Research Article

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Identification of geodetic risk factors occurring at the construction project preparation stage

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Abstract: The work contains information on the implementation of surveying works in the road construction process. The aim of the research was to identify geodetic risk factors occurring at the stage of preparation of a construction project, the presence of which can greatly disrupt the undertaking such as the road construction. The research was carried out on the basis of expert knowledge, documentation obtained from various road construction projects and the analysis of disturbances at the initial stage of works.

Keywords: geodesy, construction, risk

1 Introduction

This work is a continuation of studies on the identification of risk factors in the process of implementing linear construction projects. As is known, their elimination is not possible, however their identification and subsequent quantification may allow for the reduction of the impact of these factors on the entire road construction process. It also increases the ability to respond more rapidly to unforeseen events that may occur. Geodetic works are one of the elements of construction works. These works include, among others, the establishment of a horizontal and ver-

tical geodetic control network, inventory of the existing area, development of a road project and setting out the location of the road in the area. In order to avoid mistakes, construction works should be controlled as part of surveying work during the implementation of a given project. Identification of risk factors related to the execution of construction works forces us to undertake an in-depth review of the examined phenomenon, as the correct separation of these factors enables the correct risk assessment [1–6]. The aim of the article was to identify geodetic risk factors occurring at the stage of preparation of a construction project. The paper is a continuation and an interesting extension of the issue discussed earlier [7, 8].

2 Methods

The analysis of the provided construction documentation, literature review and interviews with experts were conducted. In addition, the data obtained from previous research was verified as a continuation of the analysis. The tests were carried out based on real cases and verified in practice.

3 Results

During the implementation of the research at the initial stage of works related to the construction of roads, 5 factors have been identified as having a significant impact on the realization of this part of the undertaking.

These include:

- R1 - the incorrectly adopted horizontal layout;
- R2 - the altitude system that was incorrectly adopted for the development of data and terrain elevation;
- R3 - a failure to prepare a general plan, and later its update;
- R4 - no GESUT information obtained from the PODGiK resource;
- R5 - development of a numerical terrain / project model.

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Table 1: Separated part of the schedule in which the R1 factor occurred, Source: own elaboration.

No.	Date	Activity
1	S	defining the scope of works
2	S+1	the scheduled start of humus removal
3	S+1	commencement of works related to the removal of humus
4	S+12	staking earthworks
5	S+24	completion of earthworks
6	S+25	staking out the indirect foundation (stakes) – finding the incorrect location of the trench in relation to the indicated stakes
7	S+26	as a result of the analysis, a discrepancy was found between the of DWG and PDF documentation - horizontal coordinates in the stake-out sheet were inconsistent with the editable version of the foundation contour
8	S+27	correct staking out of earthworks
9	S+28	earthworks - correction of the work performed
10	S+34	completion of earthworks
11	S+35	staking out the intermediate foundation - stakes
12	S+35	commencement of stake works
13	S+83	completion of stake works
14	S+84	commencement of foundation works

Table 2: Separate part of the schedule in which the R2 factor occurred, Source: own elaboration.

No.	Date	Activity
1	S+1	scheduled construction of the well together with road inlets
2	S+4	planned completion of works on the rainwater drainage system
3	S	setting the run of rainwater drainage system with two benchmarks
4	S+1	commencement of works on the rainwater drainage system
5	S+5	completion of work on the rainwater drainage system, reporting of the inventory before covering
6	S+6	carrying out the inventory of the notified scope
7	S+6	inconsistency with design ordinates was found during the analysis of the works performed
8	S+7	control measurement of the work performed, it was found that the work was not fully compliant with the design
9	S+7- S+13	works related to the reconstruction of the scope inconsistent with the project

Taking into consideration the received data and identified risk factors, actions were taken to indicate in the documentation the moments in which a given factor occurred and to determine the consequences of its presence. Tables 1-5 set out examples of occurrence of risk factors at the specific moment of construction works. Adopted in the tables marked “S” means the date of commencement of work.

The R1 factor tells us about the wrongly accepted horizontal layout that was detected during the works listed in Table 1.

Referring to the data depicted in Table 1, it was found that unfortunately the initial start date S + 78 for foundation works is delayed by 6 days due to the mistakenly

adopted horizontal layout in the editable version of the detailed design, which means that the designer’s drawing in the local layout is moved by 2.7 m, which consequently necessitates the correction of earthworks, and therefore also the delay in the implementation of stake works.

Table 2 presents the scope of work in which the R2 factor occurred. The scheduled completion of sewerage works on the day S + 4 enabled the implementation of works related to earthworks (embankment), the need to comply with the project caused a delay by 8 days, the work front moved to the neighboring section causing additional costs related to the moving of road construction machinery.

