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## MODULAR CONSTRUCTION INDUSTRY GROWTH AND ITS IMPACT ON THE BUILT ENVIRONMENT

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### DYNAMICZNY ROZWÓJ BUDOWNICTWA MODUŁOWEGO I JEGO WPLYW NA PRZESTRZEŃ ARCHITEKTONICZNO-URBANISTYCZNĄ

#### **Abstract**

The article deals with the problem of increasing demand for modular buildings as an answer to the construction industry's current situation. The author addresses the following question regarding the near future of the modular construction industry: How would it reflect on urban space, living space and the whole attitude toward modular construction issues? What is the role of the architect during the design-build process? Is it possible to make references to "beauty" in a modular construction context?

**Keywords:** volumetric modular construction, modular construction, off-site, assembled architecture, permanent modular architecture

#### **Streszczenie**

Artykuł podejmuje problematykę rosnącego popytu i zapotrzebowania na realizację obiektów na podstawie wolumetrycznej technologii modułowej. Autor stawia pytanie o przyszłość budownictwa modułowego. Jaki wpływ będzie ono miało na kształtowanie przestrzeni miejskiej i na przestrzeń życiową? Jaka jest rola architekta podczas procesu zaprojektuj-wybuduj? Czy możliwe jest odniesienie wartości „piękna” do rozwiązań w systemie modułowym?

**Słowa kluczowe:** wolumetryczne budownictwo modułowe, prefabrykacja, budownictwo modułowe, architektura

## 1. Introduction

Investment in the construction sector has been dynamically growing for several years. According to the European Construction Market Forecast [1] the growth is expected to continue into 2019 and 2020. European construction growth is broad-based and occurs in all major sectors: residential, non-residential and civil engineering [14]. The construction market is at a significant moment. However, this idea relates not only to the dynamic and constant growth of the industry's input but also to many issues which construction is currently facing.

There are several factors shaping the current situation. Mark Farmer, in his report on the UK's market "Modernise or Die" [2] suggests that the UK's construction industry faces "inexorable decline" unless longstanding problems are addressed. He identified several critical symptoms of failure, particularly the labor shortage (which relates to demographic issues as well as the poor image of the construction industry), low predictability in the sector, its lack of innovation and collaboration, and its non-existent research and development (R&D) culture. These symptoms are common to many countries in the European Union and North America. High levels of cost inflation, driven by labour shortages, have caused numerous delays as costs have risen prohibitively.

This current situation pushes the construction industry into a modern method of building and has a direct impact on the increased demand for modular construction. There are many advantages of the modular construction method. However, in the majority of cases, one of the main reasons for using modular technology is to speed up the delivery time which, compared to traditional on-site construction, can create buildings in a much shorter time frame. The schedule reduction is the biggest incentive that this method of construction ensures. It is also one of the largest claims that the industry has and the major motivation behind why permanent modular construction is used in the projects [4, p.10]. As evidence of the changing approach, it is worth mentioning that many of the public tenders in Germany require the modular construction method instead of the traditional. This is an absolutely great opportunity for the modular industry market to grow. At the same time, this challenge carries a major threat, when time is the main goal. The design and build process characteristic of the modular construction industry often limits the role of the architect and architectural design. The most promoted features are related to schedule-reduction, cost-reduction, number of units, and multiplication. The values such as relation to the urban context, aesthetic and architectural form seem to be overlooked. How would they reflect on the urban space, living space and whole attitude to modular construction issues? What is the role of the architect in the modular construction industry? Is it possible to make references to "beauty" in the context of modular construction?

## 2. Background – The Advantages of Modular Construction

Modular construction is a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing that meet the same codes and standards as conventionally built facilities – but in half the time (Fig. 1). Buildings are

produced in “modules” that when put together on site, reflect the identical design intent and specifications of the most sophisticated site-built facility – without compromise (Modular Building Institute). There are two types of modular construction: Permanent Modular Construction (PMC) and Relocatable Buildings. Permanent Modular Construction is a method of construction that greatly differs from temporary buildings, such as construction trailers or mobile homes. According to the Modular Building Institute’s definition, PMC is an innovative, sustainable construction delivery method utilizing offsite, lean manufacturing techniques to prefabricate single or multi-story whole building solutions in deliverable module sections. PMC buildings are manufactured in a safe and controlled setting, and can be constructed of wood, steel, or concrete. The structures are 60% to 90% completed in a factory-controlled environment and transported and assembled at the final building site [11]. PMC, as an off-site solution, is deemed a higher quality, faster to market, and a greener solution than traditional stick-built, site-built construction. They are custom-designed commercial buildings much the same as their traditional site-built counterparts (MBI Website). In many cases, using PMC does not change the design, structural system, or options for finish materials. The main difference is the method of construction [3, p. 17].

