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POTENTIAL USAGE OF MODERN METHODS OF CONSTRUCTION IN SLOVAKIA

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Abstract: *Currently, all over the world, there are increasingly widespread innovative methods of construction also called modern methods of construction (MMC). MMC are synonymous with off-site manufacturing and prefabrication of building components and modules in factory settings, including complete buildings. The modern method of construction has a great potential to improve the efficiency of construction production, quality, customer satisfaction, environmental impact, sustainability and predictability of construction design delivery in particular terms. MMC is focused on the looking at the possibility of improving the performance of construction. Aim of this paper is, through a questionnaire survey, to identify the main benefits and barriers of MMC usage in Slovak republic in terms of experts (architects and constructors) in the construction industry. In this paper, there is also statistically assessed (through t-test), whether respondents attitudes vary according to the company size, in which they work.*

Keywords: Modern methods of construction (MMC), classification, construction industry, úotential

1 INTRODUCTION

Globally, the construction is industry of the lowest productivity. The productivity increased on average twice in other industry sectors since 1964. On the other hand, the productivity in the construction industry decreases in 10 percent in this period (U.S.A. Bureau of Labor and Statistics, OECD.StatExtracts). Order to increase the performance of construction industry in the global innovation and research activities in the construction industry (CIB - International Council for Research and Innovation in building and Construction) solves a number of problems of construction supporting this goal through of research programs of priority themes. The priority themes of construction not only in Europe but also in globally include sustainable construction and integrated design and delivery solutions of project.

One of the key assumptions for the issues solution of sustainable construction and integrated design and delivery solutions is research focused on the more effective methods of design and realization of construction projects used the modern method of construction (MMC) and increasing the performance as a sustainable construction, as well as the integrated design and delivery solutions. Authors Chen et al. [1] argue that MMC in the construction industry has enhanced productivity and improved quality as well as several benefits as shortened construction time, lower overall construction cost, improved quality, enhanced durability, better architectural appearance, enhanced occupational health and safety, material conservation, less construction site waste, less environmental emissions, and reduction of energy and water consumption. MMC are about better products and processes. They aim to improve business efficiency, quality customer satisfaction, environmental performance, sustainability and the predictability of delivery timescales. MMC are, therefore, more broadly based than a particular focus on product. They engage people and process to seek improvement in the delivery and performance of construction. The authors [2] defined MMC as those which provide an efficient product management process to provide more products of better quality in less time. It can be classified in various ways and may involve key services (e.g.) plumbing, key items (e.g. foundations) inner shell (walls etc), external walls, or any combination of these elements. It can also be classified by material (timber, steel, concrete and masonry). According to [3] MMC are defined as a set of element or component which are inter-related towards helping the implementation of construction works activities. He also expounded that MMC are an investment in equipment, facilities, and technology with the objective of maximizing production output, minimizing labour resource, and improving quality. Trikha [4] defined MMC as a system in which concrete components prefabricated at site or in factory are assembly to form the structure with minimum in situ construction.

2 CLASSIFICATION OF MODERN METHODS OF CONSTRUCTION

Many authors mentioned various classifications of modern methods of construction. [3] classified MMC according to geometrical configuration of their main framing components which are (i) linear or skeleton (beam and column system), (ii) planer of panel system or (iii) dimensional and box system.

Housing Corporation [5] divides MMC into construction (i) volumetric, (ii) panellised, (iii) hybrid, (iv) sub-assemblies and components (v) inovative traditional methods of construction. In Malaysia, CIDB [6] classified MMC into five categories which are (i) pre-cast concrete framing panel and box system, (ii) steel formwork systems, (iii) steel frame system, (iv) timber frame system and (v) block work system.

According the study "Current practices and future potential in modern methods of construction" processed in the UK [7], MMC can be divided into following categories (i) volumetric modules, (ii) wood or steel frame constructions, (iii) kitchen and bathroom pods, (iv) composite insulated non load-bearing or load-bearing sandwich panels, (v) light steel frame systems, (vi) prefabricated panels, (vii) prefabricated lightweighted ceiling and roof panels, (viii) structural insulated panels, (ix) prefabricated cladding systems, (x) insulated concrete formworks.

