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CHALLENGES IN CONSTRUCTION PROJECTS CONTINUITY: RISK FACTORS AND RESILIENCE STRATEGIES

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This study focuses on managing the continuity of construction processes, emphasizing disruptions that affect project implementation. Ensuring continuity is critical to the quality, timeliness, and overall success of construction projects. The construction process demands meticulous planning and coordination while being highly susceptible to changing environmental conditions. Disruptions in construction processes arise from various sources, including human, technological, atmospheric, and organizational factors. The research aimed to identify the key disruption sources and assess their broader impact on project continuity. To achieve this, a literature review was combined with a case study, enabling the analysis of disruptions within a real-world context. The study examined human resource shortages, construction errors, weather-related delays, procurement issues, safety and security (S&S) challenges, and the dynamic project management responses. The study revealed that human factors, such as a lack of skilled labor and execution errors, alongside adverse weather conditions, were the most significant threats to construction process continuity. Effective continuity management, incorporating adaptive strategies, flexible resource allocation, and proactive risk mitigation, emerged as critical to minimizing disruption impact. This comprehensive analysis underscores the need for an integrated approach to business continuity that encompasses time, budget, logistics, safety, and quality considerations to enhance the overall construction project resilience.

Keywords: construction process continuity, human factor, project scheduling, risk management

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1. INTRODUCTION

Continuity of operations plays a crucial role in influencing the quality and timeliness of construction project outcomes (Grau, Abbaszadegan, Assanair, 2019). As with any complex undertaing, construction processes require good planning and coordination of activities to ensure continuity of operations, including the management of human and logistical resources. One of the documents specifying the requirements for a Business Continuity Management (BCM) system is the ISO 22301 standard. It provides a comprehensive framework for identifying key risk factors impacting an organization and maintaining its operations under the most challenging conditions (PN-EN ISO 22301, 2019). Despite its importance, a business continuity plan is often underestimated in construction management. Typically, only external circumstances, such as changes in law, collaboration with more demanding investors, or accidents on the construction site, prompt the development of documents regulating business continuity issues. Furthermore, the use of advanced technologies for continuous monitoring of operations in construction increases overall project efficiency and effectiveness. Therefore, ensuring operational continuity through effective flow management and control mechanisms significantly impacts the successful execution of construction projects (Okuno, 2023).

Construction work is highly sensitive to changing environmental factors, including weather conditions. Disruptions occurring during the execution of a construction project are closely related to the specifics of the construction industry. Additionally, success and goal achievement depend on proper and reliable cooperation between multiple entities. Based on research findings, an effective business continuity plan (BCP) for construction projects should include various key elements. These elements include the implementation of on-site operational procedures and protocols along with the use of digital technology to support virtual communication. Maintaining continuity in relationships between projects and activities, reusing important resources, and fostering mutual orientation, engagement, and trust over time are fundamental strategies for reducing uncertainty and enhancing the overall efficiency of construction projects (Okuno, 2023; Havenvid et al., 2017). Technology can optimize construction project continuity plans by minimizing work interruptions and reducing overall project duration (Zou, Wu, Zhang, 2021).

The specificity of the construction industry requires the application of solutions that take into account for a wide range of variables, such as human factors and environmental influences (e.g., weather conditions). Factors beyond human control are often very difficult to predict and require extensive experience and long-term observation. As a result, the continuity of construction work is exposed to various risks that can disrupt operations (Oyegoke et al., 2024).

Business continuity is defined as the strategic and tactical capability of an organization to anticipate and respond to events and business disruptions in order to continue operations at an acceptable and predefined level (BS 25999-2 Business Continuity Management, 2007, p. 4).

Risk is defined as the effect of uncertainty on objectives (PKN-ISO Guide 73a, 2012, p. 11). In this context, risk can mean a loss or benefit for the decision maker. It is typically characterized by the relationship between the potential consequences of a threat and the probability of its occurrence (PKN-ISO Guide 73b, 2012, p. 17).