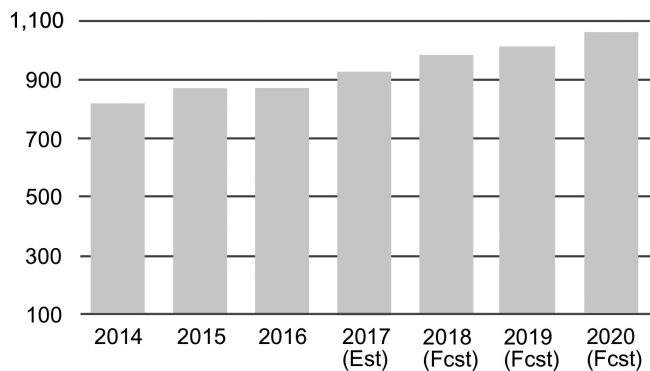


Fig. 1. Diagram of Modular Construction Schedule vs. Site Built Construction Schedule (Source: [11])

Many studies and reports indicate the undeniable superiority of modular construction over traditional buildings<sup>1</sup>. According to a recent report entitled, “Permanent Modular Construction: Process, Practice, Performance”<sup>2</sup> – published in 2015 by the University of Utah – the following are the key findings which prove that there are several advantages of permanent modular construction, when compared with traditional construction. Regarding the Quantitative Analysis, the resources saved are:

- ▶ Schedule: 39%
- ▶ Cost: 16%

<sup>1</sup> One of the most recent reports is: [4].

<sup>2</sup> The research focuses on commercial construction and does not include single family residential. The research uses a case study method to compare PMC projects to traditional site-built projects globally for construction performance parameters such as cost, schedule, quality, and safety.

- ▶ Quality: 5.4 Average Change Orders
- ▶ Safety: 0.25 Average Safety Incidents

Regarding the key benefits (there are more, ones related to ecological issues, etc.) of using permanent modular construction, they are the following: schedule reduction during the construction phase, product quality (the monitoring system ensures stable, constant quality) and site operations [4. p. 3–15]. However, when analyzing numerous documents and articles, including the abovementioned, it is noted that one important element is frequently omitted – aesthetically pleasing architectural design. Nevertheless, architecture based on modular construction should still represent a work of art. According Vitruvian theory, a good building should satisfy the three principles of durability, utility, and beauty (Latin: *firmitas, utilitas, venustas*) [19]. Unfortunately, the majority of modular buildings reduce the architecture to numerical parameters and engineering. The assessment criteria usually concerns execution time, manufacturing time, assembly time, and the number of units [15]. This problem increases with the dynamics of the development of this construction sector, which in recent years has gained a very high rate of growth.

### 3. The Boom of Modular Construction

Last years present extremely dynamic growth of the modular construction industry market. One of the fastest growing markets are the United Kingdom, the United States and China. For example, in China, in March 2017, the Ministry of Housing and Construction promulgated the “Thirteenth Five-Year Plan” of Action for Assembled Buildings, which calls for the comprehensive promotion of the development of assembled buildings. By 2020, the proportion of assembled buildings in new buildings in China will reach more than 15%. In some promoted key areas – like the urban agglomeration in the Pearl River Delta – by the end of 2025, the proportion of assembled buildings to new buildings will be more than 35%, and the proportion of government-invested projects to assembled buildings will be more than 70%. The fact that China is the country with the world’s largest population (1 390 080 000 inhabitants) and the third largest in terms of size, enables one to conclude that assembled buildings in China will have a significant impact on the global construction industry.

Regarding the U.S. market, which is the fourth largest country in the world in terms of size, modular broadly is estimated to make up 3–5 % of the total construction industry (MBI, 2018) and is still growing. Since 2014, the value has increased from 2,38% to 3,27% for year 2017<sup>3</sup>.

While focusing on European examples, the UK market for modular buildings is estimated to have increased by 6% in 2017. What is very important to indicate that the UK government is to priorities use of offsite manufacturing to improve the cost effectiveness, productivity and speed of construction delivery<sup>4</sup>. The market value includes factory-made, fully assembled

<sup>3</sup> Based on the presentation on Dave Sikora, the MBI’s Board Member, at the MBI Meeting in Munich, on 26<sup>th</sup> Sept. 2018.

<sup>4</sup> There are several publications ordered by UK government, i.e.: Farmer Review 2016: Modernise of Die; The Farmer Review of the UK Construction Labour Model’ was commissioned in February 2016 by the Construction Leadership Council at the request of the government.



