

LENKA KYJAKOVÁ\*, RENÁTA BAŠKOVÁ\*

## ADVANTAGES AND DISADVANTAGES OF MODERN METHODS OF CONSTRUCTION USED FOR MODULAR SCHOOLS IN SLOVAKIA

### ZALETY I WADY NOWOCZESNYCH METOD ZASTOSOWANYCH W KONSTRUKCJI MODUŁOWYCH SZKÓŁ NA SŁOWACJI

#### Abstract

Term of “modern methods of construction” (MMC) comes from the United Kingdom as a common name for off-site and on-site methods of construction. Modular constructions consist of three-dimensional objects known as modules (off-site methods of construction). Modules are joined together at the construction site. Currently, the construction of modular schools in Slovakia is supported by the state government. This paper presents the advantages and disadvantages of MMC emerging at the technological preparation and implementation stages of buildings, which are manifested in modular schools.

*Keywords: modern methods of construction, off-site methods of construction, modular schools*

#### Streszczenie

Termin „nowoczesne metody budowy” (*modern methods of construction*) w skrócie MMC, pochodzi z Wielkiej Brytanii i jest to potoczna nazwa oznaczająca zarówno metody realizacji konstrukcji modułowych poza miejscem budowy, jak i na miejscu budowy. Konstrukcje modułowe składają się z obiektów trójwymiarowych – modułów (metod poza miejscem budowy), które są łączone ze sobą na miejscu budowy. Obecnie budowa szkół modułowych w Słowacji jest wspierana przez państwo. Przedstawiono wady i zalety MMC na etapie przygotowania technicznego budynków i budowli oraz realizacji dla szkół modułowych.

*Słowa kluczowe: nowoczesne metody budowy, metody poza miejscem budowy, szkoły modułowe*

\* Ph.D. Lenka Kyjaková, student, Ph.D. Eng. Renáta Bašková, associate professor, Civil Engineering Faculty, Institute of Construction Technology and Management, Technical University of Košice.

## 1. Modern methods of construction

### 1.1. Definitions and classification of modern methods of construction

The majority of buildings are still constructed using traditional technology (masonry, concrete). However, in the last few years there has been an increasing use of modern methods of construction (MMC) for housing, driven by a range of factors including demands for faster construction, skill shortages, and sustainability.

The modern methods of construction primarily involve the manufacture of components in factories, with potential benefits such as faster construction, fewer housing defects, and reductions in energy use and waste [1, 6], all of which offer significant potential to minimize both construction waste [2] and construction safety risks.

The term, modern methods of construction (MMC), comes from the United Kingdom as a common name for off-site and on-site methods of construction. Off-site MMC refers to modern methods of construction which has predominantly been manufactured and assembled in a factory-controlled environment. On-site MMC refers to modern methods of construction which brings together systems or components that are predominantly assembled on site. Virtually all high quality products are built in factories around the world. Cars, planes, ships, computers, printers, cell phones – even the pen you write with – are built in factories. In addition, even homes built on site use many components that were produced in factories [3].

By studying the works of various authors [1, 2, 4, 5, 6] the following classification of MMC was prepared. According to this, we can divide the off-side MMC products into sets, which are further divided into systems. Systems are then subdivided into components.

- volumetric construction
  - modular construction
  - pod construction
- hybrid construction
  - semi-volumetric construction
- panel construction system
  - open panels
  - closed panels
  - structural insulated panels – SIPS
  - composite non-structural insulated panels
  - prefabricated parts
  - light-weight composite solid precast sandwich panel
- natural materials from renewable sources
  - timber frame construction
  - multi-layered engineered timber (solid)
  - components from renewable materials
- light-weight facades
  - brick slips
  - facade cladding
  - external insulation accessories

- sub-assemblies and accessories systems
  - floor or roof cassettes
  - pre-cast concrete foundation assemblies
  - pre-assembled products.

### 1.2. Modular construction as one of the components of MMC

As shown in the outline above, modular construction is one of the modern methods of construction. Each modular construction consists of several separate modules. A module is characterized as a three-dimensional object, which, by its size, is able to provide utility space. Each module consists of a frame, floor, ceiling, walls, and other accessories [7]. The modules are intended for permanent or temporary living, sanitary purposes, storage, etc. The comfort grade of the module depends on customer requirements or offers from suppliers. The modules are not assigned only for new buildings; they may be used for additions and superstructures to buildings, or they may be built into existing buildings. The steel structure consists of hollow profiles and rolled, self-supporting, anticorrosion primer, and polyurethane topcoat paint. The standard container module has a galvanized profiled sheet. Atypical containers can have final surface treatment such as wood, metal, fiber-cement or plaster. Figure 1a) shows the steel frame construction; 1b) is the complete module.

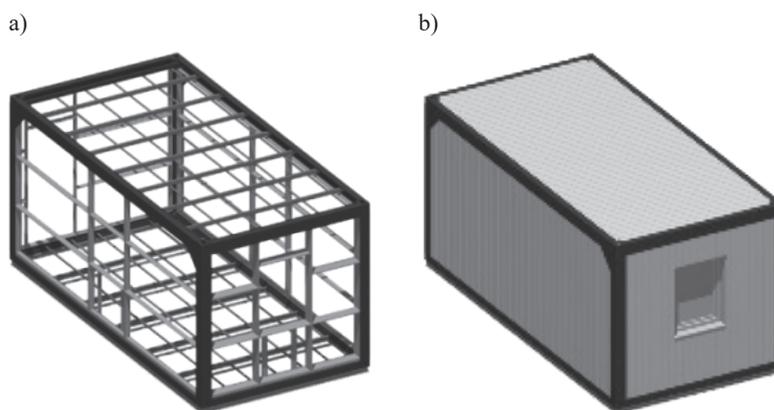


Fig. 1. The supporting structure of module: a) steel frame, b) complete module [7]

## 2. Modular schools in the Slovakia

The construction of modular schools in Slovakia is supported by the state government. The Ministries of Education, Science, Research and Sport, together with the Ministry of Finance in consultation with the Office of the Plenipotentiary for Roma Communities, has decided to provide financial support for the construction of modular schools for regions with insufficient capacity of school facilities. Villages could apply for the support from

a school project known as “Challenges for social and cultural needs and solutions extremely unfavorable situation of marginalized Roma communities” [9], worth up to 200,000 EUR. Overall, in the first stage of the project in 2013, the state managed to build or expand the capacity of several primary schools. The project is based not only on state funding, but also significant contributions by municipal governments, which provide project documentation, land and any other necessary infrastructure.

