

Factors affecting the use of modern methods and materials in construction

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Abstract. Sustainability of construction attracts much attention in construction industry. One of the factors driving this requirement is application of materials and components through modern methods and technologies. Modern methods of construction can be the way to obtain buildings assisting in minimizing the negative impact of construction industry on the environment. Article defines the factors affecting the use of these modern methods and materials of construction. At the same time it defines modern construction methods and materials that can be considered progressive in the construction process.

1. Introduction

The continued population growth affects the amount of construction. At the same time the need for housing and services is also increasing. Therefore increases the need to find new modern methods and materials for construction. Together with the needs of the population their demands for the development of technical and technological requirements steadily increases in all areas [1]. This results in the increasing demands for quality housing, which in turn also requires finding new ways and opportunities applicable in construction. One possibility includes modern methods and materials of construction. Prefabricated production construction represents mass production, which takes place in factories while greatly shortening the construction time and having positive impact on the environmental aspect. Modern construction methods and materials have very broad application in the construction industry. Their biggest advantage is ability to be implemented on site and also in the manufacture off-site, allowing shortening the time and increasing precision of construction. Usability of these methods is an important issue in regards of the ever increasing needs of the construction of buildings and structures.

2. Modern methods and materials of construction

Modern methods of construction can be defined as a method in which all building blocks (which are the walls, floor slabs, beams, columns and staircases) are mass-produced with high quality in the plant or in a place under the strict supervision [2]. The term "modern methods of construction" is launched in the UK as a common designation for off-site construction methods, using prefabricated elements or parts of structures, constructed off-site and then transported and assembled on-site and on-site construction methods when making building blocks and parts of structures take place directly on the site [1].

Esa and Nurudin [3] argued that the MMC is a continuous system used by craftsmen at each construction activity that uses production output to minimize wastage of resources and increased value to end users. MMC in construction includes an industrial process in which parts of the building are



conceived, planned, contrived, transported and erected on site. This system is a balanced combination of software and hardware components [4]. Between software features include a design that is a complex process of studying the requirements of end users, market analysis, development of standardized components, determination of the production and mounting arrangements, the process of allocating resources and materials, and definitions building designer conceptual framework. Software elements provide prerequisite to creating a favorable environment for the expansion of this industry.

Modern methods of construction are defined as those that ensure efficient management process providing more products of better quality with shorter time. The aim is to improve business efficiency, quality, customer satisfaction, environmental impact and sustainability. Modern materials are those that are used in modern methods of construction. Within the construction solutions are different types of materials whose main purpose is to speed up the construction process and minimize costs. The choice of material depends on the method of construction.

2.1 Classification of modern methods of construction

Modern construction methods can be classified in several aspects. At present, several authors start addressing this issue and the classifications in the literature is varying. The most common factor in the breakdown of modern methods of construction is production site. These methods are subdivided as follows [1] [5]:

- *Off-site production* - the production process takes place in a factory, off site. These include [6]:
 - *Systems of prefabricated houses* - consist of walls, floors and roofs in the form of prefabricated panels that are built at the place where they form a structure which then requires different levels of editing. The most commonly used open panels or frames that consist only of a skeleton and still need finishing work such as insulation and outer casing to be mounted directly on the spot. Another system which also used panels is closed. This is a more complex system more difficult to manufacture factory, which may include isolation and cladding material.
 - *Modular system* (volume / volumetric) - modules are composed and together constitute the structure of the building. This system allows the connection of a larger number of compatible modules on the spot, so often used to bigger, more standardized structures. Prefabricated modules are often referred to as cells, which are 80 to 95% complete internally in the factory, including mechanical and electrical services, and then transported to the final assembly site. They are mainly in specialized areas with typing and repetition, as kitchens and bathrooms.
 - *Hybrid* - This method combines a modular and panel system. Hybrid approach is used for the greater development opportunities while limiting uniformity of design.
 - *Sub-assemblies and components* - these methods can often be traditional, despite the use of factory assemblies or components. Examples include floor or roof boxes and kits prefabricated concrete foundations.
- *On-site production* - this approach involves technology and design systems that cannot fall into the category of off-site production. One characteristic of these methods is innovation. Illustrative examples are:
 - *"Tunnel form method"* - it is one of the most commonly used methods of cell construction. Characterized by cost efficiency, productivity and quality. This method is suitable for projects with more repeated components such as hotels, apartment buildings, student hostels. Using this technique it is possible construction of 40 floors and more. Construction process is simple and fast resulting in a 15% reduction in toll costs and 25% time savings. Construction of "tunnel" is formed by pouring concrete into the formwork, which forms the floor and walls. Every 24 hours, the formwork is moved so that it is possible to create another "tunnel". After completion of the deck, repeat this process to the next level.

