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# THE INFLUENCE OF STOPPAGES ON PRODUCTIVITY DURING CONSTRUCTION OF WATER SUPPLY AND SEWAGE SYSTEMS

# WPŁYW PRZERW NA PRODUKTYWNOŚĆ PRACY PRZY BUDOWIE SIECI WODOCIĄGOWYCH I KANALIZACYJNYCH

A b s t r a c t

This paper analyses the causes and consequences of stoppages due to cuts in the water supply and sewage systems installations. The bases for the article are direct observations conducted on 8 building projects.

*Keywords: productivity, stoppages, water supply and sewage systems constructions*

S t r e s z c z e n i e

W artykule przedstawiona została analiza przyczyn i skutków przerw w pracy przy budowie sieci wodociągowych i kanalizacyjnych. Podstawę artykułu stanowią bezpośrednie obserwacje przeprowadzone na 8 obiektach.

*Słowa kluczowe: produktywność, przerwy w pracy, budowa sieci wodociągowych i kanalizacyjnych*

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## 1. Introduction

One of the basic factors linked to the operational efficiency of an enterprise is productivity. Productivity should therefore be used as a primary factor in the assessment of building firm activities [8]. For building companies operating in the current difficult economic environment, any productivity increase brings particular benefits, constituting towards improvements, competitiveness and increased financial gain. Productivity is the ratio of goods and services to the resources used in labor, materials, energy and capital [4]. Productivity increases can be achieved by means of non-investment activities e.g. by improving the construction process organization and making better use of production resources, tools and manpower.

Actions taken to increase productivity should consist of, among other things, shortening the time planned for the task [6], which is largely based on reducing the frequency and duration of stoppages. Stoppages can be caused by external, as well as internal factors. External causes are essentially beyond company control, however, it is possible to eliminate or limit adverse stoppages, to shape growth and productivity in order to enhance the economic efficiency of construction processes. This however, can only take place after a diagnosis of the causes of any internal factors.

The aim of this paper is to identify the causes of stoppages during water supply and sewage systems installations, as well as to identify the technological stages of construction during which such stoppages occur. The basis for the article is direct observation carried out on construction sites. Information on the subject is useful for improving the construction process in terms of increasing its productivity. Frequently reported delays in construction time, including those relating to water supply and sewerage works are symptomatic of the need for such research. Failure to meet specified deadlines and calculating contractual penalties, weaken the contractors position in the construction market.

## 2. Subject of research study

Direct observation were carried out on eight building sites where water supply and sewage system installations were taking place. These were executed between 2010–2013, in the provinces of Lower Silesia and Opole. Each of these investments were carried out by different contractors. The scope of works conducted during the period of observation included the following processes:

- earthwork – excavations, pipe bedding, backfill and compaction;
- installation of pipeline and fittings;
- control work – survey work and pipeline testing;
- finishing work – land reconstruction and reclamation, removal of excess soil.

The period of each project execution is shown in Fig. 2. The top line in the Gantt's chart indicates the dates stated in the contract, while the bottom, those actually met. From the schedule presented on Fig. 1, it appears that the building works on all objects were conducted in the same seasons of the year. An analysis of documentation demonstrated that only one of them (B5) was completed on time.

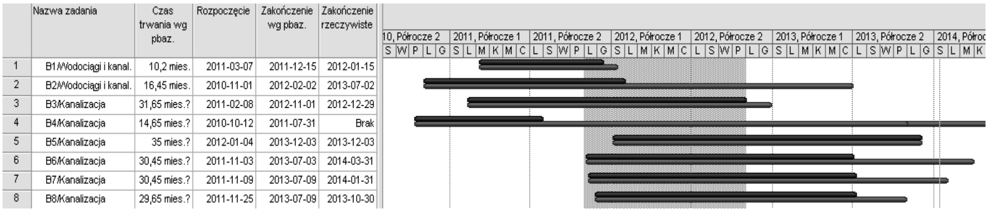


Fig. 1. The schedule of work on objects of research study

## 3. Method of research study

In order to identify and classify the stoppages, the following research methods were implemented:

- documentation review,
- direct observation on the work station on the building site,
- interviews with the persons responsible for the timely execution of processes.

The documentation review included an analyses of the following documents: design documentation, specifications, Records of Necessity and Negotiations, the building diary, Contractor's reports and programmes, as well as correspondence within the contract.