The aim of this article is to identify key disruption sources and assess their broader impact on project continuity. The article presents a comparative analysis of the schedule developed before the start of the work and the post-completion schedule. The analysis was based on data obtained during the construction process. To achieve this goal, the article outlines the definition of risks, provides a classification of potential disruptions, and discusses specific examples of how disruptions influence the progression of construction activities.

This study employs a dual-methodological approach, combining a literature review and a case study analysis to explore the management of construction work continuity and its impact on project scheduling. The literature review provides a theoretical foundation by examining key concepts and frameworks related to Business Continuity Management (BCM), risk classification, and continuity strategies relevant to the construction industry. Sources for the literature review include scholarly articles, industry standards, such as ISO 22301, and relevant regulatory guidelines. Complementing this theoretical exploration, the case study focuses on a specific construction project carried out in Poznan. It analyzes real-time disruptions, their causes, and the corresponding schedule modifications. Data were gathered through direct on-site observation, project documentation review, and interviews with construction management personnel. This combined approach enables a comprehensive understanding of both theoretical principles and their practical application, offering valuable insights into how continuity management strategies can mitigate schedule delays in construction projects.

Business Continuity Management is an ongoing process carried out and financed at the senior management level to ensure necessary activities in identifying the impact of potential losses, creating and improving recovery strategies and plans, and ensuring continuity of operations (Zaskórski, Szwarc, 2012). As a holistic process, BCM should be aligned with the overall strategic objectives of the company.

2. IDENTIFICATION OF THREAT SOURCES

Lexical definitions interpret safety as a state of being free from danger, characterised by peace and certainty. Etymologically, the term originates from the notion of being ‘without care’ – that is, without the need for protection. According to the Dictionary of the National Defence Academy, safety is defined as “a state that provides a sense of certainty and guarantees its maintenance and opportunities for improvement. One of the basic human needs is a situation characterized by the absence of the risk of losing something that a person particularly values".

A threat is defined, according to the Regulation on General Health and Safety Provisions (1997), as a state of the work environment that may cause an accident or illness.

Table 1 presents selected events whose occurrence had a significant impact on the continuity of the construction process.

Table 1. Observed factors influencing the work progress in the construction process

No.	Factor	Event
1	Human	Investor changes
		No decision from the investor (placing an order for barrier elements has been suspended until a decision is made)
		Lack of appropriate quality of work, construction errors
		Occurrence of a fatal accident, stopping part of the work front and the tower crane needed to perform the work
2	Organizational	Insufficient number of workers in relation to the amount of planned works
		Lack of space on the construction site, too much ordered material lying on the construction site
		Downtime due to lack of transport, unordered goods
3	Technological	Unforeseen additional works
		The 300% increase in material prices forced a change in the work execution technology
4	Atmospheric	Low temperature (below –5°C)
		Wind speed, tower cranes stopped working
		Rainfall

Source: own elaboration.

The occurrence of threats often results is the disruption of the continuity within the construction process. Disruption itself is described as an unexpected phenomenon that causes an interruption or at least a delay in the performance of tasks (Drzewiecka et al., 2011). The cited literature presents a classification of disruptions according to the party responsible for their occurrence (fig. 1). As shown, many of the factors identified in the literature correspond with the observational threats presented in table 1. Human factors during the implementation of a construction project have a significant impact on the occurrence of many disruptions

(Leśniak, Plebankiewicz, 2010). Factors such as rising material costs, escalation of logistics costs, supply chain interactions, labor shortages, and communication breakdowns have been identified as significant disruptive elements. Additionally, the ongoing shift toward automation and digitization in the construction industry introduces challenges in cybersecurity, which can further contribute to project delays (Vanhoucke, 2006; Xue, Chen, 2013; Demagistris et al., 2022).