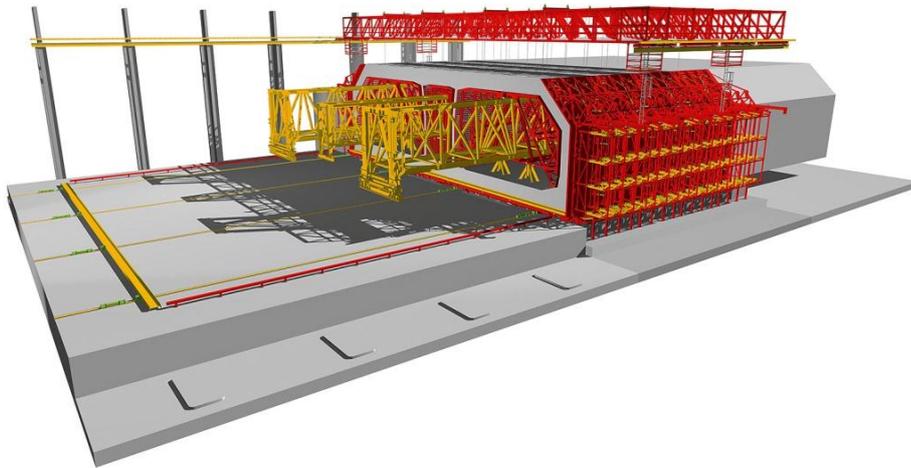


Figure 1. Tunnel form method [7].

○ *Thin-joint masonry* (easily jointed masonry) - method is characterized by rapid, clean and precise use of aerated concrete blocks, which are essential size and shape produced under strict standards associated with a thin layer mortar. This method combines shortening construction time with greater flexibility aerated concrete structures. It is characterized by the easy handling.

The following breakdown of MMC provides the classification of systems and their associated materials. As shown in Table 1, it is possible to distinguish three basic systems (frame, panel and modular system).

Table 1. Overview of construction systems and materials.

System	Category	Material
frame system	lightweight frames	wood
	mediumweight frames	metal, reinforced plastic, laminated wood
	hardweight frames	steel, concrete
panel system	light and medium heavy panels	wood, metal, composite material
	heavy panels (manufactured off site)	concrete
	heavy panels (manufactured on site)	concrete
modular system	medium weight modules (mobile)	wood, steel, composite material
	medium weight modules (fixed deposited)	wood, steel, composite material
	heavyweights modules (made on site)	concrete
	heavy modules (tunnel production on site)	concrete

1.1. Properties and characteristics of the use of MMC affecting on key factors

For successful implementation of construction using modern methods and materials one needs to examine their desired properties, which are briefly described below.

- Mass production

Investment in equipment and human resources associated with industrialization can only be justified in cases where the recorded volume production. Distribution of this size allows fixed costs for large quantities, without unduly increasing the final cost.

- Flow production

Production of large amounts of standardized prefabricated elements allows a high level of production process. This process can be divided into a larger number of larger tasks. In such system work, workers perform repetitive activities while increasing their productivity.

- Production Equipment

Capital employed for the initial investment is a very important factor. Plant, equipment and skilled workers must be obtained before they start production. Such huge investments may be used only if there is sufficient demand for the product. On the other hand, the production of the product may be carried out directly on the construction site, thus minimizing transportation costs.

- Equipment site

Construction and installation of prefabricated panels and their location on their position requires different equipment. In the case of construction of such a system it is important to incorporate sufficient operating costs. A typical device is a crane that is used in the construction of multi-storey buildings.

- Construction time

The use of different systems of modern methods of construction can significantly shorten the construction period. In a large extent this is influenced by the fact that these methods require less amount of work on the construction site. This is illustrated in Figure 2.

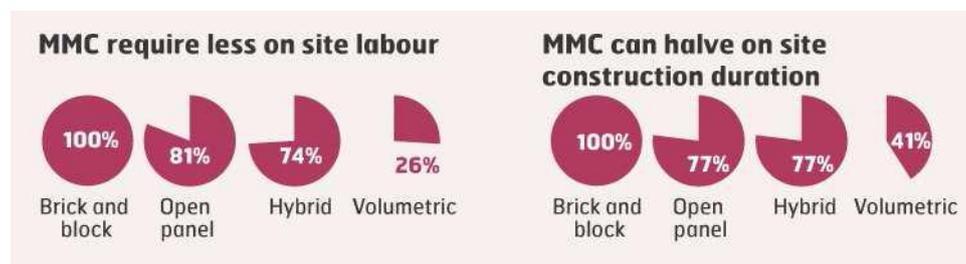


Figure 2. Degree of labor and construction time by using MMC [8].

