their decision about buying an apartment. Younger group of age (20-34) where is potential to buy their first new housing (where it is expected that they will have to deal with a mortgage or loan to buy an apartment) gives highest importance of monthly operating costs. Second important criterion for them is the number of rooms in the apartment and the third is the apartment orientation. For the second group of respondents over 35 years of age (it is expected that they housing already has and wants to obtain a new apartment) is the most important criterion the apartment orientation. This group of respondents can compare the old apartment with potential of new apartment. The second important criterion for them is the monthly operating costs, and the third in order of importance is total price of apartment.

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