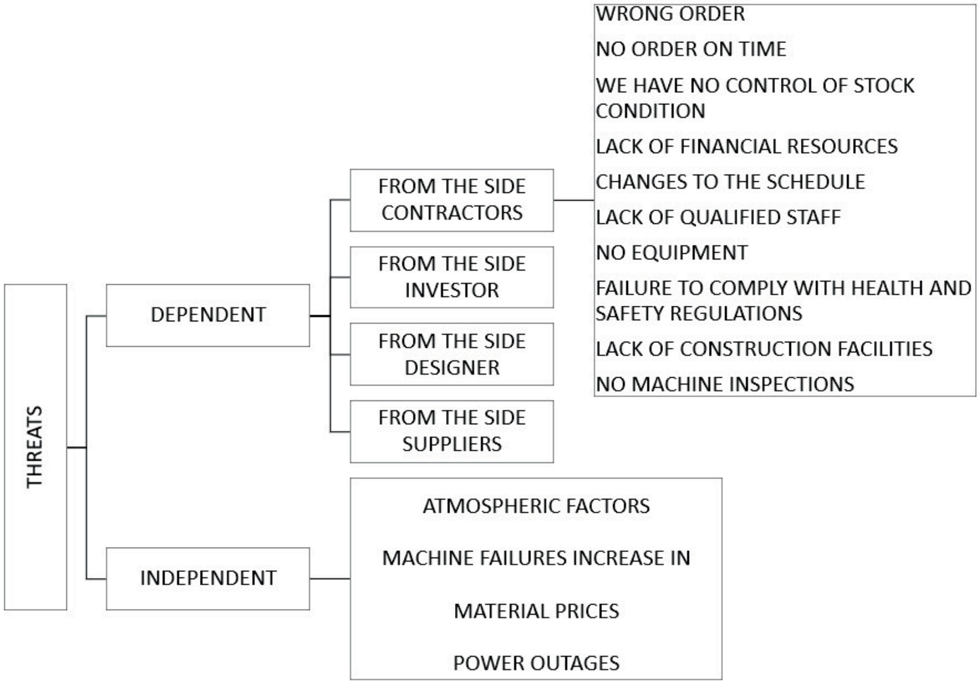

Fig. 1. Classification of disruptions based on the responsible party
(own elaboration based on Drzewiecka et al., 2011)

Every construction schedule should take into account human factors, the technologies used (e.g., cast-in-place concrete, prefabricates), and the adopted construction management method. Typical threats can generate obstacles that interrupt the construction process – such as halting ongoing activities – which can result in the need to carry out, substitute work or prolong the storage of deliveries (Drzewiecka et al., 2011). Another aspect is the selection of material suppliers, which can generate direct disruptions in the supply of construction materials, particularly in cases involving long lead times. Weather conditions are also a significant threat, as they can substantially impact the timelines of construction projects, causing delays, increased costs, and reduced productivity. Extreme temperatures, strong winds, and precipitation are crucial for specific construction activities such as concrete work and lifting operations. Adverse weather conditions are responsible for delays in about 45% of construction projects worldwide, leading to additional expenses (Schuldt et al., 2021; Ghali, Patankar, 2022; Safaa et al., 2022).

Effective and efficient project management should cover both risk simultaneously, employing approaches that are both qualitative and quantitative in nature (Głodziński, 2015).

Due to the importance of economic aspects when implementing new technologies, one interesting direction for future development is the creation of predictive models, tools, and decision support systems regarding cost-related risks. Such systems could be implemented within construction projects to assess the financial impact of implementing digital twin technology at different maturity levels. However, the implementation of digital twin technology in the construction sector carries numerous risks resulting from the inherent complexity of construction projects and the inherent risks related to the adoption of emerging technologies (Wang et al., 2024).

Heat stress was initially studied in the context of military operations during World War II, and later in the mining industry, due to its importance for the development of this sector. In contrast, the construction industry has historically paid limited attention to heat stress as a risk factor for workplace accidents, although the documented seasonal fluctuations in accident rates, with noticeable peaks in the summer months, observed since at least the late 1970s. Climatic heat stress leads to accidents on construction sites, which are caused by a number of human factors, such as heat-related illnesses and fatigue, leading to impaired physical and mental abilities. These effects are particularly characteristic of construction work. Industry-specific guidelines for managing heat stress in construction can be a driving force for redesigning the entire safety management system (Rowlinson et al., 2014).

