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ANALYSIS OF THE IMPACT OF THE GLOBAL CRISIS IN 2021–2024 ON THE DEVELOPMENT TIME OF MULTIFAMILY BLOCKS

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ABSTRACT

The study describes the timeline of a construction project comprising six residential buildings, green spaces, and a playground. The project was carried out in the Warsaw area between 2022 and 2024. The investment was undertaken following significant events such as the COVID-19 pandemic, rising inflation, and the armed conflict in Ukraine. The study focuses on the analysis of selected phases of construction work performed as part of the investment described. The specific tasks highlighted include the installation of window joinery, the construction of internal masonry walls, the installation of partitions and balcony railings, as well as the delivery and installation of lifts. Additionally, general data on the work progress, construction schedule, and entries from the construction logbook referring to the specific completion dates of various stages were examined. Based on the provided data, an analysis was conducted to compare the time required to complete individual construction tasks against the schedule established during the project planning phase. The text addresses the challenges of meeting deadlines in large construction projects, where the technology used, the number of personnel employed, and the scale of the investment contribute to the extension of the construction process by the contractor.

Keywords: schedule, project completion time, investment process, global crisis, multifamily housing construction

INTRODUCTION

The period between 2020 and 2023 presented Poland with a series of significant challenges, with a notable impact on the economic sector and the residential property market. The primary factors that contributed to the deterioration of the economic situation in Poland were consequences of the global pandemic caused by the SARS-CoV-2 virus (COVID-19), and the ongoing armed conflict in Ukraine. The pandemic led to a significant disruption of cities, negatively affecting areas such as employment, property sales, the emergence of new investments, and the expansion of existing ones. In order to stop the spread of the virus, governments around the world introduced a number of restrictions that affected business and social activity. Many people lost employment, which contributed to a decline in housing sales, but also an increase in the collection of loans and credit (Karpio, Wielechowski & Woźniakowski, 2020; Kaźmierczak, 2021; Łaszek, Olszewski & Augustyniak, 2024). Additionally, the Polish government implemented measures to restrict the spread of the virus, which contributed to the overall decline in the country's economic activity. The first wave of restrictions came into

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force in March 2020, which included bans on gatherings, closed public places such as shopping centres, gyms, hairdressers and beauty salons, suspended the activities of nurseries, kindergartens and schools, and prohibited people from city beaches and green areas. More stringent restrictions came into force in May 2020. The holiday period passed quietly, but the autumn of 2020 again brought more COVID-19 cases, prompting the authorities to re-implement the strict restrictions (Związek Przedsiębiorców i Pracodawców [ZPP], 2021; Markowska & Strahl, 2022). A significant number of construction sites experienced delays or complete stoppage of work due to a shortage of manual and office-based personnel. Some of the existing staff were in home quarantine or hospitalised, which created obstacles to work. Consequently, some investments came to a standstill and the entire implementation plan was delayed. Another reason for the stoppage of construction work was the difficult transport of materials. Orders were shipped late or transported in parts, due to shortages in crews, restrictions due to the need to quarantine shipments, or difficulties in communication with the logistics company (Dutka, Stołecka & Janiak, 2021). The restrictions were upheld until 17 January 2021. Further restrictions, lockdowns and closed plants would have led to even greater losses, resulting in fears of a complete economic collapse. Restrictions also applied to the number of workers on the job and included the maximum number of people based on the work area (ZPP, 2021; Kłosowska, 2022; Kraska & Kot, 2024; Marecik, 2024). This caused another staffing problem in the execution of large investments, where many works could not be carried out simultaneously.

All the constraints and staff shortages affected the execution time of the investments, which were delayed in relation to the original assumptions and schedules. The restrictions on the functioning of the economy had numerous negative consequences, both globally and for the Polish economy. In the second quarter of 2020, the European Union's gross domestic product (EU GDP) fell by 13.9%; in Poland, the decline was 8% and unemployment rose by 2.7%. These were the steepest declines since the measurements in 1995 (Liu, 2020; Kaźmierczak, 2021; ZPP, 2021). In Poland, the change observed in the level of inflation was influenced by multiple factors, extending beyond the direct impacts of the ongoing pandemic. These include both internal developments and external events occurring beyond the country's borders. These included the war in Ukraine, the migration of people, and an increase in lending rates. There was an increase in inflation and housing and rental prices. However, when interest rates were raised, demand fell, which resulted in stagnation in the construction sector and the housing sales market. Purchasing a house or flat became unattainable for many people, resulting in an increase in demand for residential rental properties. However, the cost of renting flats at that time was lower than the cost of paying the mortgage needed to buy a flat or house (Węgrzyn & Topczewska, 2023; Kraska & Kot, 2024; Łaszek et al., 2024). In the first half of 2020, there was a sharp decline in interest in loans due to the current credit market situation, but the second half of the year saw an increase.

This was a result of the lack of a stable financial situation for many companies, which prompted a significant part of the population to take out loans. In response to the growing credit risk, the requirements for borrowers were tightened. As a result of lower lending rates and negative interest rates, the loan portfolio increased by 0.9 billion PLN in June 2021. In the first quarter of 2021, there was a change in the terms and conditions of loan intake. The own contribution was reduced, but loan margins for borrowers were raised. The third quarter of 2021 saw strong demand driven mainly by demand for the purchase of durable goods and an improvement in the economic situation in the country (Czajkowska, 2021). By the first quarter of 2022, inflation had reached its highest level in the 21st century. In May 2022, inflation was at 13.9%. At the end of 2021, the National Bank of Poland (*Narodowy Bank Polski*) started to raise interest rates, but inflation continued to rise. The rapid rise of inflation contributed to an increase in lending rates. This situation affected borrowers who had taken out a loan when interest rates were close to zero. This condition persisted throughout 2022 and early 2023 (Marcinkowska, 2022; Węgrzyn & Topczewska, 2023; Kraska & Kot, 2024; Łaszek et al., 2024).

The war on the Ukrainian territories, which began in February 2022, caused a significant influx of Ukrainian refugees into Poland, especially women with children, which resulted in them needing to find new locations to live. The increased cost of renting flats and houses prompted the Polish government to introduce additional financial support schemes for Ukrainian refugees. The war forced many small business owners to flee Ukraine, which contributed to an increase in demand for housing and commercial premises, as they had to find new locations to run their businesses on Polish soil. The situation was also exacerbated by an increase in the price of construction materials from Ukraine and Russia; shipments to Poland were restricted, and some even stopped. This put additional strain on the construction market in Poland and the search for new suppliers began, which proved to be a difficult undertaking to carry out in a short period of time. As a result, delivery and construction times were extended (Sosna, 2022; Kałuża-Kopias, 2023; Węgrzyn & Topczewska, 2023; Łaszek et al., 2024).