Fig. 2. UK Market for Volumetric Modular Building and Temporary Accommodation – 2014–2020  
(Source: [8])

3-dimensional modules. The biggest market for modular construction products includes housing (including majority part of temporary accommodation), education, healthcare and hospitality industry (hotels). Over the next few years, to 2020, steady growth is forecasted in the sector. Importantly, there is now a strong likelihood of an increase in the use of volumetric to help meet the chronic housing shortage and cope with the lack of traditional construction skills within the construction industry [8].

#### 4. Modular Buildings: From Container-Based Temporary Accommodation to Modular Turn-Key Luxury Hotels

It is difficult to overlook the EU migrant crisis<sup>5</sup> which has seriously increased the demand for modular construction in the European Union as well as the image of modular construction, including a negative impact on the urban space [10]. There are many modular housing estates or complexes (permanent as well as temporary accommodation) built “in a rush” for refugees in Germany, including in such cities as Hamburg, Munich and Dresden. However, there is still a huge lack of housing, as well as schools and kindergartens for new inhabitants-migrants. There are more than 400,000 apartments needed in Germany to meet increasing demand [9]. Conventional construction methods (based on long-term processes and on-site construction) have not been able to carry this challenge in such a time frame. Modular construction methods of building are the most promoted by both public sectors (tenders) and private ones.

What does this demand actually mean – aside from the economic benefits – for the modular construction industry and built environment? Facing such a big challenge in a very short time frame means that the risk of failure is much higher. From the architectural and urban perspective, the failure mostly refers to the architectural design and the quality, resulting in an impact on the urban landscape and the society. Providing fast solutions often means creating temporary

<sup>5</sup> The European refugee crisis in the 21<sup>st</sup> century is described as the most serious since the Second World War. According to Eurostat, in 2015, EU member states received over 1.2 million first time asylum applications, a number more than double that of the previous year [1]. The highest number of first time applicants was registered in Germany, with 35% of all first time applicants in the EU member states [1].



shelters, low quality grey boxes or containers. Indeed, many projects are planned as temporary accommodations that will be relocatable or will just collapse in three to five years. [15]. However, many of them will remain permanently in the built environment, shaping the housing environment and human life.

Time and money are indeed the key benefits of factory-built construction versus traditional construction, and the main reasons for increasing demand for permanent modular construction. It is good to see that, next to those key advantages that define important boundaries for the whole design and build process, there are examples, in which values such as architectural form and its impact on the urban space constitute an important element of the project based on modular construction technology.

Parallel to this situation in Europe, there is a quality modern hospitality industry growth driven by modular construction. Some experts even note the revolution in the hospitality industry, the modular construction method a major contributor to this process. The world hotel chains, including some of the largest, started to use modular construction method to provide their hotels in a much shorter time frame (thus ensuring a quick return on investment). For example, a Netherlands-based hotel chain – CitizenM – build several hotels based on turn-key modular guestrooms in Europe and US. One of the most interesting project is the Hotel CitizenM Tower of London which is located in London, within the World Heritage Site. The scheme was developed with consideration of the historical part and was designed to integrate within Trinity Square’s townscape, as well as to work harmoniously with the numerous historical assets within the site’s surroundings. The site design phase has involved the creation of a complex basement, connecting two lifts to the Tower of London tube station [16]. The project was designed by AnyoStudio



Fig. 3. Modular Hotel: CitizenM Tower of London, London, UK  
(Source: Image via official citizenM website [20])

and presents a breakthrough in which the modular building – designed with particular care - is located in the historical and central part of the City, creating sensitive and contextual contribution to the World Heritage Site. The architectural focus on details, proportions, materials, as well as relation to the urban landscape presents very good example of cutting-edge modular architecture.

Another example presents the biggest hotel chain and well recognized world luxury hotel brand –the International Marriott, is strategically expanding in North America based on modular construction. In the next few years, the company plans to build around 50 modular hotels in North America. If such a powerful brand can choose this method, it represents a big step in moving modular construction to a higher level, one in which high quality luxury products and modular construction can be identified as integral elements. At the turn of 2019 and 2020 AC Marriott plans to open the world's tallest modular hotel. A new 25-story AC Hotel by Marriott is planned at 842 Sixth Avenue, very prestige location in Manhattan, New York City. The hotel will include 168 turn-key modular guestrooms, which will create 21 modular stories (the base, which includes the first four stories, will be built with conventional technology). The hotel is designed by New York-based architect Danny Forster, who makes a significant statement on his website “high-quality consistency marries inventive architectural expression, with a sophisticated balcony strategy that puts to rest the