Based on the analysis of the basic design of five modular schools (Tab. 1) built in Slovakia in 2013, it is clear that two specific schools are identical in terms of the number of classes, the number of modules for each class, or the total number of modules. Classes consist of three modules, with one module having dimensions of 2604 mm × 6830 mm. Cabinets for teachers are composed of two modules. The total number and the design of the modules for each modular school vary depending on the number of floors [7].

Table 1

**Overview of modules of modular schools built in Slovakia in 2013**

|   | Village            | Number of classes |             | Number of modules for classes | Total number of modules |
|---|--------------------|-------------------|-------------|-------------------------------|-------------------------|
|   |                    | Ground floor      | First floor |                               |                         |
|   | Strane pod Tatrami | 8                 | –           | 24                            | 33                      |
|  | Podhorany          | 4                 | 4           | 24                            | 40                      |
|  | Krizova Ves        | 4                 | 4           | 24                            | 28                      |
|  | Jarovnice          | 8                 | –           | 24                            | 33                      |
|  | Kečerovce          | 5                 | 6           | 29                            | 40                      |

By analyzing the information obtained from abroad and in Slovakia, we can conclude that modular technology has significant potential in modern architecture. As reported by foreign authors, modular construction has a number of benefits over traditional construction. On the website of the Ministries of Education, Science, Research, Sport, and Finance [10], it is stated that the investment in the construction of modular schools in Slovakia is only about a quarter of the cost for the construction of a traditional masonry school.

### 3. Advantages and disadvantages of modern methods of construction

Many of the benefits of using MMC for housing are still unproven or contentious. On the other hand, the advantages and disadvantages are closely related to the drivers and barriers of prefabrication use [8].

Table 2

**Advantages and disadvantages of modern methods of construction**

| Advantages of MMC  | Disadvantages of MMC   |
|--|--|
| Smaller demands on facilities and equipment construction site  | requirements for size and site equipment for handling MMC components MMC                   |
| Safer working environment at the off-site production of building components; faster construction over labor costs              | security risks when mounting MMC components MMC at the construction site                   |
| The possibility of using state budget funds, special purpose funds, or foundations   | higher costs for construction products (prefabricated and higher costs for subcontracting) |
| Fewer design errors and better quality in the manufacturing of components  | initial costs of setting up a production line for manufacturing components                 |
| Easier quality control at the factory  | time-consuming proposals   |
| Less waste on the construction site and less environmental pollution during construction easier quality control at the factory | compliance and quality control in the contact joints                                       |
| Less waste on construction site and less environmental pollution during construction   | multiple transport materials: into the factory and from factory to construction site       |

According to Doherty, [4] there are always three aspects that are the most fundamental for an investor: cost, time and quality. The Eternal Triangle states that you cannot alter any aspect without directly affecting the other two. Authors [1] divided the advantages of MMC according to three pillars: a) *economic* – MMC houses typically have fewer defects and can be built more quickly, the components are of better quality and higher standards, the construction process can be sped up by the mass production of prefab components in factories; b) *social* – there may be fewer accidents and less impact on local residents during construction, it reduces labor-intensive activities and provides a safer working environment,

designers from different disciplines can work closely together in the early design stage to help to reduce abortive work; c) *environmental* – the houses can be more energy-efficient, may involve less transport of materials, and produce less waste.

On the basis of foreign studies, we have summarized the advantages and disadvantages of modern methods of construction used of modular schools (Table 2).

#### 4. Conclusions

This article focused on the advantages and disadvantages of modern methods of construction used for modular schools. We can establish the main advantages of MMC used for modular schools: less partial processes (specialized team) on the construction site; smaller demands on facilities and equipment at the construction site; lower labor costs; the possibility of using state budget funds, special purpose funds, or foundations; safer working environment at the off-site production of building components; faster construction; higher productivity in construction; fewer design errors and better quality in the manufacturing of components; easier quality control at the factory; less waste at the construction site; less environmental pollution during construction; better working and social conditions in the manufacturing. Among the disadvantages we can include: new (non-traditional) technological processes; requirements for size and site equipment for handling MMC components; higher costs for construction products (prefabricated); higher costs for subcontracting; initial costs of setting up a production line for manufacturing components; security risks when mounting MMC components at the construction site; time-consuming proposals; lack of experience with the implementation of MMC; compliance and quality control in the contact joints; multiple transport materials: into the factory and from factory to construction site; distrust of the new system.

The project was implemented by the Ministries of Education, Science, Research, and Sport, in cooperation with the Ministries of Finance, Government Plenipotentiary for Roma Communities, and representatives of regions continuing in 2014. After a positive response in the regions and more requests from the municipalities, the government has allocated 3 000 000 EUR for additional modular schools. The construction of modular schools has proceeded in other villages: Chminianske Jakubovany, Gemerská Ves, Muránska Dlhá Lúka, Dunajská Lužná, Miloslavov and Žehra.

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