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Research Article

Administrative Modular Buildings/ Co-Working Spaces. A review

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Abstract – The paper presents an analysis of the current state of administrative modular buildings and co-working spaces in some European countries and Latin America. The study provides an overview of the concept of modular buildings and co-working spaces, including their history and evolution and their energy efficiency. They also examine the benefits and drawbacks of these types of buildings, as well as the factors that contribute to their success.

The authors analyze several case studies of administrative modular buildings and co-working spaces in different European countries and Latin America, such as the UK, Germany, Slovakia, and Ukraine ending with Brazil. The paper takes into consideration the design and construction of these buildings, as well as the services and amenities they offer.

The paper also considers the impact of administrative modular buildings and co-working spaces on the environment, as well as their potential for promoting sustainable development. The authors discuss the challenges and opportunities associated with the development of administrative modular buildings and co-working spaces and provide recommendations for future research in this area. Energy-efficient modular buildings and co-working spaces have the potential to support organizations in achieving their sustainability goals while also providing a range of benefits for employees and stakeholders.

Keywords – Administrative Modular Buildings, Co-Working Spaces; Energy Efficiency; Cost Savings; Flexibility

I. INTRODUCTION

Any construction method that makes use of standardized parts in order to construct a structure that is substantially larger than the parts is known as modular architecture. The components have to be straightforward in order to replicate and put them together [1].

Today, the development of a nation's economy is largely dependent on the building industry. The construction industry is required to meet the demands for housing proposals, administrative buildings, infrastructure, and other operations. The most popular building techniques worldwide right now are on-site projects. This old approach has several drawbacks, including inefficiency, safety issues on the job site, extended project completion times, decreased quality, cost overruns, and increased construction waste [2], [3].

In Europe, modular buildings are not new. Since more than 50 years ago, it has been in use. Its quick construction, tremendous variability, and little environmental effect contribute to its success. Modular structures provide the ideal response to circumstances that require flexibility and speed [4].

Han Slawik, a German architect, is one of the most well-known representatives of container architecture in Europe and is recognized for some successful realizations [5]. Le Corbusier's module, which expresses the given system, is the module's most intricate component. He combined the convectional scale with the human scale. Meanwhile, in so-called sandwich system structures, the module of a modular design is made of different materials. All of the modules that make up the building are assembled to be the same size [6]. Different companies that produce modular items will adopt modular organization forms due to the benefits of modular structures. Only a few explicit causal models and even actual studies support this linkage [7]. There are nonetheless reasons to think that modular organizational models might not be adopted. The advantages exceed the dangers and expenses of doing so [8].

A new area of research that examines the hitherto underappreciated expenses of planning and sustaining a modular building benefits from modular construction [9].

In contrast to the conventional construction process, several of the major industrialized nations are refocusing on novel construction techniques. Organizational design became modular as a result of product design modularity. Unit coupling, independent functioning, and simple setup are all implied by modularity.

Citizens are often served by public buildings, and many of those services are free. There are several types of public buildings, including post offices, courthouses, administration buildings, public schools, hospitals, and libraries [10].

The administrative building carries a wide range of design vocabulary such as location, form, functionality, circulation, etc. These factors help us to understand them, providing interconnections between spaces, and comfort to the visitors and staff [11].

Governance, on the other hand, plays a crucial role as a buyer and supplier of modular constructions related to administrative buildings that interact over time. Past behaviors can increase trust between contracting partners [12].

Generally, modular administrative buildings have to match the historical appearance of the neighborhood when it is constructed within the city. Innovative and unique architectural enhancements are introduced in order to ensure the blending of the building with the historical appearance of the surrounding structures. The designing of such structures also aims to implement highly functional and secure interiors as well [13].

Modular architecture must respond to the needs of the community, to the production of economically affordable housing and administrative buildings, to the lack of space in the city, and to an eco-friendly way of life. Modular constructions are smart and a comfortable solutions for today’s lifestyle [14].

II. MODULAR ADMINISTRATIVE BUILDINGS IN NORTHERN EUROPE. A REVIEW

Modular administrative buildings have become increasingly popular in recent years due to their versatility, cost-effectiveness, and flexibility. Northern Europe is a region that experiences extreme weather conditions, which makes it challenging to construct permanent buildings. Therefore, modular buildings are an ideal solution for administrative purposes in this region.