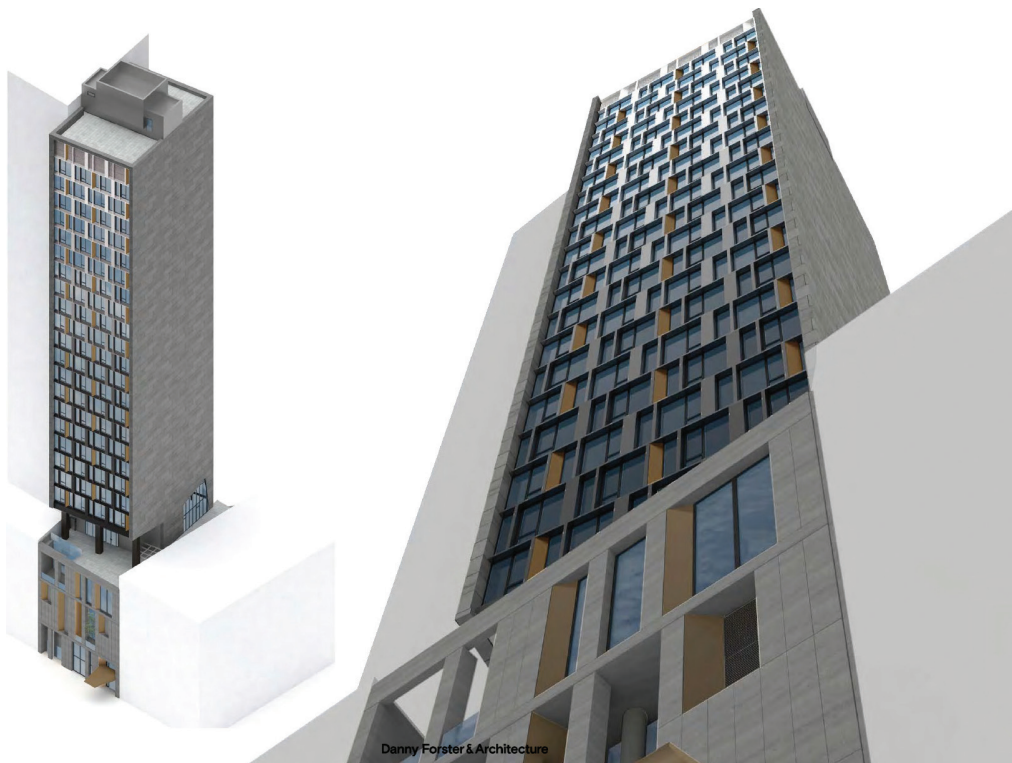


Fig. 4. Modular Hotel: AC hotel by Marriott, project destination: Manhattan, New York, UK (Source: [17])

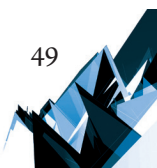




Fig. 5. Modular Hotel Extension: Bonifacio Spa and Sport Resort, Sochocin, n/Warsaw, Poland (Source: [18])

stigma of the cheap pre-fab double-wide” [17]. This idea is a proper expression of the current trend in the modular construction industry, where, more and more, architects are emerging as creators and image-transformers.

Another interesting modular example is extension of the four-star Hotel Bonifacio Spa and Sport Resort in Poland. The hotel is located in the center of a wonderful landscape, on a forest clearing in the picturesque scenery of the Wkra valley, about 70 km from Warsaw. The sophisticated location is an intriguing challenge that only this technology could meet. The development of the hotel in such a lush place, while ensuring the silence and comfort of guests staying in the existing part of the hotel, was only possible by limiting the heavy work to a minimum, and thus the noise, pollution and discomfort characteristic of traditional construction methods. The new section, which consists of 34 modules, was assembled in less than 10 days, while in traditional construction, it would take around eight months. The add-on consists of a two-story building. The first floor includes the spa rooms and the fitness facility, while the second one includes eight guestrooms. Due to the extension, the new modular segment had to follow the props and composition of the existing part, since it would consist of a new and better quality in relation to the existing building. The project was designed and built by DMDmodular[18], the Polish-based manufacturing company lead by architects that aims to integrate three crucial features: beauty, design, and modular technology.



## 5. Conclusions

Despite the overwhelming presence of the modular construction developments lacking high aesthetic values which are a carrier of negative connotations, there is more and more projects that present the changing approach to the modular construction market. Modular Construction technology gives some huge possibilities for architectural creations. The key benefits – competing for traditional technology – are also a base of a much wider range of aesthetic options that allow designers to achieve architectural variety. The last years demonstrated the growing role of the architect during the design-build process based on modules. Architects emerged as stigma-breakers and image-transformers of the dominant negative associations with off-site construction.

Although the process of using modular technics by hospitality sector is very fresh, because it started significantly only three years ago, it is suspected that hospitality sector based on modular construction might play a crucial role in redefining image, the position on modular architecture in wider design & visual context by providing cutting-edge architecture.

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