The management of necessity in construction is a complex process that requires the involvement of all stakeholders at every stage of design and implementation. Effective risk mitigation depends on a shared understanding and awareness of risks among participants. While most stakeholders are able to identify health and safety hazards in construction processes, their assessment of the probability of such risks may significantly differ. For instance, architects notice that probable events are triggered, engineers enable high risk, and start and ds. basic safety, basic perceptions (Zhao et al., 2015).

Project finances, on-site accidents, and poor design are the most significant risks that affect the majority of construction projects. During the execution phase, the contractor is responsible for managing most of the risks that occur on construction sites, such as subcontractors, labor, machinery, material availability, and quality. The client, on the other hand, is typically responsible for managing risks related to finances, design documentation, changes in codes and regulations, and the scope of work. Developing a proper schedule by obtaining updated project data and guidance from previous, comparable projects are the most effective techniques for managing preventive risks. Close supervision and effective coordination across projects are the most effective techniques for managing corrective risks. Preparing a proper schedule and good coordination during the execution phase are very important because they can help project managers focus on critical areas, ultimately leading to better project management (Iqbal, 2015).

Project risk identification mainly consists of determining what types of risks may affect the project, along with identifying their characteristic parameters and estimating the probability of their occurrence. In recent years, construction companies and investors have increasingly recognized the value of tools such as schedules and computer analyses for effective investment planning. It was understood that a properly executed project plan and early risk identification can contribute to the success of the project in later stages. Project management is a complex, long-term, and far-reaching process that begins long before the investment phase and sometimes continues even after its completion. Smart risk management does not aim to eliminate all risks, but rather to properly identify and define all the opportunities and threats associated with them (Szymański, 2017).

The literature emphasizes that effective risk management in construction begins with the accurate identification and assessment of potential threats. Effective communication between all parties involved in a construction project is crucial to the success of risk management efforts. Moreover, the use of modern information technologies and project management systems can significantly improve the ability to monitor and manage risks in construction projects. Literature research indicates the need for continuous training of employees in the field of risk management. The knowledge and skills acquired during such training can help in better recognition and response to potential threats.

3. CASE STUDY – SCHEDULE ANALYSIS

The subject of the analysis was the construction process of five residential buildings in Poznan along with a two-level underground parking garage. The research was conducted from the perspective of the general contractor, with the research sample selected using a purposive sampling method. The primary criterion for selecting case study was the ability to gain access to detailed project data, mainly related to its progress, including risk management. The main methods used in the empirical research included participant observation, expert opinions, and direct interviews with industry professionals.

The comparative analysis included a schedule prepared before the commencement of construction works and an as-built schedule, developed on the basis of as-built documentation, a construction log, and photographic documentation. A simplified engineering approach was used to evaluate the as-built schedules.

Six areas of construction work were selected for analysis, each of which significantly shifted or extended in time due to factors disrupting the continuity of operations. As part of the analysis, the initial project schedule, developed before the start of construction, was compared with the post-completion schedule. The data was entered into MS Excel and compiled. A comparison of selected fragments of the pre-construction and post-construction schedules, along with the key reasons for delays, is presented in figure 2.