Fig. 1 Volumetric modules [8]

Fig. 2 Panellised construction [9]

Fig. 3 Hybrid construction [10]

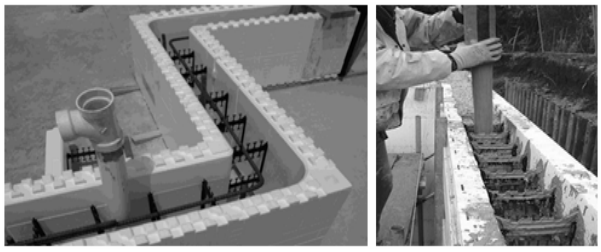

Fig. 4 Insulated concrete formwork [11]

3 BENEFITS AND BARRIERS OF USING MODERN METHODS OF CONSTRUCTION

According many authors modern methods of construction have a great potential to improve the efficiency of construction production, quality, customer satisfaction, environmental impact, sustainability and predictability of construction design delivery in particular terms.

Adopting of MMC has the following main benefits to the practitioner when compared to the conventional construction method [3,12,13,15,16]: (i) construction process is not affected by adverse weather condition, because prefabricated components are done in a factory controlled environment, (ii) prefabrication takes place at centralized factory, thus reducing labor requirement at site, (iii) MMC allows faster construction time because casting of pre-cast element at factory and foundation work at site can occur simultaneously, (iv) MMC components produces higher quality components attainable through careful selection of material, use of advanced technology and strict quality assurance control, (v) reduction of waste at site and (vi) safer construction sites.

However, despite these undisputed benefits some stakeholders think, that MMC has not yet had the impact they expected, or hoped for and they are little bit sceptical on using MMC [17].Same authors who described benefits of using MMC, pointed also to barriers that prevent the spread of MMC in many countries: (i) prefabrication elements are considered inflexible with respect to changes with may require over its life span, (ii) non acceptance by clients - many people think that repetitiveness and standardization element of MMC cause monotonous complexes and they prefer conventional methods of construction, (iii) an adaptation of standardization requires a tremendous education and training effort, (iv) problem of making joints, locking, gluing, welding, hammering or snapping components together which need time and experience for perfection and reduced wastage, (v) higher initial cost compared to conventional methods of construction, (vi) limited suppliers of prefabricated elements - MMC is not locally available, (vii) architects, designers have little experiences with MMC.

Each country has its own specifics that affect the acceptance / non-acceptance of new technologies in general, not excluding the adoption of the modern methods of construction. The MMC are increasingly becoming more popular and gradually find their place in the market in Slovak republic. However for perfect acceptance of MMC as innovative method of construction it is necessary to remove barriers to adoption. It is necessary to know the perception and attitudes of architects, designers, constructers, and not least attitudes of clients for implementation of MMC in the Slovak construction industry. Aim of this paper is, through a questionnaire survey, to identify the main benefits and barriers of MMC usage in Slovak republic in terms of experts (architects and constructors) in the construction industry. In this paper, there is also

statistically assessed (through t-test), whether respondents attitudes vary according to the company size, in which they work. For the perfect MMC implementation on the Slovak construction market is identification of main barriers (hindering the increased use of these methods) in terms of experts in the field of construction. Expert's barriers removing is very important, because only after that, architects will suggest buildings build by MMC to investors and constructors will want to build them. This would be the first step of wide acceptance of MMC in Slovak construction conditions.