Modular administrative buildings offer several benefits in Northern Europe. Firstly, they are prefabricated in a controlled factory environment, which guarantees quality control and minimizes waste. Secondly, they are easily transportable, which is advantageous for remote locations. Thirdly, they are customizable, allowing them to be adapted to different locations, purposes, and environmental conditions. Finally, they are cost-effective, making them an attractive option for businesses and governments with tight budgets.

Despite the many benefits of modular administrative buildings, there are also some challenges to consider. One of the main challenges is the extreme weather conditions in northern Europe, including heavy snowfall, high winds, and cold temperatures. Modular buildings must be designed and built to withstand these conditions, which may require additional insulation, ventilation, and heating systems. Secondly, obtaining permits for modular buildings can be challenging in some areas due to local regulations and zoning laws. Finally, some people may view modular buildings as less attractive or less permanent than traditional buildings, which may affect their overall perception and acceptance [15].

Despite the challenges, there are many successful examples of modular administrative buildings in northern Europe. One such example is the modular office building at the Port of Oslo, Norway [16]. The

building was constructed in 2016 and houses administrative offices for the port authority. It is designed to withstand extreme weather conditions and is fully customizable to meet the needs of the port authority. Another example is the modular office building at the University of Helsinki, Finland. The building was constructed in 2017 and houses administrative offices for the university. It was designed to be energy-efficient, with high-quality insulation and ventilation systems to reduce energy consumption [17].

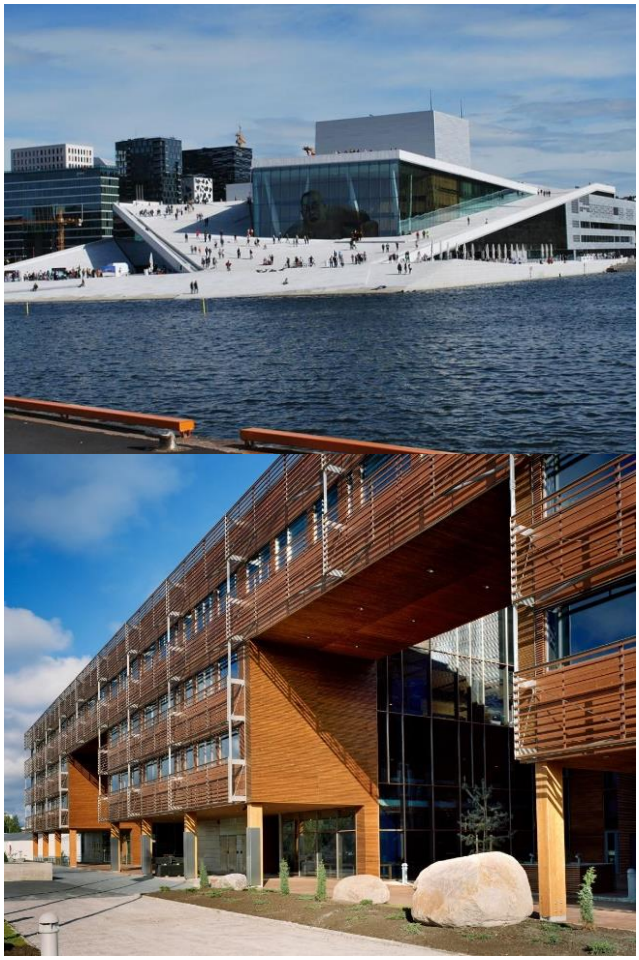

Fig. 1. A. Modular office building at the Port of Oslo, Norway [18]. B. Finnforest Modular Office. Finland [19].

Fig. 2. A. Modular dormitory structure. Kiev, Ukraine. B. General Plan [20].

Another modular dormitory structure for 120 students was installed also in Kiev, Ukraine. The modular building has two floors and a common gable roof. The delivery set includes external escape stairs as well as internal stairs [20].

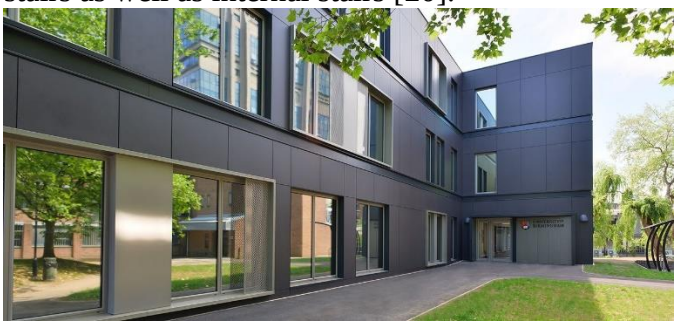

Fig. 3. Modular construction of the University of Birmingham offices [21].