- Modular coordination

Modular coordination is a unified management system for sizing space and components so that all elements fit into one another without any modifications, such as the trimming or lengthening, even if they are supplied by different manufacturers.

- Integration

Optimum results require a high degree of cooperation between the different parties, which are the designer, manufacturer, customer and supplier. This can only be achieved through an integrated system.

- Transport

Panels can reduce production costs by up to 30%. However, this saving is partially offset by shipping costs. Transport of large panels is also subject to certain restrictions. These limitations should be taken into account even for a friend that method of construction.

3. Factors and barriers affecting the use of MMC

These are not all advantages of using modern methods and materials in construction. They are closely related to factors that influence the use of MMC. Several authors have attempted to define the key factors. These factors include the following [1] [8]:

- political context,
- construction skills,
- quality of construction,
- costs,
- pace of construction and construction time,

Sustainability of construction is one of the main reasons to use modern progressive methods and materials of construction. Currently, the pressure on the sustainability of construction is increasing. There are several perspectives on sustainable construction. One is the economic view. Important is the social aspect and the environmental aspect also. It also has an impact on creating the environment in the form of legislation. Process automation, emphasis on environmentally friendly materials and technologies in the construction process is large.

- Construction skills

Construction skills are an important factor in choosing construction methods and materials. Progressive materials are in many cases difficult to integrate into the construction process because of the lack of knowledge about them. Construction companies should seek training programs for employees. Emphasis is on knowledge about new materials and work with them.

- Quality of construction

Quality construction and final construction work has a significant impact on the decision on the selection of materials and methods of construction. Perceived quality construction also plays a big role. Progressive materials should not only be flexible in terms of time and cost of construction sites, but also quality.

- Costs of construction

Perception of costs is very sensitive. Economic assessment of projects is often the basis for decision making. In general, it is the pressure to develop economically available materials. Modern methods often offer more efficient use of materials. When using modern methods of construction, costs are minimized, which has a positive effect on their use. [9]

- Pace of construction and construction time

For decision making, the choice of materials and methods used in construction is also important for planning the duration of construction time. The use of MMC has positive impact on the construction period. This is one of the biggest advantages of using these methods.

4. Conclusion

The use of MMC has indisputable advantages. Several studies declare an economic advantage and shorten the construction period. Similarly, the use of progressive materials has a positive impact on the sustainability of construction. Defining of these benefits is very important for several reasons. One of them is the interconnectedness of the key factors in the use of MMC and advanced materials in the construction with their advantages. These are characterized by multiple authors. Together with the economic efficiency of the solution the important factors are also building skills. The need for education and dissemination of material knowledge is the basis for their use.

The use of new materials and MMC has the potential in the future. In view of the growing need for sustainable construction projects is the assumption that they will benefit from an even larger extent than at present.

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References

- [1] Bašková R and Kyjaková L 2013 *Parametrizácia konštrukčných riešení stavby pri uplatnení moderných metód výstavby* In: Multi-dimenzionálne prístupy podporujúce integrované navrhovanie a riadenie stavebných projektov
- [2] Richard R B 2006 Industrialized, flexible and demountable building systems: Quality, economy and sustainability *Proc. of the CRIOCM 2006 Int. Sympos. on "Advancement of Construction Management and Real Estate"*
- [3] Esa H and Nurudin M M 1998 Policy on industrialised building systems *Report on Colloquim on Industrialised Construction System Kuala Lumpur*
- [4] Jaillon L and Poon C S 2009 *The evolution of prefabricated residential building systems in hong kong: A review of the public and the private sector*
- [5] Bura Steering and Development Forum Report October 2005 *Modern Methods of Construction - Evolution or Revolution*
- [6] Gibb A G F & Pendlebury M C 2005 *Buildoffsite Glossary of Terms*
- [7] Incremental launching forming machine for the world's longest underwater tunnel [online resource] http://www.peri.com/en/press/press/press-releases/pm2013/hzmb_china.cfm
- [8] Lane A 2006 *Barriers and solutions to the use of modern methods of construction*
- [9] Kozlovska M and Zupova L 2013 Modern methods of construction as a challenge for energy efficiency buildings *Proc. of 13th Int. Multidisciplinary Scientific Geoconf.: Nano, bio and green - technologies for a sustainable future* (Albena, Bulgaria) 677-684