The research was carried out from November 2011 to October 2012. Direct observations were of a shutter nature and concerned particular work stations. The state of work or stoppages on workstations was recorded randomly by the observer. In case of stoppages, the reasons were determined. On each construction the same number of observations was carried out. The results of measurements were noted in a specially prepared questionnaire. The choice of such a research method was dictated on the basis of continuity and repeatability of the work.

In most cases, at the moment of record, the work was ongoing on stations. Stoppages were found 52 times (for a total number of observation: 192), which represents 27% of all observations. Relating the result to the classification used in construction [8] it can be stated that the activity of the production teams on the constructions analysed was at a "normal level". Such a level is defined as corresponding to three quarters of optimal performance. However, the optimal effect occurs when skilled workers do not have to work after hours, provided that they follow the established work method. 98% of the contractors in the building industry reach normal levels of activity [8]. Based on the research results, all of the contractors under observation could be listed in this category.

Actions for increasing productivity require improvements in work efficiency. It is therefore important to strive to eliminate, or limit, stoppages. Based on data from the observations, three sets of elements were associated with the occurrence of stoppages were distinguished. These are:

- factors causing the stoppage of production teams,
- type of work
- building project under analysis.

A matrix diagram was compiled in order to determine the relationship between the elements of these sets, as shown in Fig. 3. In this diagram, the measure of the relationship between each element is the number of stoppages observed during the research. For example, during

| Total | B8 | B7 | B6 | B5 | B4 | B3 | B2 | B1 | | Formal and legal problems | Faults in Project documentation | Adverse weather conditions | Faulty work organization | Violation of work rules | Regular breaks | Collisions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | | 1 | | | | 1 | | 1 | Land reconstruction and reclamation | | | | 1 | 2 | | |
| 2 | | | | | | 1 | 1 | | Backfill | | | 2 | | | | |
| 3 | | 1 | | 2 | | | | | Installation of fittings | | | 1 | | 2 | | |
| 16 | | 1 | 1 | 4 | | 4 | 6 | | Installation of pipeline | 1 | | 10 | 5 | | | |
| 2 | | | | 1 | | | 1 | | Pipe bedding | | | | | 2 | | |
| 26 | | | 5 | 10 | 8 | 1 | 2 | | Excavations | 8 | 2 | 1 | 1 | 8 | 5 | 1 |
| 9 | | | 1 | | 8 | | | | | | | | | | | |
| 2 | | | 2 | | | | | | | | | | | | | |
| 14 | | 1 | 1 | | | 5 | 7 | | | | | | | | | |
| 7 | | 1 | | 4 | | | 1 | 1 | | | | | | | | |
| 14 | | | 2 | 7 | 1 | 2 | 2 | | | | | | | | | |
| 5 | | | | 5 | | | | | | | | | | | | |
| 1 | | | | 1 | | | | | | | | | | | | |

Fig. 2. The occurrence of stoppages on the objects of research study

a manhole installation, three stoppages were reported (on objects B7 and B5), wherein one of them was caused by bad weather, and the other two by violation of work rules. However, the total number of stoppages due to bad weather conditions on all sites was 14 (1 + 1 + 5 + 7).

The placement of the stoppages in the rows and columns of the diagram indicates the random nature of their occurrence. This makes it difficult to develop a strategy that allows a reduction in their number. For this reason, each set was analysed separately. The basis for the analysis is the relationship between each element of the set and the number of stoppages observed. Result of the analysis are presented in Fig. 3.