Transporting material to the construction site is a complex process. It is often the case that an order passes through several suppliers, as a result of which the delivery time may be extended. When large-volume deliveries are involved, the timing of the transport must also be considered so that the delivery is as fast as possible and does not create traffic problems for other road users (Szruba, 2021; ZPP, 2021).

In the years 2021–2024 described, transport was hampered by lockdowns, quarantines, staff shortages, and shortages in material deliveries from Ukraine and Russia. Working hours on site were prolonged because material deliveries were extended. As a result, subsequent construction work was delayed, resulting in increases in the overall project duration (Czapla, 2020; Sosna, 2022). Construction is an important branch of the Polish economy, which also has a significant impact on other industries. Figure 1 shown all the links of the construction industry with other industries. When the development of the construction sector is stunted, other industries are impacted, and as a result, the development of the country's economy is also affected.

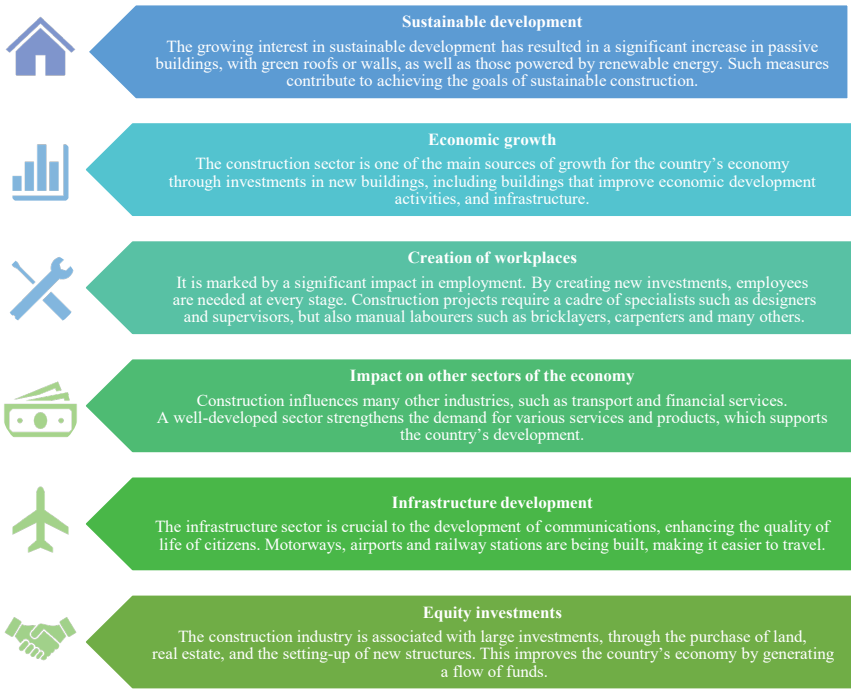

Fig. 1. Impact of the economic sector on construction

Source: own work based on Adamczak-Bugno (2023).

In the construction sector, inflation has been high for several years, both for construction works and the prices of materials, including raw materials. Industry fluctuations are due to the low number of new businesses, but also to price volatility and staffing (Kaźmierczak, 2021; Markowska & Strahl, 2022; Adamczak-Bugno, 2023).

In the construction industry, strategic materials such as cement, concrete and aggregate can be distinguished. The listed materials are the main components needed to create, among other things, concrete mix. According to the Polish Association of Construction Industry Employers (*Polski Związek Pracodawców Budownictwa*), phenomena such as problems in obtaining components for production, production, or disrupted logistics through COVID-19 and the military action in Ukraine have contributed to the rise in prices of strategic products (Polski Związek Pracodawców Budownictwa [PZPB], 2023).

Figure 2 shows the four most important strategic materials in the construction sector, without which the work on a construction site could not take place. These are cement, concrete, aggregates-mixes and aggregates-grits. It is with these intermediate products that mixes are manufactured, such as reinforced concrete or reinforced cement, mortar, and the proper mix for pouring floors.

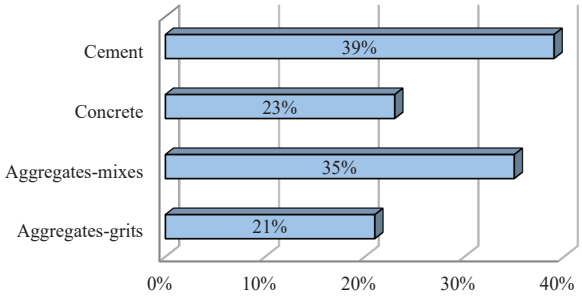

Fig. 2. Increase in the price of strategic materials

Source: own work based on PZPB (2023).

In the construction sector, the main drivers of the industry are employment and wages. Construction is a sector that creates many jobs for skilled workers as well as beginners without significant experience. Wages depend on the skills and training of the worker. The rate is also influenced by aspects such as the advancement of the work, complexity, size and location of the project. According to Statistics Poland (*Główny Urząd Statystyczny*) data, the average employment in September 2023 was 6.5 million full-time equivalents (FTEs), while the average salary in September was 7,379.88 PLN gross. There was an increase in all Polish Classification of Activities (PKD) sections. For the construction industry, it amounted to 6.9% (Adamczak-Bugno, 2023). 'Based on the *Global Powers of Construction (GPoC) 2022* report prepared by Deloitte, the total cash inflow of the top 100 global companies in 2022 amounted 1.94 trillion USD. Total revenue increased by 6.3% year-on-year, but capitalisation decreased by 14.9% to 598,577 million USD [own translation]' (Adamczak-Bugno, 2023, p. 23). Similar statistics have been presented in Poland by Statistics Poland and concern, among other things, price indices for selected construction works over the period 2021–2023, reflecting the dynamic situation of construction and assembly production prices. By analysing the statements available on Statistics Poland's website, for multifamily buildings of five- and six-storeys, which according to statistics belong to the category of buildings of collective residence, one can notice an increase of approximately 2–7% of the prices of finishing works. The statements presented here concern the prices of masonry structures, building brick partitions, window joinery, scaffolding, as well as aluminium structures and interior furnishings.

The data in Table 1 shows a comparison of the percentage increase for December in selected years, where prices in the previous months of the given year are set at 100%. Masonry construction or brick partitions cost the most in 2022. In 2023, there was a decrease of 7% and 9%, respectively. Carpentry saw the largest price increase for 2022, with a rise of just under 12% compared to 2021 and 2023. The biggest increase in 2023 was for scaffolding, which registered a jump of 5.4% compared to 2022.

Table 1. Price indices of construction objects in 2021–2023

Specification	21st of December	22nd of December	23rd of December
		%[a]	
Masonry structures	6.5	12.5	5.3
Partition walls made of building bricks	6.7	14.5	5.7
Construction joinery	8.2	20.6	8.2
Scaffoldings	4.5	9.0	14.4
Aluminium constructions and interior furnishings	8.9	25.3	9.9

[a]100% previous month of the year.

Source: own work based on Statistics Poland.

