Open Access. © 2019 M. Kowacka et al., published by De Gruyter. This work is licensed under the Creative Commons Attribution 4.0 License
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-
Identification of geodetic risk factors occurring at the construction project preparation stage

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 | works relating to correction of the slope inclination |
|     | S+39 |                           |
| 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.

References

[1] Ghorbani M., Sharifzadeh M., Yasrobi S., Daiyan M., Geotechnical, structural and geodetic measurements for conventional tunnelling hazards in urban areas – The case of Niayesh road tunnel project, Tunnelling and Underground Space Technology, 2012, 31, 1–8
[2] Kuburić M., Lero M., Surveying works in road designing and construction, Journal of Applied Engineering Science (Istraživanja i projektovanja za privredu), 2011, 9, 393-400
[3] Leśniak A., Plebankiewicz E., Opóźnienia w robotach budowlanych, Zeszyty Naukowe Wyższej Szkoły Oficerskiej Wojsk Lądowych, 2010, 3 (157), 332 – 339
[4] Perera B. A. K. S., Dhanasinghe I., Rameezdeen R., Risk management in road construction: the case of Sri Lanka. International Journal of Strategic Property Management, 2009, 13 (2), 87-102
[5] Sturk R., Olsson L., Johansson J., Risk and decision analysis for large underground projects, as applied to the Stockholm ring road tunnels. Tunnelling and Underground Space Technology, 1996, 11(2), 157-164
[6] Vose D., Risk analysis: a quantitative guide, 3rd ed., John Wiley & Sons, England, 2008
[7] Skorupka D., Duchaczek A., Kowacka M., Determining the Hierarchy of Selected Geodetic Risk Factors for Linear Ventures, W: Proceedings of the International Conference on Numerical Analysis and Applied Mathematics 2017, Thessaloniki, Greece, 2017, 25-30 (2017)
[8] Skorupka D., Kowacka M., Identification of risk factors of development and operation of roads in the light of surveying work. Archives of Civil Engineering, 2016, 62 (2),183-190