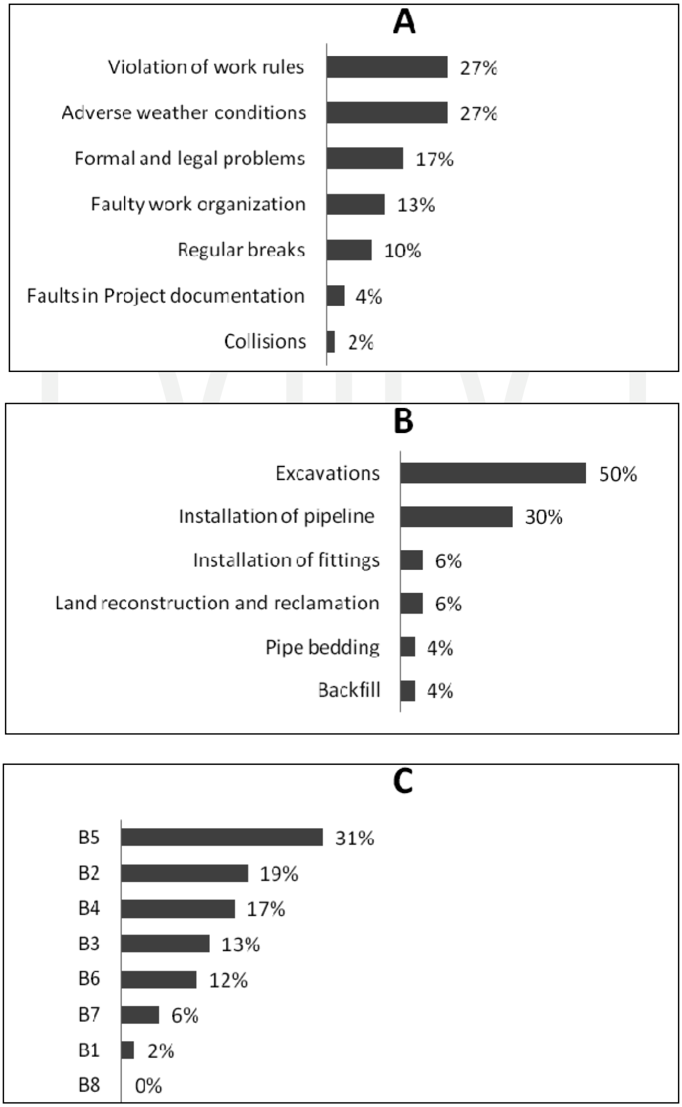


Fig. 3. Structure of the occurrence of stoppages observed on objects of the research study

The classification of stoppages shown in Fig. 3A, 3B, 3C allows us to conclude that the responsibility for stoppages of work on water supply and sewage systems construction is held by both managers and workers. Managers are responsible for: choosing suitable dates for particular works during periods of adverse weather conditions (winter), the occurrence of formal and legal problems during the work (lack of documents required to carry out the work) and faulty work organization. These factors resulted in 50% of stoppages. Particular attention should be paid to the fact that the weather risk is not taken into consideration in the signed contracts, although this problem is already well recognized in the construction industry [1, 3, 7, 10]. The schedule presented in Fig. 2 is evidence of this. All of the projects under observation started in October – November, so that their execution always fell in winter, and therefore burdened with the greatest probability of adverse weather conditions.

From Fig. 3B, it appears that the causes of stoppages were violations of work rules by employees, to the same degree as adverse weather conditions. Observations have demonstrated that they arise most often from a lack of direct supervision. Violation of work rules mainly consisted of delays, unplanned breaks and unexplained abandoning of the work position.

In the case of works related to water supply and sewerage systems, two critical technological processes should be considered: excavations and pipeline installation. These works should not be executed during winter, as they are particularly sensitive to temperatures below zero (ground freezing, low resistance of pipes and fittings, lack of possibility for pipe testing).

The existence of significant production reserves on construction of water supply and sewerage systems is indicated in Fig. 3C. Construction no. B5 is an example of this. Despite incurring the largest number of stoppages during execution, this was the only investment to be completed on time. In contrast, there were no stoppages on construction B8, but the duration of this project was prolonged. 'The Organization and Management Encyclopaedia' defines "reserve" as "... the unused part of production potential" [2]. The under load or slack of work stations is regarded as a production reserve. This concerns the next problem in production process organization determines the appropriate level of reserves related to the under loading of work stations. Some reserves should be kept in case of disturbances in the production system. On the other hand, it should be considered that too low a load results in losses. Determining the optimal level of these reserves is a difficult issue and should be associated with the analysis of time and cost risk of an executed object [5, 9] as well as its individual circumstances.

## 4. Conclusions

Construction project management is effective when it is based on facts, and not on speculative or unverified assumptions. Therefore, work stoppages, their frequency and their causes were analysed in the article. By eliminating these stoppages, a company can improve its activity index, which is labor productivity. As a result, the economic efficiency achieved by the firm can be raised.

The research findings indicate that actions for productivity should be taken by every employee, from contractors through direct supervision of the construction, to the management of the company involved in the planning of the work. This is indicated by the most frequently noted causes of stoppages: violation of work rules, faulty organization, execution of work during periods of the adverse weather conditions.

The research conducted draws attention to the need to resolve the problem of the amount of production reserves during the installation of water supply and sewage systems. One of the components necessary for the proper determination of their level is to identify interferences in the production process and then take appropriate actions to eliminate them, or reduce them to the minimum level. The higher the number of building objects covered by observation and analysis related to the causes of stoppages, the more reliable the results will be.

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