Figure 3 presents the price indices of construction objects in 2020–2024. It shows changes in the years of the pandemic and the war in Ukraine. The analysis of building price indices conducted by Statistics Poland for many years shows significant price fluctuations between 2022 and 2024, characterised by both drastic decreases and increases. Figure 3 illustrates price fluctuations between 2020 and 2023. As can be seen, the largest percentage index was recorded in 2022, reaching almost 16%. In contrast, the smallest percentage index for building prices, just over 2%, was recorded in 2020. That year, the economy was going through

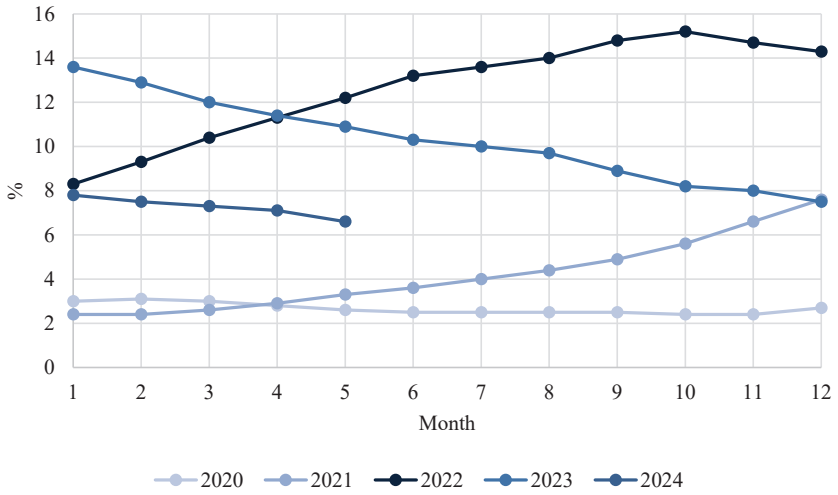

Fig. 3. Price indices of construction objects in 2020–2024

Source: own work based on Statistics Poland.

a very difficult time; the COVID-19 pandemic started, which slowed down the economic development as a result of the lockdowns. In contrast, 2022 was a time of economic recovery for the country. Considering both domestic and global events, an increase in prices was observed from 8% to 15%. In 2023, a decrease was observed from 14% to around 7%. For April 2022 and 2023, the value was the same, at around 11%. The first quarter of 2024 did not bring a sharp change, rolling along at an even level compared to the third quarter of 2023 (Fig. 3). Considering all the described aspects and situations in the country, it can be deduced that the statistics published by Statistics Poland for 2023 in the first quarter and second quarter brought a decrease in the prices of materials and construction works, resulting in increased activity in construction and assembly production. The current value for 2024 is observed to decrease at 7–8%.

An equally important aspect besides pricing in the implementation of a construction project is timing. In order to create a good work schedule, all possible factors that may occur during the project must be considered.

The project timescale defines a range of dates for the construction work divided into appropriate stages. However, it is made up of what are known as sub-stages: placing the formwork, creating and placing the reinforcement, and only the final stage is concreting the previously prepared base for the floor in question (Siewiera, 2018; Kłosowska, 2022; Sitek, 2022).

The investment process is a complex time consisting of many interrelated stages, as each investment is independent and unique and therefore needs an individual approach to developing its implementation plan. Each of the four stages of the investment process illustrated in Figure 4 discusses the entire construction process from start to finish, covering the most important aspects during the planning of the investment, the creation of the investment and the handover of the finished product to the client. More information about each of these stages can be found in Figure 4.

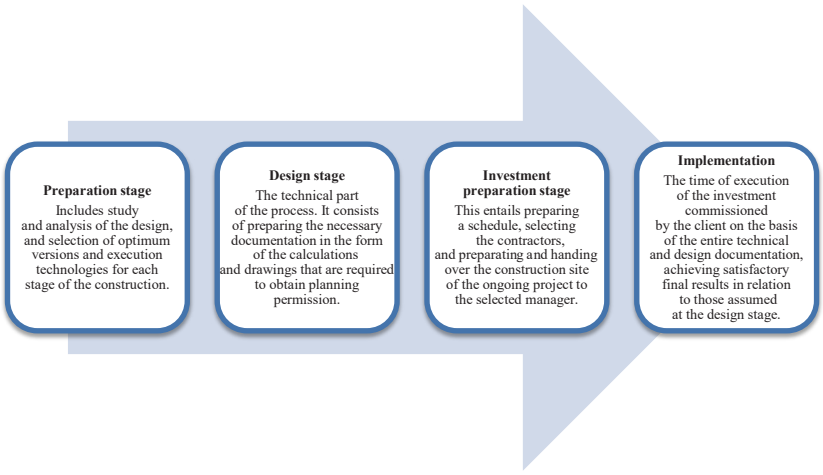

Fig. 4. Stages of the investment process

Source: own work based on Sitek (2022).

Time is an important factor that determines productivity. Inefficiencies in construction processes and unplanned expenses can prolong the construction time and increase its cost. The chosen technology and materials determine how long the construction will take. Nowadays, there are many options, with finances being the only limitation. Innovative solutions and creative approaches by engineers on site can

effectively reduce the execution time of an investment (Siewiera, 2018; Dutka et al., 2021; Sitek, 2022). Over the past 10 years, the construction industry has seen the emergence of many innovative solutions that increase productivity and efficiency. The COVID-19 pandemic is a factor that accelerated development specifically in the field of innovative approaches in construction, as it forced entrepreneurs to change the way they operate. The available software and mobile solutions significantly help manage the investment at every stage – from design to construction to facilities management. Construction companies are taking advantage of the new technologies available on the domestic market to improve productivity, communication between contractors and even decision-making between trades. In the past three years, only a quarter of construction projects have been completed within the original deadlines (Kaźmierczak, 2021; Sitek, 2022).

Non-productive activities such as researching project information, resolving controversies or finding errors and reworking them take up around 35% of a construction worker's time, which equates to 14 h per week. Therefore, new technologies, the use of cloud or building information modelling (BIM) software streamlines their work and allows them to find solutions to conflicts between different trades within a project (Sitek, 2022).

Aspects such as the technology and timing of prefabricated balconies, the installation of window joinery, the installation of lifts and internal masonry works in the selected buildings were considered in the analysis. The choice of specific works was motivated by the fact that the selected works were carried out between 2022 and 2024, i.e. during the crisis caused by the COVID-19 pandemic and the armed conflict in Ukraine. All the works described need teamwork, long lead times, and worker-engineer cooperation, and their execution time depends on availability and supply in both the domestic and international markets. The specified works also give an individual architectural character to the buildings. The stages of execution of these works are different, as each is carried out at different points in the overall construction process. The selected elements are part of the construction process, through which we achieve the raw closed state of the investment.