A three-store modular building was installed also in Birmingham, UK, called the University of Birmingham's Edgbaston Campus. New offices were meant to accommodate University academics. Time was the essence, but without compromising the finishing works. The modular systems used allowed the architects to customize the internal and external finishes, according to the budget and schedules. Large sections of glazing were implemented. The resulting space benefits its prestigious surroundings. 36 units were produced and installed after six weeks in the factory, giving

the impression that the building was always been there [21].

Modular administrative buildings offer many benefits for businesses and governments in northern Europe. They are cost-effective, easily transportable, customizable, and offer high-quality construction in a controlled factory environment. However, challenges such as extreme weather conditions, permit acquisition, and perception must also be considered. Successful examples of modular administrative buildings in northern Europe demonstrate that these challenges can be overcome with careful planning, design, and construction.

III. MODULAR UTILIZATION IN ADMINISTRATIVE BUILDINGS AND THEIR ENERGY EFFICIENCY

Modular buildings were first created in United States of America. A high percentage of houses, residential ones, were build using this method. Meanwhile in Europe the most developed country in this particular way is the UK, where there are constructed a big number of primary schools, kindergartens, administrative building and other similar buildings.

Also, Slovakia, gets inspired by the use of modular constructions. In addition to that, there are some administrative buildings under construction as seen in Figure 4. In Slovakia, school facilities are still build using the traditional methods, which create the problem of underutilization.

Fig. 4. Administrative modular building; source: Algeco

In addition to being employed in the construction of hotels, stores, restaurants, and other commercial structures, modular buildings may also be used in the business sector. Modular buildings are increasingly preferred by investors because of their speed and flexibility. The building site is quiet, clean, and air pollution is reduced, making the process environmentally friendly [22].

Assuring both thermal comfort and electrical supply is necessary to minimize the operational expenses of modular buildings. Additionally, the cost of heating and cooling of modular dwellings might occasionally equal the rent. In modular structures, direct electrical heating units are typically used for heating, while separate air conditioners are used for cooling. The building's energy demand is measured by the energy needed to keep it running. The building's whole energy use is tracked. Energy for heating, heat-loss protection, cooling, hot water, ventilation, lighting, and electrical appliances are included in the overall amount of the required energy [23].

The field placement, form, glass surfaces, composition of the outer structures, and other elements may have an impact on the operational energy values. Internal heating systems, hot water systems, air treatment and ventilation, air conditioning, and the usage of heat gain are all variables that may be changed in structures that have already been built.

The Energy Performance of Modular Buildings may be enhanced for both new and existing structures, in accordance with Durdán et al. (2014) study. The building's location, dimensions, form, and age must first be determined. Secondly, also considers the building's physical and structural state, as well as its roof, floor, and aperture qualities. It is necessary to study the building's technical aspects, including the energy supply systems, their usage, and their technical specifications, as well as the technical aspects of heating, cooling, hot water systems, and lighting systems. It is necessary to balance the type, amount, and purpose of energy as well as losses in the supply and distribution networks in order to calculate the building's energy efficiency [24].

Each structure requires a unique set of energy sources, that should be chosen carefully. The technical features of the structure, its location, its operational use, its operational hours, and other factors must also be taken into account [25]. Renewable energies are preferred to be used as the primary type of energy compared to traditional energy sources. They are usually financially more demanding; therefore, they are appreciated to be introduced in the preliminary design phase of modular construction [26].

Calculations are required in order to determine the investment's payback time. The variation with the highest internal rate of return and shortest payback period will be the best option.

PV panel installation is crucial for the requirements of modular constructions. Since roofs in these

situations often are covered with sandwich panels, the weight of the roof must be taken into account as a key component.

Fig. 5. Modular building equipped with PV system Tegola Solar [27].

In addition to the aforementioned remarks, a building's shape can have a significant impact on its energy performance [28]. Another crucial factor to take into account is the orientation of the structure. However, in order to make the building appear more desirable, investors frequently demand designs with odd forms. As a result, the parameters of thermal losses are greater if the building is fragmented [29]. The buildings which show a smaller percentage of fragmentation are the best solutions in terms of energy consumption.

IV. HOW MODULAR ADMINISTRATIVE BUILDINGS CAN CONTRIBUTE TO THE REDUCTION OF GREENHOUSE GAS EMISSIONS

One of the greatest concerns facing humanity today is climate change. The United Nations Environment Program emphasized the need for immediate climate action to ensure our society's standard of living [30].