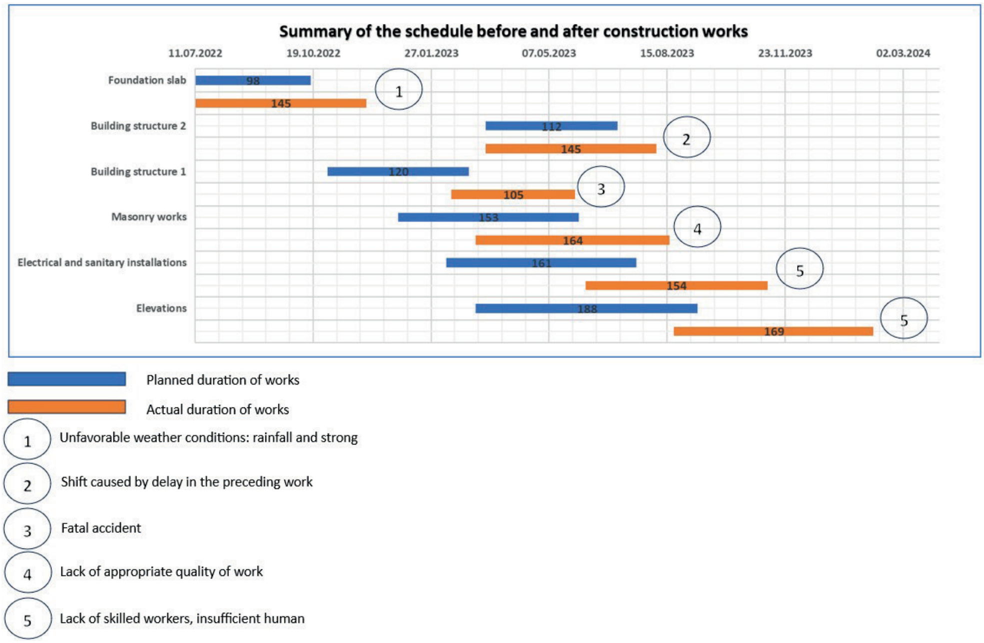

Fig. 2. Summary of the schedule before and after construction works (own study)

Figure 2 presents a fragment of the construction schedules before and after project completion, along with the most important causes of delays. The planned duration of individual tasks according to the construction manager's schedule is marked in blue, and the actual durations of these tasks are marked in orange. The causes of delays were determined based on our own observations. As a result of the schedule analysis les, a summary of data from the work progress was developed, taking into account, among others, the planned and actual durations of individual works, the planned day of handover of work fronts together with possible shifts. A fragment of the summary is presented in table 2. The result of the comparative analysis of schedules, taking into account weather conditions and identified causes of delays, is the development of a list, an excerpt of which is included in table 2. This list includes individual items from the schedules along with their planned duration, deviations that occurred during implementation, and the observed causes of the delays.

4. EXAMPLE ANALYSIS

To illustrate the impact of disruptions on the continuity of construction work, the case of a residential project in Poznań was analyzed. Events that occurred during the construction significantly altered the planned construction processes, necessitating adjustments to the project schedule. The execution of the foundation slab was disrupted by adverse weather conditions. In particular, months of August, October, and December experienced rainfall levels reaching 94%, 80%, and 88% of the monthly norms, respectively (Meteorological Yearbook, 2022). In October 2022, wind speeds reached up to 10 m/s on certain days, resulting in the suspension of tower crane operations and temporary work stoppages. Similarly, in December 2022, strong wind gusts prevented the full utilization of tower crane capacities. According to the Regulation of the Minister of Entrepreneurship and Technology of October 22, 2018, concerning safety and occupational health when handling tower cranes and quick-erecting cranes, it is prohibited to operate cranes during handling of oversized loads when wind gusts exceed 10 m/s. As a result of such atmospheric factors, the construction of the foundation slab was delayed by 47 days.

Initially, the construction of the structural elements of Building 1 was delayed by as much as 105 days due to a lack of qualified workers. To reduce labor costs, workers were brought in from abroad, of Turkish nationality, which subsequently led to communication issues between the general contractor and the subcontractor. This decision resulted in structural errors and poor work quality, necessitating additional corrective work. Midway through the construction of Building 1, a fatal accident occurred, disrupting the entire project implementation. The incident triggered a series of formalities and related inspections, which halted construction for 30 days. Due to the significant delay caused by the accident, the construction management decided to shorten the duration of the work front by 15 days by increasing workforce deployment.

The delay in completing the facade works stemmed from earlier delays in the construction of Buildings 1 and 2, as well as a shortage of labor assigned to these tasks. The initially selected facade contractor did not have sufficient human resources, leading to the early termination of the contract and the search for another contractor. The construction management opted to shorten the deadline for completing the facade works by 19 days to meet contractual deadlines set by the investor.