The aim of the study was to analyse the impact of the external factors discussed earlier on the execution time of a multifamily apartment block investment in Warsaw in the timeframe 2022–2024. All considerations will focus on selected aspects of the execution of the construction on six buildings with five or six storeys, founded on two garage slabs. The analysis was conducted as a comparison of the investment's execution schedule to the construction logbook, which is systematically kept in accordance with the Act of 7 July 1994, known as the Construction Law (Journal of Laws of 1994 nr 89, item 414).

Works such as the installation of lifts, installation of window frames, construction and installation of prefabricated balconies, and internal masonry works in the selected two buildings will be considered. The data were interpreted using graphs created in Microsoft Excel, R (programming language), and via the creation of a summary of the results in illustrative and descriptive form, considering the current situation in the construction market between 2020 and 2024. Events that significantly affected the performance of the described investment were mainly the COVID-19 pandemic and the war in Ukraine. Last but not least, there were staff shortages and logistical problems in the then unstable domestic market. The article considers such aspects, which could have significantly influenced the time of delivery of the investment to the contracting authority. The above-mentioned aspects were considered when analysing the execution time of the investment of six multifamily blocks of flats in Warsaw.

MATERIAL AND METHODS

The development being analysed was built between 2021 and 2024. It consists of six independent residential buildings with a total of 316 flats, situated on two garage slabs with a total of 220 parking spaces in garage slab G1 under buildings numbered B1, B2 and B3, and 232 parking spaces in garage slab G2 under buildings

numbered B4, B5 and B6. Figure 5, designed following the provisions of the local development plan, shows all the main elements of the development construction project. Figure 5 shows a bird's-eye view of the site area, including the buildings with their entrance staircases, garage access roads, pavements and landscaping. The green roofs on buildings B1, B2 and B4 are also shown.

Fig. 5. Site development plan of the described investment

Source: Authorship – PIG Architects.

A technology that indicates the investment's connection with nature is the use of green roofs on buildings B1, B2 and B4. Sedum matting was used to achieve this effect. The use of such a solution on the roofs of the buildings provides an additional biologically active area and a harmonious visual result to the entire structure.

Table 2 summarised the buildings, the number of storeys above ground, the number of dwellings in each building and the commercial premises. The number of parking spaces on each of the two garage levels and the location of the garage levels under the buildings are also shown in the table. Labels following the pattern B1 mean building number 1, etc., while G1 refers to garage slab number 1.

Table 2. Summary of the number of flats in each building

Building	Number of floors above ground	Number of apartments	Commercial premises
B1	5	33	–
B2	5	40	–
B3	6	76	10
B4	5+ mezzanine	54	–
B5	6	75	9
B6	6	38	4
G1	under B1, B2, B3	220 parking spaces	–
G2	under B4, B5, B6	232 parking spaces	–

Source: own work based on construction data.

Table 3 shows a breakdown of the different areas for the investments described. The data shown in the table comes from the construction log. The area in question is equipped with many innovative and environmentally friendly system solutions. One of these is the retention and drainage systems designed to drain rainwater. This solution was applied because the area where the project is located has a low groundwater table. Also, the area is flat and located in the Vistula wetlands.

Table 3. Balance of the development area of the described project

Specification	Land balance		
	size	coefficient	local development plan
Site area	18,926.05 m^2	–	–
Building surface area	5,103.2 m^2	–	–
Hard surfaced area	3,431.5 m^2	–	–
Biologically active area on native ground	4,318.2 m^2	–	–
Biologically active area on garage floors and roofs	3,273.9 m^2	–	–
Total biologically active surface area	7,592.1 m^2	0.4011	min. 0.40
Total surface area (aboveground)	28,322.48 m^2	–	–
Total surface area (underground)	12,426.48 m^2	–	–
Intensity		1.496	max. 1.5
Height	max. 19 m	–	max. 19 m
Number of floors	5–6	–	–
Number of parking spaces for flats	452 (garage) + 25 (land)	–	1.5 parking spaces per location
Number of parking spaces for services	30 (land)	–	30 per 1,000 m^2

Source: own work based on construction data.

An analysis of Table 3 shows that the height of the blocks is up to 19 m in accordance with the local development plan (LDP). The development intensity factor is 1.496. The land balance shows that the total area of the aboveground part of the development is 28,322.48 m^2, and the underground part is 12,426.48 m^2.

The entire area is fenced off, making it a separate estate. The internal area is equipped with small architectural features such as benches, children's playgrounds, an outdoor gym complex and bicycle repair stands. The area has many green zones, with numerous plantings of flowers, shrubs and low trees. The biologically active area is 7,592.1 m^2, which gives a coefficient of 0.4011, in accordance with the LDP. All the important figures for the investment in question can be found in Table 3.

The space is dotted with numerous paths leading to the entrance cages of the blocks, as well as to landmarks throughout the square. As a whole, it is an intimate neighbourhood ideal for families with children, seniors, as well as young people.

A timesaving technology used in the construction of the multifamily blocks of flats is prefabricated balconies. Prefabricated balconies are prefabricated building elements that are manufactured in factories, then transported to the construction site and assembled using special balcony connectors. The balcony connectors are designed in such a way that all vertical and horizontal forces are transferred directly to the floor slab. These balcony connectors are made with innovative technology that ensures easy installation and reliable load transfer (Halfen, 2020).

The use of this solution helps to reduce the construction time, as the balconies are ordered much earlier so that they arrive on site in good time. The whole process of making the balconies is economical; we do not need several workers to make one monolithic balcony, because all the work of these people is done by a precise machine controlled by a specialist. The whole technology optimises the time of creation, delivery and installation (Halfen, 2020; Yang, 2023).

Masonry walls are an important part of the whole building, dividing the internal space of the building into smaller rooms and acting as sound insulation. The construction of partition walls is carried out in several stages, which can be divided into preparation, bricklaying, and finishing. The first involves preparing the surface, marking out the course of the wall. In the next stage, we lay the masonry components while controlling for the level and straightness. The final stage is filling the joints with mortar and smoothing the surface. This wall is then prepared for further finishing works (Rodrigues & Šipoš, 2019; Wang et al., 2023).

The vertical partitions consist of several layers, arranged in such a way as to provide adequate acoustic, thermal, and comfort conditions. Several types of internal masonry walls can be distinguished in the developments described. Each has thermal insulation, a load-bearing and insulating part and a plaster layer. The main part of the wall structure is made of 8–18-centimetre-thick silicates. For example, a 12-centimetre wall element, used as a partition between a utility room and a bathroom. Figure 6 shows a cross-section of the wall described.

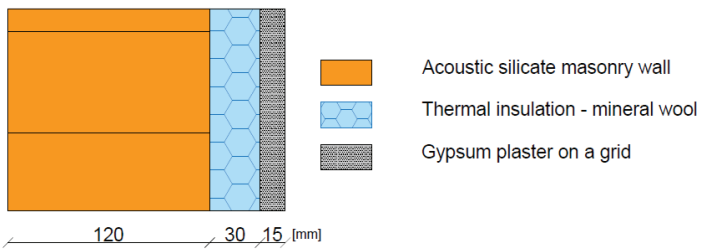

Fig. 6. Site development plan of the described investment

Source: Authorship – PIG Architects.