4 STUDY OF MMC USAGE POTENCIAL IN SLOVAKIA IN TERMS OF EXPERTS

In order to identify the main MMC benefits and barriers in Slovakia in terms of experts the questionnaire was created and this study analyses data collected by questioning in the first half of 2015. A questionnaire was focused to find out the main benefits and barriers of using MMC in Slovak republic in terms of experts. Respondents (architects and constructors randomly selected from the listing in The Slovak Chamber of Civil Enginners) were asked by e-mail to answer eleven questions. Introduction to the questionnaire was focused on general information about the construction enterprise where respondent works. The main part was focused on the perception of the MMC benefits and barriers selected on the basis of comprehensive literature review. A five-point Likert-type scale was used, where 1 represented "completely disagree" and 5 stood for "completely agree". The questionnaire should reflect the real view of the Slovak construction industry on MMC and determine the main barrier hindering the increased use of these methods. In order to unveil the benefits and barriers of the applications of modern methods of construction, a questionnaire survey was conducted, which were sent to 427 respondents. Forty-eight have been completed and returned with a response rate of 11%. All respondents work in construction enterprise focused mainly on architectural engineering and 83% have experience with MMC. Breakdown of enterprises by size and by region is shown on Figure 5.

The purpose of this study is to evaluate perception of MMC benefits and barriers in terms of experts from the construction industry and determine the main barrier hindering the increased use of these methods. Aim of this paper is also statistical assessing (through t-test), whether respondents attitudes vary according to the company size, in which they work. In order to perform a statistical test (t-test) the answers of respondents were divided into two groups according to company size in which respondents work. The first group consists of architects and contractors from micro and small companies (under 50 employees) and the second group consists of respondents from medium and large companies (over 50 employees).

Our null hypothesis is: H0 = Attitudes on the MMC benefits and barriers of experts working in companies under 50 employees are the same as experts attitudes working in companies over 50 employees. The analysis of data is performed using the t-test to compare the mean responses for mentioned groups. Mean ratings are calculated from the feedback received. The t-test assesses whether the mean of the two groups are statistically different from each other. This analysis is appropriate to compare the mean of the two groups, and especially appropriate for comparison of two groups. Individual attributes, mean scores, gap sizes and the results of the attributes via the t-test analysis are presented in the Table 1. The significance level (α) for this study is set at 0.05. When the p-value is less than 0.05 then we reject null hypothesis and we accept alternative hypothesis H1 = Attitudes on the MMC benefits and barriers of experts working in companies under 50 employees are different as experts attitudes working in companies over 50 employees. Otherwise, we accept null hypothesis.

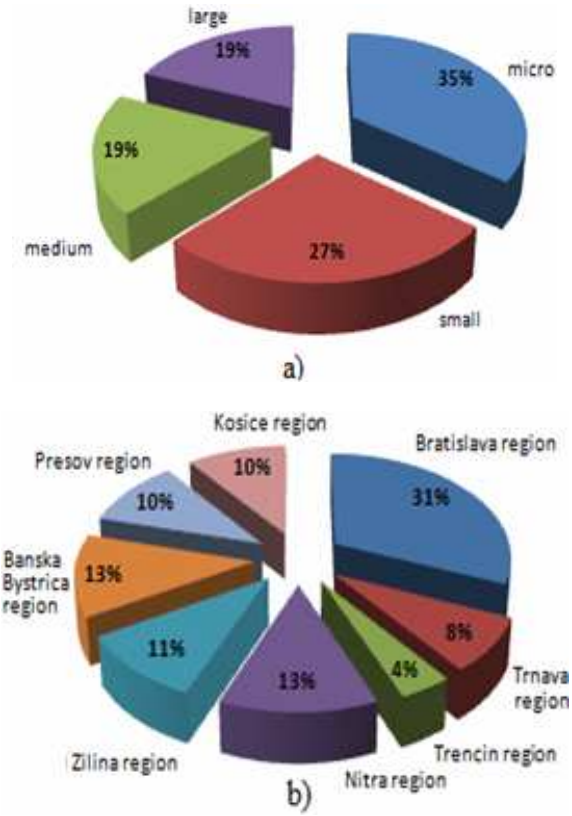

Fig. 5 Breakdown of questioned enterprises a) by size b) by region

5 RESULTS AND DISCUSSION

This section outlines the results from analyses conducted on empirical data obtained from the questionnaire survey, which was focused to find out the main benefits and barriers of using MMC in Slovak republic in terms of experts in construction. Perception of MMC benefits and barriers in terms of architects and constructors is summarized in Table 1.

