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Water Construction in Undermining or Otherwise Bylubrabanization Adversely Affected Environment

Marek Teichmann, Natalie Szeligova, Petr Srytr and Frantisek Kuda
Department of Urban Engineering, Faculty of Civil Engineering,
University of Ostrava, Ludika Podeste 1875/18 Ostrava-Poruba 70833, Czech Republic

Abstract: The study deals with the problems of adverse and long-time impacts of urbanization and mining subsidence of populated areas and the approaches of the state and administrators of individual branches of interest and that of expert public in relation to administration and maintenance of their immovables so that sustainable development is ensured. Legislative and normative requirements for building structures on undermined or otherwise affected areas, including the measures ensuring the durability of these structures against effects of natural and anthropogenic forces and phenomena are described here. In addition, the study deals with the specific example of effects caused by undermining on the territory of the shopping centre at Horní Litvínov. This example illustrates how changes induced by movements of subsoil may affect adversely the system for draining away mainly rain water from the territory.

Key words: Hydraulic structures, mining operations, mining subsidence, sewerage, water-supply line

INTRODUCTION

Mining operations usually show significantly adverse and long-acting effects on the territories of cities and municipalities and on their surroundings. However, there may also occur other actions with analogous adverse effects, e.g. in case of highways structures (in embankments, channels, in tunnels) in combination with the instability occurring in the landslide area in combination with the streaming modes of underground waters and surface waters, or there are adverse effects of relatively thick anthropogenic layers in combination with underground waters streaming modes, or there are adverse effects of leaky water pipes in vicinity of leaky sewerage, drainage systems and drainage elements taken out of service and left underground for good. Similar adverse effects are shown by old basements under historic city centres, etc., for example, also in combination

with shock and vibration effects induced by traffic or seismic effects (seismic clusters), etc. The flooded development areas have similar adverse effects on the lines and objects of the utility lines including their protective structures.

As these are usually the circumstances tied to specific local conditions, the original scope, quality and combination including their specific historical development, also their investigation and evaluation is often very specific including the specific procedure for designing and implementing the appropriate measures to eliminate their influences. In such cases, the generalization of knowledge and experience is desirable, however with adequate attention and caution.

These tasks, by their assignment, summary of background data and information, represent primarily the necessity to specify problems occurring in the area of interest and to explain their their causes including the desirable general allocation of responsibilities for the given state. At the same time, the order party's target is monitored, i.e, the provision of effective and feasible problem solving, ensuring the rectification of the undesired state causing damage to the given area, rectification of the state having often the signs of common danger. In this regard, it is also desirable to remind the requirement of sustainable development of settlements according to the applicable Building Act, i.e., also bound to the corresponding state of the public infrastructure. It is often necessary to count with a relatively considerable heterogeneity and with a limited range of available information.

Hydraulic structures in mining subsidence areas: An aid to solve not only water management objects on the undermined territory is the normative prescription CSN 73 0039 design of constructions on the mining subsidence areas (CSN, 2015) valid from January 2015, superseding the original wording of 1989. This standard applies not

Corresponding Author: Marek Teichmann, Department of Urban Engineering, Faculty of Civil Engineering, University of Ostrava, Luduika Podeste 1875/18, 70833 Poruba, Czech Republic

only to designing new objects but also to restoration of existing objects, possibly to evaluation of the existing objects in mining subsidence areas. The standard deals with various types of objects in light of their protection against mining subsidence effects based on structural-technical state of objects, mining conditions for the given area and last but not least, based on results of the existing geotechnical and/or hydrogeological surveys in some case. Despite the adverse conditions, the designed objects must then meet the requirements of CSN EN 1990 Eurocode: Basis of structural design (CSN, 1990) with regard to limiting states of bearing capacity and limiting states of usability (serviceability). As mentioned above, the standard deals with various types of structure whereas engineering facilities of settlements such as sewers and sewer systems, water-supply lines and water-supply systems, gas pipelines and gas distribution systems, analogously also heating distribution lines, power lines and power distribution systems and electronic communication lines and systems and all of their objects and protective structures.