In residential building, windows provide thermal, acoustic and aesthetic comfort. In the project described, PVC (polyvinyl chloride) and aluminium joinery were installed. There were three types of glazing: standard, and glazing with a total solar factor *g*0.35 and *g*0.27. Such glazing was used in premises where the sun shines for most of the day. This provides a comfortable living environment in every room, without the need for additional sunshades. Window acoustics is a property that is currently gaining importance. It is considered an essential feature of glazing due to the location of multifamily buildings in city centres, along busy streets or near industrial plants. Taking all these elements into account, we have to define the right parameters for the designed dwellings in order to ensure appropriate indoor conditions (Nurzyński, 2002). This enables us to meet the relevant sound insulation conditions in accordance with the product standard PN-EN 14351-1:2006+A2:2016 (Polski Komitet Normalizacyjny [PKN], 2016). In the investment described here, warm-mount aluminium frames were also used for the shop windows of the ground floor commercial premises in buildings B3, B5 and B6. This solution provides a pleasant view into the interior of the premises. Figure 7 shows a cross-section of the north elevation of the B3 building as an example of all buildings in the investment. This picture shows details of each element of the external part of the building, which represents the whole project designed by the architecture group.

Fig. 7. Cross-section of the north elevation of building B3

Source: Authorship – PIG Architects.

Lifts are vertical transport devices used to move people and loads and are an essential element of modern multistorey buildings. Lift can be equipped with electric, hydraulic, or pneumatic drives. In the described project, lift cabins with gearless drives, without machine rooms, and with landing doors compliant with fire safety requirements were installed according to the lift guidelines of the selected company. The dimensions of the lift cabs are 110 × 140 cm. There are 15 lifts in the described project. Figure 8 shows an example of the first floor of the building B3.

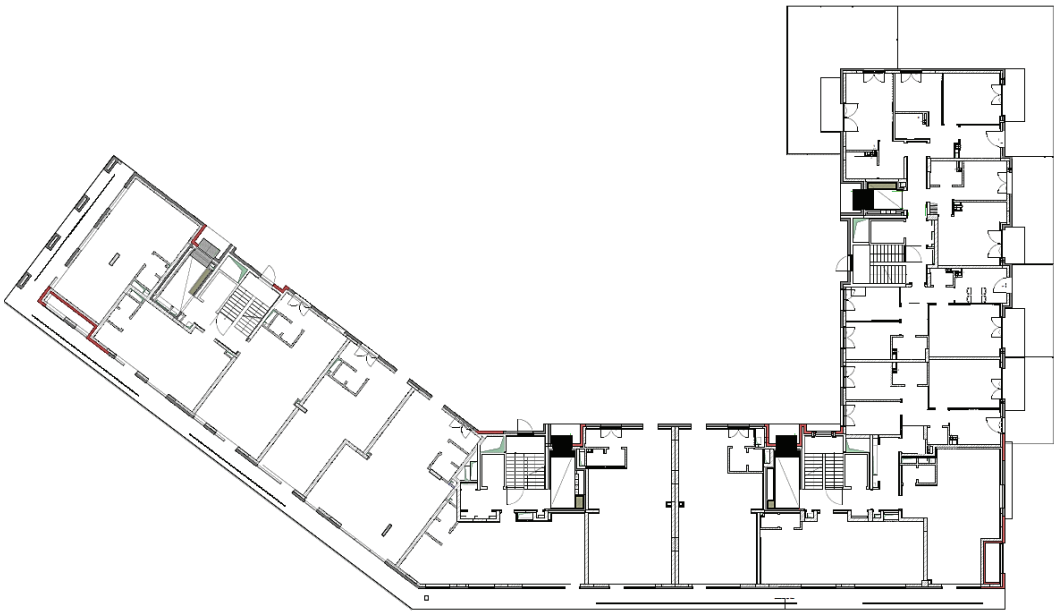

Fig. 8. First floor plan of building B3

Source: Authorship – PIG Architects.

Figure 8 shows the subdivisions for each block entrance staircase, the apartments and the service spaces. The figure also shows the wall thicknesses used to divide the individual rooms in the apartments, between the units and the separation walls between the service and residential areas.

RESULTS AND DISCUSSION

The investment described was developed between 2022 and 2024 and was affected by events such as COVID-19, inflation, and the ongoing armed conflict in Ukraine. All these factors had a significant impact on the duration of the construction. Figure 9 presents a timeline that includes external events and the timeframe of the described investment for the work covered in the analysis: window joinery, masonry walls, and the installation of the lifts and balconies.

Figure 9 presents a timeline of all the described events. It is evident that the COVID-19 pandemic was the first to occur, resulting in a lockdown. For a year, the state operated within a limited scope of its activities and capabilities. Next, an armed conflict broke out with Poland's eastern neighbours, which also significantly contributed to restrictions in the functioning of the state, including in the construction sector. Shortly after that, inflation reached its highest level, which was 13.9%. This affected all sectors of the economy, including the construction materials sector. At the same time, the described investment commenced, which lasted until January 2024, when the construction manager submitted the completion report for the works. Based on the construction data, comparative tables of time were created for the specified construction works related to bringing the construction to a state of raw closure, and then bar charts and Gantt charts were created. Figures 10–16 present a comparison of the number of days spent on a given task to the number planned during the investment schedule creation stage. Figure 10 shows the time for building masonry. It takes into consideration the time of both the plan and the actual implementation.

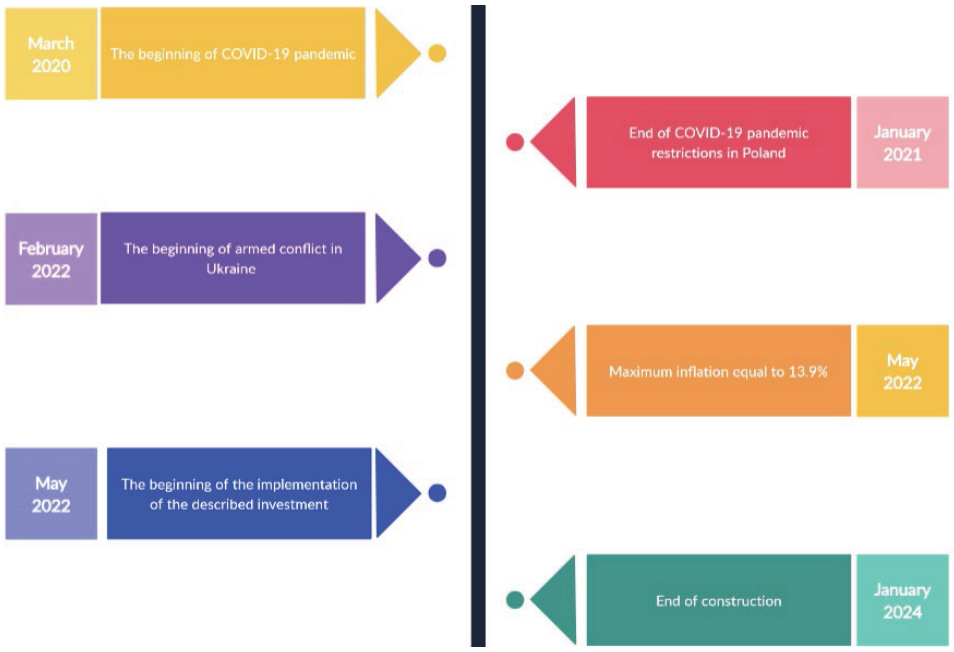

Fig. 9. Timeline that considers external events and the time of the described investment's creation