Table 1 contains a list of 14 attributes, mean scores, gap sizes and t-test results. A five-point Likert-type scale was used in questioning, where 1 represented "completely disagree" and 5 stood for

"completely agree". Without taking into account the size of the company in which the respondents work, benefits mean values vary from 3.54 (Safer construction sites) to 4.13 (Controlled quality) and barriers mean values vary from 2.90 (Non acceptance by client) to 3.85 (Lack of expertise in implementation and installation). These results indicate that MMC benefits perception in term of architects and contractors in Slovakia is similar as perception in the world. As the greatest advantage was identified controlled quality. In identifying MMC barriers respondents agreed least with non-acceptance by client as a barrier and as the main barrier was identified lack of expertise in implementation and installation. Aim of this paper was also statistically assessed (through t-test), whether respondents (architects and constructors) attitudes, in Slovakia, vary according to the company size, in which they work. T-test analysis was used for comparison of mean values for all attributes. The mean value for all attributes was calculated for two research groups (companies under 50 employees and companies over 50 employees) and they were compared using t-test analysis (significance level $\alpha = 0.05$). As we can see in Table 1, p-value for majority attributes is higher than 0.05 so we accept null hypothesis, that attitudes on the MMC benefits and barriers of experts working in companies under 50 employees are the same as experts attitudes working in companies over 50 employees. In three cases p-value is lower than 0.05 so we reject null hypothesis, and accept alternative hypothesis that attitudes on the MMC benefits and barriers of experts working in companies under 50 employees are different as experts attitudes working in companies over 50 employees. The biggest difference of mean values (1.02) between two research groups was in perception of "Problem with joints" as MMC barrier. Respondents from bigger companies perceive this barrier to a greater extent as respondents from smaller companies. Different perception was noted also in perception of MMC benefits, namely "Safer construction sites" and "Faster project completion".

Tab. 1 Comparison of MMC benefits and barriers perception in terms of experts

times		Attributes	Mean		Gap	p-value	mean
			under 50employ.	over 50employ.			
Benefits	1	Reduction on site works	3.68	3.94	- 0.26	0.478	3.85
	2	Minimal wastage	3.64	4.11	- 0.47	0.189	3.83
	3	Less site materials	3.60	4.11	- 0.51	0.171	3.77
	4	Cleaner environment	3.52	4.11	- 0.59	0.072	3.77
	5	Safer construction sites	3.28	4.11	- 0.83	0.012	3.54
	6	Faster project completion	3.68	4.44	- 0.76	0.047	4.02
	7	Controlled quality	4.24	4.06	0.18	0.499	4.13
Barriers	1	Higher cost	3.36	3.55	- 0.19	0.626	3.42
	2	Problem with joints	2.64	3.66	- 1.02	0.007	3.08
	3	Non acceptance by client	2.80	2.83	- 0.03	0.926	2.90
	4	Problems in design alternation during or after construction	3.04	3.22	- 0.18	0.667	3.17
	5	Limited suppliers of prefabricated elements	3.24	3.33	- 0.09	0.819	3.31
	6	Preference of traditional methods of construction	3.72	3.72	0.00	0.995	3.77
	7	Lack of expertise in implementation and installation	3.96	3.61	0.35	0.337	3.85

6 CONCLUSION

The goal of this study was, through questionnaire survey, to evaluate and compare (through t-test) perception of MMC benefits and barriers in Slovak construction conditions between two groups: (i) architects and constructors from companies under 50 employees and (ii) architects and constructors from companies over 50 employees. More than 80% of the respondents had own experience with some kind of MMC. They were asked to answer eleven questions. The main part of questionnaire was focused on the MMC benefits and barriers perception. Results of questionnaire data analysis showed that in the majority (in 11 from 14 attributes) architects and constructors from companies under 50 employees have the same attitude to MMC benefits and barriers as respondents from companies over 50 employees. The questionnaire survey also confirmed that modern methods of construction have significant benefits. As the main benefits respondents identified controlled quality, faster project completion, reduction on site works and minimal wastage. Despite this, MMC has not been effectively implemented in Slovak republic. According this study we can claim, that the main barriers hindering the increased use of these methods are preference of traditional methods of construction and lack of expertise in implementation and installation.

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