MATERIALS AND METHODS

Sewers and sewer systems: When designing severs and sewer systems in mining subsidence areas, the most important thing is to expect possible variations of hydraulic conditions, induced changes in inclination of the sewer, changes in drain modes caused by changes in size of partial drainage areas and further the changes of static and dynamic loading conditions caused by changes in action of the forces on pipe lines due to ground subsidence, eventually ground displacement, etc. For these reasons, it is advisable to design, e.g, sewers in such specific conditions to the necessary extent (in case of separate sewerage, head sewerage or vacuum sewerage is more resistant). When it is necessary to build a sewer system is such an affected area, then it is necessary to situate secondary and subsidiary sewers in these areas whereas it is suitable to situate main and collection sewers in the area with more moderate effects of mining subsidence. It is recommended to design the individual sewers within their maximum permissible and available inclinations. In case of foreseeable parameters of the ground slope given by mining conditions, it is suitable to design the route in such a manner that the slope of the altitude route can rather grow owing to subsidence over time. On account of possible changes in the slope of the severs, it is recommended to pay more attention to relief objects and sewers namely due to their greater sensitivity (with the consequence of possible relief of undesirable amount and quality of sewerage water into the water object in question). When selecting pipe material for building sewerages in subsidence areas, it is necessary to select such a type that can accommodate better to changes in ground and prove sufficient mechanical strength, i.e., to be able to withstand the induced effects of subsidence. Pipe connections must be tight enough also when the the shape of the connection is partly deformed due to subsoil movements. The tightness of the pipeline not only in joints is desirable for prevention of infiltration and exfiltratio. The significant influence on quality and durability of the sewers has the method how the pipes are laid and on the quality of its execution. A significant role is played namely by the material of the pack, its processing, pliability, etc. (CSN,1990).

Water-supply lines and water-supply system: When designing water mains, it is necessary to anticipate their increased sensitivity to subsidence effects and the possibility of more frequent occurrence of failures and breakdowns. For this reason, it is desirable, e.g., to guarantee a bigger accumulation reserve in the appropriate water-supply tanks. When selecting pipe materials and pipe fittings, it is necessary to be particular about using the materials with a maximum resistance to potential changes in subsoil and guarantee an adequate strength of the material used (tensile strength, compressive strength, torsional strength, sturdiness of pipe joints, etc.). These parameters and others must ensure permanent sustainability and serviceability of water mains. On account of the possibility of more frequent occurrence of losses (failures and breakdowns) in water mains in subsidence areas, it is suitable to reduce operating pressures in the water mains aimed at reduction of water loss caused by their leakage and further the reduction of their mechanical stress as well. Much like in case of sewers, pipe laying plays the substantial role here, particularly also the material of the pack (possibility of shaping the pipeline according to changes in the ground). In case of water mains, it is also suitable to consider the possibility of using compensators, making it possible to eliminate both tensile and compressive strengths (CSN 1990;Teichmann and Frantisek, 2015).

Generally, it is necessary to pay more attention to designing the structures on the subsidence area and not to leave out all necessary explorations, whether geological, hydrogeological surveys and also the exploration of mining conditions if appropriate. It is necessary to perceive that building a water supply line, sewer, etc., not only on subsidence area, does not end by putting them into regular operation. In light of their sustainable development, it is necessary to perform their routine checks, maintenance, repairs, restoration, etc. In

terms of these activities, it is also desirable and possible to monitor the locations with the maximum risk of occurrence of losses (failures and breakdowns) on a long-term basis (to monitor signs of subsidence and remoulding the ground in connection to CSN (1990) and Caha and Mikulinec (2011).