Source: own work.

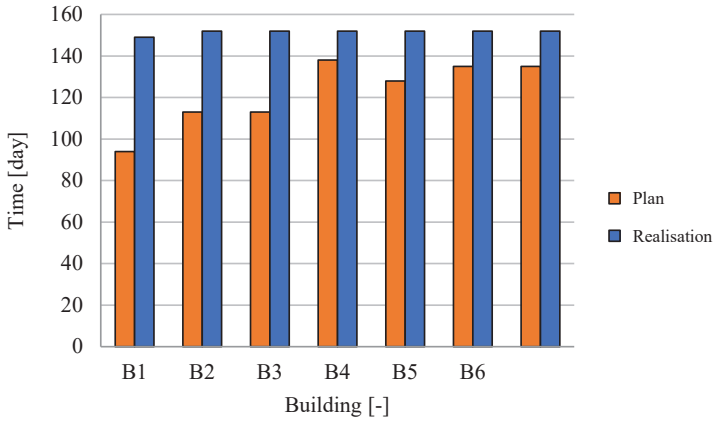

Fig. 10. Completion time for masonry walls

Source: own work.

Further to this, Figure 11 shows the timeline for building the masonry walls, but with the specific end-dates for completion. The construction of the masonry walls experienced delays, which are illustrated in Figures 10 and 11. Both figures show that the execution time significantly deviated from the schedule. The delay was sometimes up to a month. The commencement of construction on buildings B2, B3, and B5 was delayed by a period of several to a dozen days in comparison to the original schedule.

Furthermore, the projected completion date for building B2 was extended by up to two months. The work on buildings B1 and B4 started as scheduled, but the overall completion times were also delayed. However, the entire execution of the work was completed by mid-September 2023, which resulted in a total delay of approximately one month. The completion time for the masonry walls was somewhat longer than anticipated from the planned time due to the weather, staff shortages, and delayed deliveries. Figure 12 presented a summary of the time taken to complete the window installations, including delivery to site, in total days for the plan and actual completion.

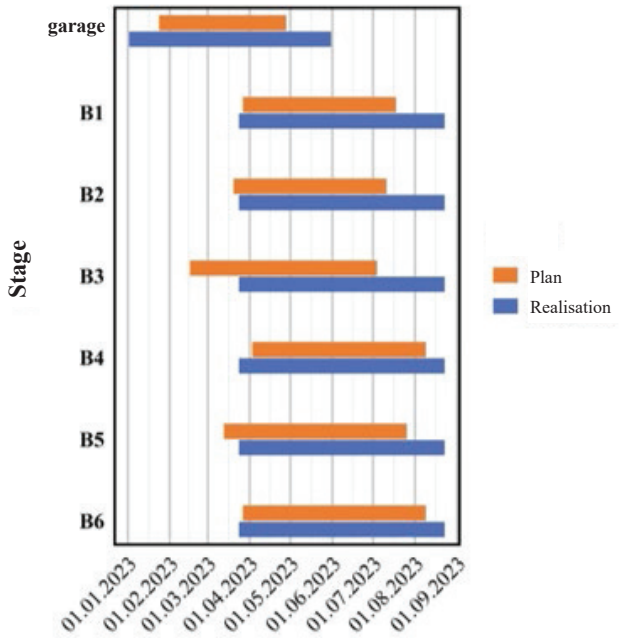

Fig. 11. Completion time for masonry walls

Source: own work.

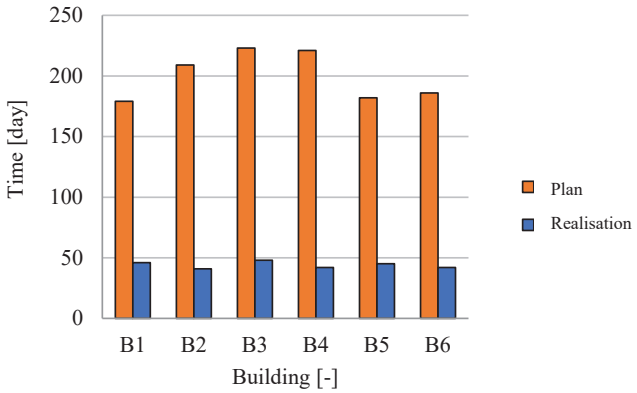

Fig. 12. Summary of time for the installation of window frames

Source: own work.

For a better comparison, Figure 13 also shows the time taken to complete the window installation according to plan and the actual completion time, but with specific dates taken from the construction logbook. Figures 12 and 13 present the time taken for the installation of the window joinery for the described investment. The basic unit in the scheduling process is working days. The indicated time discrepancies in the figure bring attention to the quick execution time of this work. For all buildings, the completion period did not exceed 50 working days.

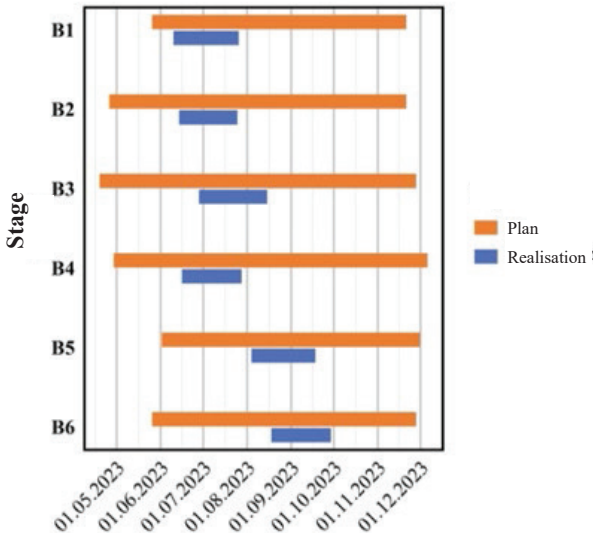

Fig. 13. Summary of time for the installation of window frames

Source: own work.