The production of greenhouse gases (GHG), the use of fossil fuels in industry, deforestation, forest degradation, and other factors significantly contribute to climate change [31].

The United Nations claims that the global environmental impact of the civil construction industry is the highest one. This sector takes 30% of its resources from the environment, uses 40% of the energy, produces 25% of the solid waste, uses 25% of the water, and consumes up to 12% of the land. The construction sector may help reduce the amount of greenhouse gas emissions released into the environment. Therefore, in order to encourage emissions reductions, it is necessary to investigate sustainable alternatives [32].

Figure 6, depicts a case study that was carried out in Brazil that is taken into consideration by AA Ribeiro and C S Guimares (2021). For the national museum's administration building, modular construction was a possibility. Their knowledge indicated that the structure was a union of 34 metallic habitation modules, divided into four groups by a hallway. Chassis, roof, pillars, and trapezoidal steel plate for the exterior façade make up modules. High manufacturing rates, low lead times, reuse and mobility, flexibility, eco-efficiency, and sustainability are the key features and benefits of such structures. [33]

Fig. 6. Modular administrative building in Brazil [33]

The goal of the study was to identify the direct and indirect sources of GHG emissions and categorize them. The following factors are taken into consideration: transportation, the acquisition of necessary electricity, the generation and disposal of solid waste, the consumption of building materials used on the construction site, and the use of fossil fuels for transportation. The consumption of fuel by stationary and mobile equipment used on building sites as well as transportation is included in the direct greenhouse gas emissions. The production of the thermal or electrical energy utilized in its operations is one of the indirect sources of greenhouse gas emissions. Electricity usage must be sufficient to power all of the construction site's machinery, including lighting and equipment operation. Additionally, various indirect emissions that are a result of the company's operations are taken into account but are not within its control.

The building's construction time determines the inventory. A permanent inventory that is determined on an annual basis and constitutes the GHG emissions of the project from the start of construction to delivery for use is required. Once compared to direct and indirect emissions, it is shown that other indirect emissions, such as the ones caused by the use of building materials throughout the execution, have the highest representativeness

and relevance. Following metallic structures (housing modules) and hydro-sanitary facilities, modular construction contributes mainly to greenhouse gas emissions in the infrastructure and superstructure stages (reinforced concrete, cement, and steel) during various building operations. Approximately 80% of all GHG emissions are accounted by these phases. The interior partitions and external closings contribute to additional GHG emissions. The use of ceramic bricks, which predominate over dry wall and metallic sheet barriers in modular structures, is credited with these emissions. The usage of mortar and cement during construction is also credited in producing these higher values. Steel is the main component of the roof structure, which results in lower emissions. In contrast, the emissions from painting vary depending on the amount of materials utilized [33].

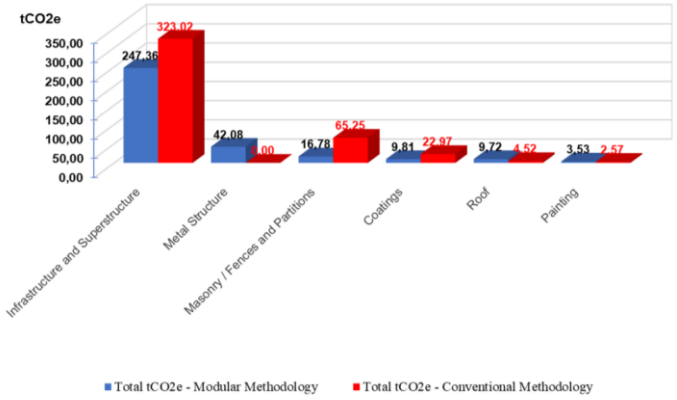

Fig. 7. GHG comparative analyses during construction of administrative modular buildings [33].

V. CONCLUSION

Modular buildings and co-working spaces are viable solutions for companies and organizations seeking to reduce their carbon footprint and improve their energy efficiency.

The design and construction of modular buildings and co-working spaces can be optimized for energy efficiency through the use of insulation, energy-efficient lighting, and HVAC systems. The use of renewable energy sources such as solar panels, wind turbines, and geothermal systems can further improve the energy efficiency of these buildings.

The benefits of energy-efficient modular buildings and co-working spaces extend beyond environmental considerations, with potential cost savings on energy bills, increased productivity, and improved employee satisfaction. The success of energy-efficient modular buildings and co-working spaces is dependent on factors such as location, design, and operational efficiency.

Further research is needed to explore the impact of energy-efficient modular buildings and co-working spaces on the environment, as well as their potential to support sustainable development.

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