RESULTS AND DISCUSSION

Localization of udergrounds mining workings: When preparing a building program, it is often possible to encounter the fact that building will take place in subsidence areas or in otherwise adversely affected areas due to urbanization and we must be aware of these facts beforehand. The fact that the area of interest is found, e.g., in the active zone of the subsidence area, can be searched out easily in the development plan of the given municipality where there is usually a mention of the state of ground subsidence, i.e., if subsidence in the area is still active, stabilized, etc., the working districts with terminated or continuing operations can also be searched out, e.g., on Czech Geodetic and Geological Service geofund web pages. There may be found, e.g., historical objects or historical areas such as basement or corridors underground. These historical areas can also be searched out partly in thelocal plan of the given municipality where a prehistoric site may be identified which is usually quite extensive and it may delimit the entire historical city centre. Therefore, it is more convenient to search out such objects by means of State Monument Care offices or in the Institute of History, Academy of Science of the Czech Republic (namely old basement, corridors, graves). However, it is necessary to point out that the responsibilities for the state of their underground are borne by municipalities or cities themselves which should have relevant databases to file all of these facts. Individual administrators of technical infrastructure should have a sufficient survey of the condition of underground.

Appraisal of intentions and consultancy in case of building in subsidence area: Currently, according to relevant legislation, no duty exists where it is necessary to solve particularly the problems of building in subsidence area or have a special permit to building in the area affected in this way. Nevertheless, it is suitable to consult the upcoming building projects at least from the very beginning, e.g. with the State Mining Administration of the Czech Republic with other competent state administration bodies, eventually with other specialists in the issue in question. However, in contemporary practice we often encounter the fact that building proceeds absolutely identically as in case of other "standard" building projects. The only exception to usual procedure for the assessment of civil engineering projects (i.e., building permit, possibly territorial consent) here are the requirements for execution of the structures resulting from CSN 730039 (CSN, 2015). In case of accession to building on subsidence area, it is suitable to consult the structure of the subsoil and its state during preparatory stage at the relevant District Mining Authority. It is also suitable to consult the technical solutions with other experts and specialists in this field possibly with help of knowledge and experience of persons, firms, companies, etc. that have solved the similar issues.

Adverse effects of mining susidence and urbanization to drainage in the place of the kaufland shopping centre and in its neighbourhood on the cadastral territory of horni litvinov: Furthermore, an example of the area with specific conditions including fading effects of former shaft mining in a part of Horni Litvinov (large part of Litvinov city is potentially influenced by historically finished brown coal mining).

The state of drainage in the area of interest and in its neighbourhood shows the state of disrepair which was confirmed by results of its reconnaissance. Next, Fig. 1-3 photo documentation. Within the framework of reconnaissance of the area of interest, the Building Authority at Litvinov Municipal Office and the Branch office of Severoeeske vodovody a kanalizace a.s. were contacted. with the aim of getting more exact information to the drainage systems in the given area. In both cases, this information was not available as to the sufficient extent and accuracy; no particular satisfactory background data on structure and function of the drainage systems, drainage elements or objects in the area of lots No. 2287/12, No. 2288/2 in the cadastral district of Horní Litvínov and in their surroundings, adjoining to both sides towards Jirasek street was acquired. This area is characterized by morphology of the ground space inclined to Jirasek street on both of its sides (Fig. 2).

The new zone of the Kaufland shopping centre (hereinafter the SC only) itself has a contemporary concept of drainage solution; it is equipped with separate sewerage and separate storm-water drainage systems. Due to its tight spatial and operational connection to its surroundings, it is important to evaluate and eliminate risks resulting from more frequent occurrence ensuing from more frequent occurrence of inundation of lowest section of Jirasek street (Fig. 1), i.e., also with regard to global hydrogeological conditions, morphological ground and water management conditions and those given by the section of the local communication drained with difficulty (Jirasek street) and to conditions in subsidence area.

Fig. 1: Photo documentation-the photos showing the emergency state, common danger state at the Kaufland shopping centre caused by insufficient of the Local Road Space Catch Drain (LRSCD) at Jirasek and insufficient function of the follow-up concentration and transfer object of the (LRSCD) and the relief sewer