The deadlines set during the design phase were significantly longer; for buildings B3 and B4, they were around 220 working days. An additional figure based on the data regarding the time taken for the window joinery is presented using a Gantt chart. It also shows the time frame for completing a given task, but it considers specific dates. In the diagram, one can observe the time, but for specific months during which the window installation took place. All buildings were equipped with windows between June and October. The installation of the window joinery was planned for so many days because the plan scheduled the masonry walls in each of the buildings to be completed in different time frames, along with the time spent on defect repairs.

Figure 14 illustrates the time schedule for the installation of the prefabricated balconies and the lifts in the individual staircases, showing both the periods planned based on the time schedule and the actual installation times.

Figure 15, similar to Figure 14, presents a summary of the time required to complete the installation of the balconies and lifts, but with the specific start and end dates for each task. The installation of the partitions and railings took place during the finishing stage, after the painting of the facade. The implementation of the aforementioned work on the balconies began with a significant delay of almost a month and a half.

The work began at the end of October 2023 and was completed, also with a delay, at the end of December of the same year. However, the delay did not significantly affect the execution of other construction work on the described facility. The delay in the installation of the balconies resulted from the small crew size and mistakes in the execution of an order. The second element presented in Figures 14 and 15 is the lifts,

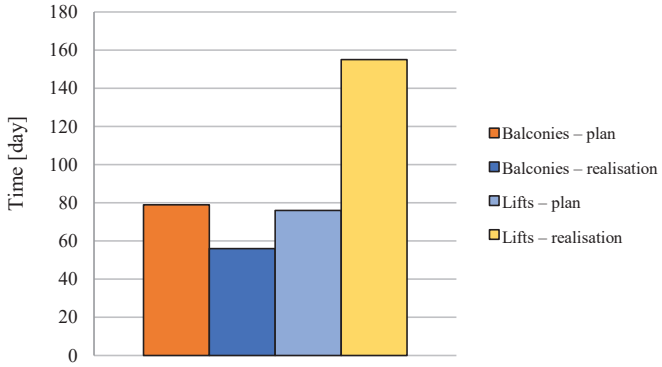

Fig. 14. Installation of balcony railings and partitions, delivery and installation of lifts

Source: own work.

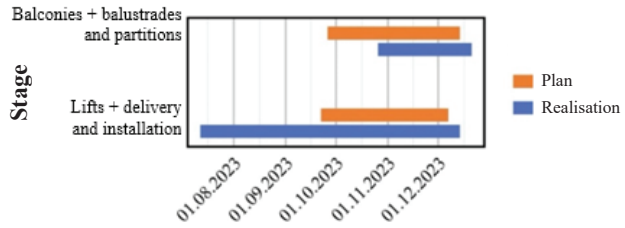

Fig. 15. Installation of balcony railings and partitions, delivery and installation of lifts

Source: own work.

specifically their delivery and installation. A significant change in the timeline for project completion has been noted on the Gantt chart showing information about the specific dates. The schedule planned for completion in the months of October to December. However, the entire process began much earlier, as early as at the end of July 2023. The lift turbines were delivered successively, and their installation took place within a few days of delivery. Despite starting this process without delay, the completion deadline was extended somewhat compared to the plan. This delay was a result of bad weather, as these days saw heavy rain that flooded the lift shafts, and their installation had to wait until the water dried out. The extension was about 15–20 working days. Nevertheless, the delay was not significant, and its postponement to the end of December 2023 did not affect the other deadlines. However, the plan was shorter than the implementation because the order was delivered faster than expected, which is shown in Figure 16. A summary of all the tasks described in the article is shown in Figure 16, which provides the time taken to complete each task, as well as the specific start and end dates. For each of the tasks listed, the planned and actual execution times are shown.

The specified works began approximately eight months after the start of the investment, that is, from May 2022. Additionally, the submission of the acceptance protocol for the investment and the handover of the property to the client were completed within five months. Table 4 shows a comparative summary for the described works, planned execution time, completion time and percentage of delays.

Table 4 presents a time comparison for the schedule and execution of the investments for the described works. The dates listed in the table show the times for individual and selected stages of project implementation.

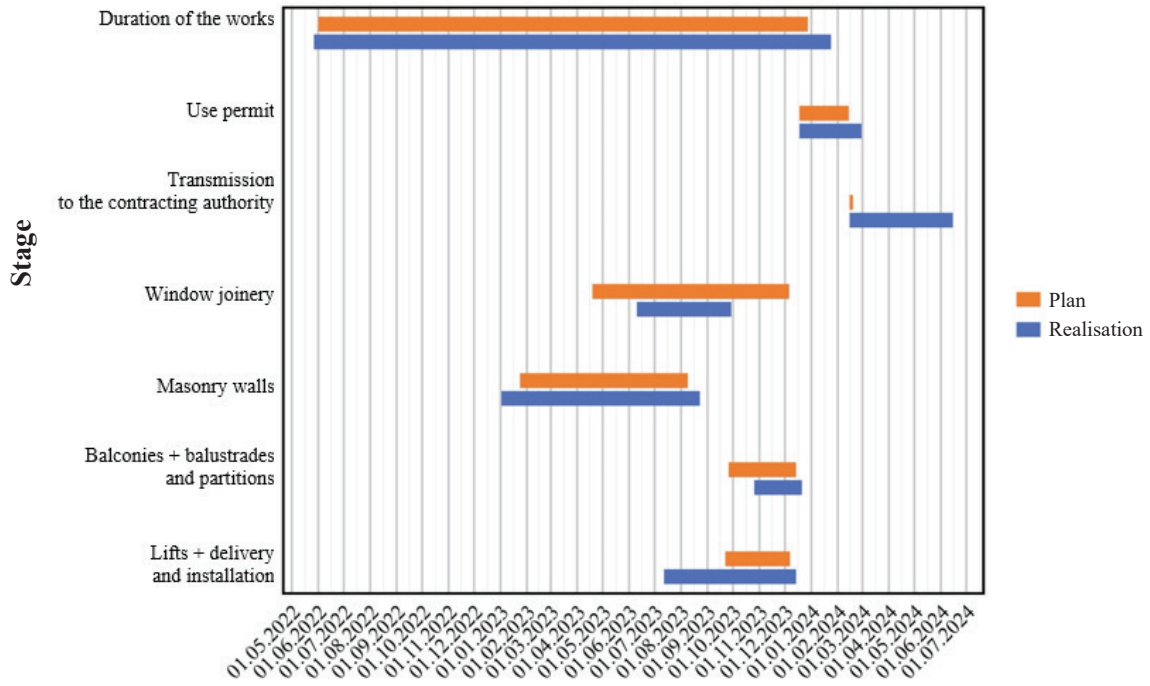

Fig. 16. Comparison of schedule time and implementation for the listed works

Source: own work.