In most cases, multiple factors contributed to work delays. For instance, the postponement of sanitary installation works was primarily due to prior delays in the construction of Buildings 1 and 2, labor shortages, and a significant increase in the prices of certain materials by up to 300%, resulting in downtime and temporary work stoppages. It was necessary to find a new supplier, order a sample order, and then place the full order, a process that took about 14 days. During this time, substitute work was organized, with employees reassigned to these tasks.

Disruptions in masonry works mainly involved the need for demolition and re-execution of defective sections, which extended the completion by 11 days compared to the original schedule. The above analysis is presented in table 2.

Table 2. Characteristics of robot fronts

Name of the work front	Number of days of the work front		Extension/shortening of the work front [in days], offset	Reasons
	Planned	Actual		
Foundation slab	98	145	+47 days	Unfavorable weather conditions: rainfall and strong wind
Building structure 1	120	105	–15 days, offset +105 days	Lack of skilled workers Fatal accident
Building structure 2	112	145	+33 days	Lack of appropriate quality of work, construction errors
Masonry works	153	164	+11, offset +66 days	Shift caused by delay in the preceding work, Lack of appropriate quality of work, construction errors
Electrical and sanitary installations	161	154	–7days, offset 118 days	Lack of skilled workers, Material prices increase by 300%
Elevations	188	169	–19 days, offset 168 days	Lack of skilled workers

Source: own work.

Based on the data presented in table 2, the following conclusions were drawn: during the execution of the works, changes in the project and additional works occurred, which led to an extension of the total duration of the complex of works. The factors responsible for deviations from the original schedule can be divided into four basic groups: human, organizational, technological, and atmospheric.

The presented example clearly illustrates the critical importance of the human factor in construction projects. Without adequate human resources, a construction project cannot succeed. Human resources are essential for managing construction and supply logistics, as well as directly executing tasks (Grzyl, 2011). At this point, it is impossible to completely replace humans in the construction industry. As shown in the above analysis, the human factor is also the weakest element of the system because it generates the most serious risks. It is therefore important that personnel possesses appropriate qualifications for the tasks performed (Sobczak, 2016), as many aspects of construction require specific skills and knowledge.

Numerous disruptions that affect the course of construction can be repetitive, making it possible to develop standardized response procedures. However, many events are unique and specific to only one construction project or even one situation, requiring immediate action to limit losses and costs. During the construction phase, there are two fundamental types of action: immediate responses and analysis of past events for which procedures have already been developed.

An example of continuity management in the event of an accident on a construction site is the implementation of post-accident documentation and established response procedures by the construction management team. The response protocol for accidents should be included in the Construction Safety and Health Plan (BIOZ plan), in the Safe Work Procedure Instruction (IBWR) for subcontractors, and made available, for example, as brief information at the construction site entrance.

To enhance business continuity in construction projects, proactive measures should be implemented to mitigate risks and improve operational resilience. Addressing key risk factors such as skilled labor shortages, risk management inefficiencies, and project disruptions can significantly reduce delays and enhance project success. The table 3 presents a structured approach to these challenges, outlining specific actions and their expected benefits.

Table 3. A structured table grouping the proposed proactive actions

Risk Area	Proposed Actions	Expected Benefits
Addressing Skilled Labor Shortages	– Implement workforce training programs and certification incentives – Develop partnerships with vocational schools and universities – Utilize automation and prefabrication to reduce reliance on manual labor	– Increased availability of skilled workers – Reduced project delays due to labor shortages
Improving Risk Management for Future Projects	– Adopt Business Continuity Management (BCM) tailored to construction – Create contingency plans with alternative suppliers, flexible scheduling and buffer periods – Establish techniques AI-driven risk assessment	– Improved project planning and execution – Enhanced risk forecasting and mitigation
Enhancing Project Resilience	– Strengthen supplier relationships for stable material supply chains – Implement real-time monitoring and early warning systems for weather conditions	– Minimized supply chains disruptions – Reduced weather-related project delays – Improved on-site safety and continuity of work

Source: own work.