The "Assessment of subsidence effects to surface at the site of SC Kaufland in the cadastral territory of Horni Litvinov" of 12/2011 which was available; it was confirmed that the area of interest is found in the coal basin with production development of coal bed which is tectonically impaired in abundance. The SC Kaufland zone is undoubtedly undermined (by room and pillar mining in its larger eastern part and by drifts and blind shafts in its smaller western part). Collapse processes at ground level induced the development of a synclinal valley (drainless ground depressions) of a larger surface area. In terms of hydrogeology, it is solely a synclinal valley (consisting of man-made ground and tertiary clays) in the area of interest which is saturated from the Divoki potok stream flood plain and also with subsurface water from the quarternary group of strata. The datum on the occurrence of underground water at a depth of approx. 4.5 m under ground level can be considered as important information. A shallow subsurface groundwater body developed in the quarternary filling corresponding to the development of free water surface in the nearby Divoki potok stream. In terms of filtration parameters of superjacent clays, it can be stated that the value of the filtration coefficient k_f ranges from $\times 10^{-7}$ to $\times 10^{-9}$ m.s.$^{-1}$ by which means this hanging wall can be considered as poorly permeable up to impermeable.

Then there was a poor quality of results acquired from a video exploration of the DN 200 concrete relief sewer, following up on the local road space catch drain (hereinafter the LRSCD only) between two roundabouts in Jirasek street, the roundabout at the SC Kaufland and the roundabout at the connection of Jirasek-Lomska-S.K. Neumann streets with the technically problematic, i.e., insufficiently resolved leaf object including insufficient operational maintenance and control with functionless opening to the Divoky potok stream. The relief sewer is clogged to such an extent that standard cleaning technology (before camera survey was carried out) failed there. It is also confirmed that it lost its operability due to absence of its operational maintenance and control with all consequences resulting from this. It can be estimated realistically that even efficient high pressure cleaning would not likely clean this concrete pipe of poor quality but it is very likely that the pipe would be completely destroyed. It is also surprising that the existing "Program for development of water mains and canalization in North Bohemia Region" as well as "Territorial-analytical documents of the North Bohemia Region" do not virtually respond in this area to the circumstance that it is an area affected by mining operations and they do not respond to a number of other urgent and serious problems either.

This commentary to documents and initial available information can be undoubtedly considered as a partial analysis of the situation that has its historical background in the area of interest related to brown coal mining and development of the city of Litvinov.The area of interest here consists of a partial drainage area, being more complicated in terms of its long-time influencing by anthropogenic activity, by its gradual urbanization. Hydraulic self-regulation has its influence as well in cases when basic conditions are changed according to situation, primarily the parameters of production of atmospheric water, parameters of rainfall. In interaction with the ground surface, it is important if the ground is permeable, semi-permeable or impermeable, flat, sloping, wavy, saturated or unsaturated with water, frostbitten or not, etc. This subsequently and also in terms of structure and parameters of local roads, influence the mode, parameters and directions of water flow which is directed here at the monitored flow profiles, to the critical point with the Concentration and Transfer Object (hereinafter CTO) of the LRSCD (between two roundabouts in Jirasek street, i.e., the roundabout at the SC Kaufland and the roundabout at the contact of Jirasek Lomska S.K. Neumann streets). The final section of the LRSCD,

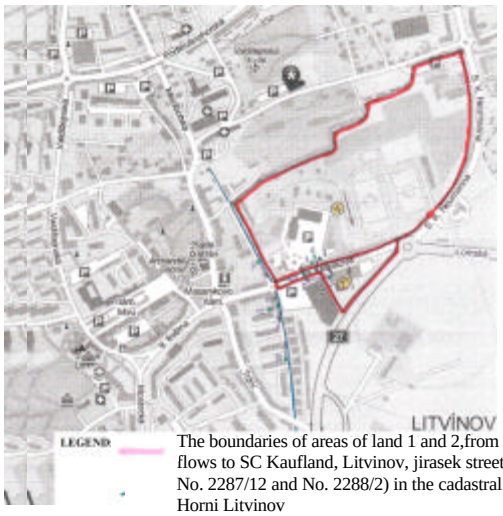

Fig. 2: Situation with denotation of surface of lands from where atmospheric water and ground water flow out towards the local road space catch drain (hereinafter the LRSCD only), Jirasek, subsequently into the concentration and transfer object (hereinafter CTO only) and it should then continue into the relief sewer (hereinafter the RS only). Due to inoperable state of the CTO and RS, the state of emergency, the state of common danger develops at the SC Kaufland, Fig. 2