Table 4. Summary: comparison of schedule time and implementation for the listed works

Type of work	Building	Scheduled time [days]	Implementation time [days]	Difference [days]	Time extension/ /reduction [%]
Window joinery	B1	179	46	133	74
	B2	209	41	168	80
	B3	223	48	175	78
	B4	221	42	179	81
	B5	182	45	137	75
	B6	186	42	144	77
Masonry walls	garage	94	149	−55	−59
	B1	113	152	−39	−35
	B2	113	152	−39	−35
	B3	138	152	−14	−10
	B4	128	152	−24	−19
	B5	135	152	−17	−13
	B6	135	152	−17	−13

Table 4 (cont.)

Type of work	Building	Scheduled time [days]	Implementation time [days]	Difference [days]	Time extension/ /reduction [%]
Balconies – railings and partitions	B1–6	79	56	23	29
Balconies – assembly	B1–6	–	98	–	–
Lifts – delivery and assembly	B1-6	76	155	−79	−104
Beginning of the work	–	18.05.2022	01.06.2022	14	–
Protocol for the completion of work	–	24.01.2024	28.12.2023	27	–
Occupancy permit	–	14.02.2024	29.02.2024	15	–
Transfer to the ordering party	–	19.02.2014	15.06.2024	3,769	–

Source: own work.

The presented table shows the percentage discrepancy between the duration of completing a given task in days. It can be observed that the difference in the investment completion time is about four months. What does it mean that the transfer of the construction object to the client was delayed? The remaining stages did not undergo significant changes. For the window joinery, the execution time was shortened, compared to the execution of the brick walls, which was extended by almost 60% for the garage. This was one of the stages of implementation that, due to its delay, required delaying subsequent stages of the work, such as the installation of the window joinery, which was planned for 180 to 220 days because the plan defined that the masonry walls in each of the buildings would be completed at different times, along with the time spent on defect repairs. What is more, the delivery of the windows was stretched over time. Table 4 shows the plan's time and lead time in days. However, the masonry walls were built faster than the plan anticipated, so the window joinery was completed in less time. In addition, the construction crew for the windows was sizeable, which made it possible for the task to be completed more quickly.

In the case of the balconies, the technology used for their construction was changed; prefabricated balconies were used, which accelerated their execution time. This is a creative approach by the engineers that significantly reduced the time for the execution and installation of the balconies by utilising available solutions in the construction market. The balcony partitions and railings were installed in 30% less time than allocated during the design phase. For the lifts, the set time differed by only four days compared to the execution time. The total duration of the investment according to the schedule was 642 days, which is just under 92 weeks, while the actual implementation took 745 days, resulting in 107 weeks of work. The described development of six blocks with underground parking and landscaping was built during COVID-19 and the war on the Ukrainian territory. This fact meant that the construction had to face staff shortages, delayed deliveries, and inflationary increases in the construction sector. Despite this, the investment was built only three months behind schedule.

CONCLUSIONS

Given the considerable scale of the investment, it is evident that a detailed work schedule is essential at the design stage to ensure the successful and efficient implementation of the project, which presents a significant challenge. A schedule makes it easier to plan orders, manage construction teams, and hire additional labour. One of the factors motivating construction contractors is financial penalties, which

in the case of such large investments can reach up to 20% of their costs. Of course, there are also reasons that can delay certain stages of the work, which may significantly impact subsequent tasks. In the case of the described investment, the total implementation time was extended by 103 days, resulting in a delay of over three months. The halt in work was mainly due to a lack of manpower and delays in material deliveries. However, inclement weather was also a contributing factor to the delays. A creative solution was the use of prefabricated balconies, which were installed during the construction of each floor. Such an approach demonstrates flexibility and a tailored search for new solutions, as well as adaptability to changes and the current challenges faced daily on the construction site. As a result, we can engage in effective discussions about proper investment management and create new action plans for future constructions. Despite the delays in some phases, the construction did not come to a standstill and continued to progress with the next stages of work, independent of the existing delays. The project was completed, and the premises handed over to the client, and then to their owners. This outcome underscores the importance of adaptability and innovative problem-solving in construction management, contributing valuable insights for future large-scale investments. The article presents a comprehensive and systematic analysis of case studies within the construction sector with the aim of highlighting the potential benefits of the investment under consideration. By systematically analysing the case studies, the paper demonstrates that construction companies can gain valuable insights from this investment, particularly with regard to the importance of flexibility in construction practices, as evidenced by the incorporation of prefabricated balconies. In addition, the article evaluates alternative investment delivery methods that could be effectively implemented in other construction projects to optimise outcomes. Although the investment described is a single case, it may highlight common issues that arise on comparable sites in large urban conurbations. This provides a basis for future research and practical applications in construction management.

Authors' contributions

Conceptualisation: K.W. and J.D.; methodology: K.W. and J.D.; formal analysis: K.W. and J.D.; investigation: K.W.; resources: K.W.; data curation: K.W.; writing – original draft preparation: K.W.; writing – review and editing: K.W. and J.D.; visualisation: K.W. and J.D.; supervision: J.D.

All authors have read and agreed to the published version of the manuscript.

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ANALIZA WPŁYWU GLOBALNEGO KRYZYSU W LATACH 2021–2024 NA CZAS REALIZACJI INWESTYCJI BUDOWNEJ BLOKÓW WIELORODZINNYCH

STRESZCZENIE

Praca opisuje harmonogram realizacji projektu budowlanego obejmującego sześć budynków mieszkalnych, tereny zielone oraz plac zabaw. Projekt realizowano w Warszawie w latach 2022–2024. Inwestycja została podjęta po znaczących wydarzeniach, takich jak: pandemia COVID-19, wzrost inflacji oraz konflikt zbrojny na Ukrainie. Studium skupia się na analizie wybranych etapów prac budowlanych przeprowadzonych w ramach inwestycji. Szczególną uwagę zwrócono na takie zadania, jak: montaż stolarki okiennej, budowa wewnętrznych ścian murowanych, instalacja ścianek działowych i balustrad balkonowych, a także dostawa i montaż wind. Ponadto zbadano ogólne dane dotyczące postępu prac, harmonogram budowy oraz wpisy z dziennika budowy odnoszące się do konkretnych terminów zakończenia poszczególnych etapów. Na podstawie dostarczonych danych przeprowadzono analizę porównawczą czasu potrzebnego na ukończenie poszczególnych zadań budowlanych względem harmonogramu ustalonego w fazie planowania projektu. W artykule poruszono kwestie związane z dotrzymaniem terminów w dużych przedsięwzięciach budowlanych, w przypadku których zastosowana technologia, liczba personelu oraz skala inwestycji przyczyniają się do wydłużenia procesu budowlanego przez wykonawcę.

Słowa kluczowe: harmonogram, czas realizacji projektu, proces inwestycyjny, globalny kryzys, budownictwo mieszkaniowe wielorodzinne