The incorrect performance of the part of the rainwater drainage system was caused by the erroneous installation

Table 3: Separate part of the schedule in which the R3 factor occurred, Source: own elaboration.

No.	Date	Activity
1	S+2	planned commencement of works related to staking the foundation of cement stabilized aggregate
2	S	setting out the stabilization range
3	S+2	commencement of stabilization works
4	S+3	completion of stabilization works
5	S+10	positive testing of the layer strength after 7 days; permit for the performance of further construction layers
6	S+15	transport of material to the connectors of the rainwater drainage system
7	S+16	PW information of the rainwater drainage system with no transversal crossings (connectors)
8	S+16	setting out the run of the connectors, starting work related to cutting the stabilization made in the trace of the planned drainage
9	S+17- S+22	implementation of dewatering continuity
10	S+22	inventory of rainwater drainage works; positive analysis of its execution
11	S+23	supplementing the layer of cement stabilized aggregate in places of transverse crossings
12	S+31	obtaining the correct results of the layer's strength, permit for the execution of subsequent construction layers

Table 4: Separate part of the schedule in which the R4 factor occurred, Source: own elaboration.

No.	Date	Activity
1	S	setting the scope of work
2	S+3	scheduled commencement of work relating to the trench excavation
3	S+4	commencement of work relating to the trench
4	S+7	interruption of work, damage to an unidentified underground utilities network
5	S+7	inventory of a damaged sanitary network
6	S+10	notifying the Engineer about the location of underground utilities not included in the project documentation
7	S+34	receiving a collision solution for a sanitary sewage system
8	S+35	the analysis of the received documentation for compliance with the road construction project
9	S+41	staking out the designed sanitary sewage system
10	S+41	commencement of sewerage works
11	S+47	completion of works; registration for inventory
12	S+47	inventory of works, confirmation of compliance with project documentation
13	S+49	resumption of works related to road trench excavation

of the benchmark. The geodetic team performing the stake out had mistakenly adopted the Kronsztadt 60 system from the topographical description instead of the Kronsztadt 86 ordinate.

The team performing the inventory adopted the correct data based on the control network established to the proper system.

The R3 risk factor, *i.e.* the lack of preparation of the general plan, has a very major impact on the implementation of the road construction project. The scope of works performed during the occurrence of this risk factor is presented in Table 3.

Any delay in the implementation of subsequent construction layers due to lack of coordination of work could improve the conduct of the general plan, which would be caused by a message when reporting the staking of the cement stabilized aggregate and non-performance of underground utilities.

GESUT, or *Geodetic Register of Land Utilities Network*, allows for the identification of its individual elements in the field. The delay in the implementation of the road trench excavation was caused by the lack of information about the existing underground utilities. The surveying services used the data only from the submitted design doc-

Table 5: Separate part of the schedule in which the R5 factor occurred, Source: own elaboration.

No.	Date	Activity
1	S	setting the scope of work supplementing the slope excavator control system with the correct model
2	S+3	scheduled commencement of works related to performing of the embankment
3	S+3	commencement of works related to performing of the embankment
4	S+4	inventory of work - control measurement of the body width, inclination of slopes, identification of the inclination slope compliance failure, required 1: 1.5
5	S+34	discrepancy analysis, 3D model coherence check with cross-sections of executive documentation - model construction error
6	S+35	performance of the correct 3D model
7	S+36	supplementing the slope excavator control system with the correct model
8	S+38- S+39	works relating to correction of the slope inclination
9	S+41	control measurements of works performed, confirmation of compliance with design documentation
10	S+43	commencement of works relating to strengthening the slope with 20cm humus layer

umentation, which resulted in a damaged sanitary sewage system located in the GESUT PODGiK database. Such damage shifted the work presented in Table 4 and affected the costs of works.

Table 5 presents works during which the R5 risk factor occurred. The delay in the implementation of the road embankment was caused by a wrongly developed 3D model being a batch file for both control systems in construction machines and measuring instruments. Lack of control of the developed model resulted in the construction of a slope with the incorrect inclination. Generation of cross sections would reveal erroneously connected points of the top of the slope with the outer edge of the ditch (the correct connection should be with the inner edge of the ditch). The error in the development of the model resulted in a longer construction time of the embankment.

4 Discussion

The effect of the analyzes carried out is a summary of the schedules of completed construction projects along with verified risk factors that may occur at the initial stage of work, as well as the consequences of their occurrence. As a result of these activities, factors that have a real impact on the duration of the work have been presented. This identification will allow for the transition to the next stage of works, i.e. their quantification.

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