including the adjoining local road, actually and involuntarily takes and simultaneously fails to fulfil duly and it cannot fulfil the function of a pseudoretention tank. The extent of the gathering ground from the lands allotted by the boundary of areas of partial drainage areas of lands 1 and 2 (Fig. 2) is then bound to various situations of rainfall that is manifested here as extreme one. The emergency situation at the SC Kaufland at Jirasek street was actually raised by the circumstance that the ground surface in proximity over the LRSCD shows a considerable break which induces a risk of outflows of phreatic water, a risk of subsequent enlargement of the volume of water flowing in. Photos in Fig. 1 show the emergency state, virtually the state of common danger at the SC Kaufland caused by poor function of the LRSCD at Jirasek street and by unsatisfactory function of the following CTO and by malfunction of the relief sewer in consequence. It is also likely that a certain portion of waste water or water containing oil products gets into the LRSCD, e.g., as a consequence of leaking sewers as well as a result of mistakes or a result of irresponsible

Fig. 3: Photo documentation - general view of the LRSCD in the direction of the roundabout at the connection of Jirasek-Lomska-S.K. Neumann streets; the catch-drain is not maintained. With proper function of the pipe underpass, the water should be transferred to the opposite side of the local road and further through the concrete DN 200 relief sewer into the Divoki potok stream; however, this important concentration and transfer object is in a poor state; the inlet to the pine underpass and to the following relief sewer is not secured against inlet of sediments which in connection with absence of operational maintenance had a harmful influence on the permeability of the pipe underpass and to subsequent relief sewers

behaviour of designers, property owners, etc. It is then possible to infer that the risk of emergency states there is increased by a sanitary risk.

Even if accurate data and information on canalization and other water management objects with the function of harmless and trouble-free drainage of this monitored area of interest were available, it will not evidently influence the basic evaluation of its poor state caused by low foresight of effects of mining operations and urbanization processes and by technical actions implemented there in the past. Sewerage systems and equipment, no matter if they were available there in the past or are available at present are either functionless or their function is poor also due to unsatisfactory operational care. Town planners and traffic engineers underestimated the situation by not responding in a timely manner and they allowed primarily the preservation of drainless depression there (consequence of initial mining operations).

CONCLUSION

In case of the above mentioned example of adverse effects of mining subsidence and urbanization in Horni

Litvinov it is possible to state, pursuant to above described problems and elementary analysis of the conditions for their solution, that the problems of the monitored area of interest in the neighbourhood of the LRSCD confirm the occurrence of recurrent human failures when making decision on urbanization of such areas and when making decision on particular investment projects of the public infrastructure, their implementation and their operation in consequence. Furthermore, the causes of inlet of rain water and other waters to the SC Kaufland are combined as explained above. The emergency state, a virtual state of common danger at the SC Kaufland is then currently caused namely by unsatisfactory and distorted function of the LRSCD at Jirasek street including the poor state of its CTO and pipe underpass and by malfunction of subsequent relief sewer. It seems that the optimum variant of the solution to the described problems is the most suitable execution of a new relief sewer route using the HDD (Horizontal Directional Drilling) technology and further in the reconstruction of CTO of the LRSCD so that transfer of sediments into the new relief sewer can be prevented.In general, it is possible to say that such settlements are in advantage in the field of technical attendance of the urbanized area by means of public infrastructure that used to be there from the very beginning of their faultless establishment where a well-integrated concept of technical attendance, corresponding to specific local conditions, state of the art, the nature and development of conditions of such solutions, including a timely response to their important changes, was developed. Such settlements are in disadvantage where from the very beginning of their establishment, repeated improvisation in solving their technical attendance, traffic and technical infrastructure, often with the occurrence of evident erroneous decisions with adverse effects (often of irreversible nature), took place. Particularly, in case of solving the sewerage of the urbanized area, such settlements were and are less problematic, the morphology of which hydrological and hydrogeological conditions and the position by the adequate water recipient assist to their solution in a natural way themselves. In greater part of areas of interest, it can be said that the situation was rather less favourable from the very beginning and it was subsequently intensified by their relatively swift development with many turning points, requiring even more demanding global solutions (Caha and Mikulinec, 2011; Proske and Srytr, 2012).

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