The proposed strategies focus on three key areas aimed at enhancing business continuity in construction projects. By integrating these approaches into project planning and execution, construction processes can become more efficient, resilient, and capable of withstanding unforeseen challenges.

5. CONCLUSIONS

Business continuity management should be treated as one of the integral areas of ensuring organizational security (Zaskórski, 2012). During the implementation of the construction process, it is essential to apply dynamic actions adapted to rapidly changing conditions. Certain threats to continuity are unique to the construction industry and are not found in other industries. As the analysis of the above example shows, the main generator of threats to a construction project is the human factor, which has a fundamental impact on the success of the entire implementation. The human factor is the main resource necessary in construction for erecting structures. With access to a qualified workforce, it is often possible to mitigate the effects of disruptions and even shorten the duration of certain tasks, despite earlier delays.

These proactive measures not only help mitigate risks but also contribute to the long-term sustainability of construction projects by fostering a more stable workforce, improving planning accuracy, and enhancing overall operational efficiency. By integrating technology and strategic risk management, companies can reduce costly disruptions and ensure smoother project execution. Ultimately, the added value of this approach lies in its potential to create a more resilient construction industry, capable of adapting to changing conditions while maintaining high standards of safety, quality, and operational efficiency.

The analysis relies on data obtained from a single construction site, limiting the ability to generalize conclusions to other projects with different geographical, regulatory, or environmental conditions. Observations specific to the Poznan project may not fully represent broader industry trends. The focus on a single project also prevents comparative analysis with other construction sites or industries, which could provide deeper insights into the distinction between common and project-specific risks in construction business continuity.

This article serves as an introduction to further research on the course of construction processes and risk assessment for construction projects. Data obtained from observations conducted on the construction site were used. Further work will aim to analyze the human factor and develop a method that will allow the optimization of managing its individual elements in construction companies.

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WYZWANIA W ZAKRESIE CIĄGŁOŚCI PROJEKTÓW BUDOWLANYCH: CZYNNIKI RYZYKA I STRATEGIE ODPORNOŚCI

Streszczenie

W artykule skoncentrowano się na zarządzaniu ciągłością procesów budowlanych. Położono nacisk na zakłócenia, które wpływają na realizację projektu. Zapewnienie ciągłości ma kluczowe znaczenie dla jakości, terminowości i ogólnego sukcesu projektów budowlanych. Proces budowlany wymaga skrupulatnego planowania i koordynacji. Jest jednocześnie bardzo podatny na zmieniające się warunki środowiskowe. Zakłócenia wynikają z różnych źródeł, w tym czynników ludzkich, technologicznych, atmosferycznych i organizacyjnych. Badania miały na celu zidentyfikowanie kluczowych źródeł zakłóceń i ocenę ich szerszego wpływu na ciągłość projektu. Przegląd literatury połączono ze studium przypadku, aby przeanalizować zakłócenia w ich rzeczywistym kontekście, badając niedobory zasobów ludzkich, błędy budowlane, opóźnienia związane z pogodą, problemy z zaopatrzeniem, wyzwania związane z bezpieczeństwem i ochroną (S&S) oraz dynamiczne reakcje zarządzania projektami. Badanie wykazało, że czynniki ludzkie, takie jak brak wykwalifikowanej siły roboczej i błędy, obok warunków pogodowych były najpoważniejszymi zagrożeniami. Zarządzanie ciągłością, obejmujące strategie adaptacyjne, elastyczną alokację zasobów i proaktywne łagodzenie ryzyka, okazało się kluczowe dla minimalizacji wpływu zakłóceń. Ta kompleksowa analiza podkreśla potrzebę zintegrowanego podejścia do ciągłości działania przedsiębiorstwa uwzględniającego czas, budżet, logistykę, bezpieczeństwo i jakość w celu zwiększenia odporności projektu budowlanego.

Słowa kluczowe: ciągłość procesu budowlanego, czynnik ludzki, harmonogramowanie projektu, zarządzanie ryzykiem