THE UNTRADITIONAL METHODOLOGY OF ENGINEERING-GEOLOGICAL APPLICATION IN THE EXPLORATION OF RIVER DAMS AFTER A FLOOD

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ABSTRACT

The submitted paper presents partial results of an engineering geological project of considering the right river levee of the Odra river in a section km 8,600 - 21,995 between Ostrava - Jih and Pudlov. Disastrous floods in July 1997 connected with local failures of the levee in examined area came out a question of necessary analysing those failures with a prognosis of possibility of their repetition in case of next loading of the levee with high water stands. The most critical for the filtration stability of the levee from a standpoint of their base conditions could be the places of transition of a levee fill over an original river bed and the dead channles, which can be often hardly defined in space by analysis of the graphic bases, which are lucidly elaborated in the relevant geographical information system. During next stages of the levee stability analysis is possible to pay particular attention to above mentioned critical sections well defined in space, if required.

Key words: Stability, old stream channel, flood protection dam, GIS, engineering geology.

RESUMEN

Este artículo presenta los resultados parciales del proyecto de ingeniería geológica "Evaluación de los diques de protección en el margen derecho del río Odra en la sección 8.6 - 21.99 Km entre Ostrava - Jih y Pudlov". Debido a la ruptura de varios diques como consecuencia de las inundaciones que se presentaron en el área de estudio en julio de 1997, se generó la necesidad de analizar las causas de dichos daños y de predecir su posible recurrencia en el caso de nuevas sobrecargas por altos niveles de agua en el río. Los cruces de los llenos por los cauces antiguos del río y sus brazos secos pueden considerarse, desde el punto de vista de las condiciones de cimentación, como los sitios más criticos para la estabilidad de los diques de protección. Estos sitios se pueden delimitar y definir claramente en el espacio mediante el análisis de bases gráficas dentro de un sistema de información geográfico (SIG) apropiado, y asi concentrar los análisis de estabilidad de los diques de protección en los tramos criticos.

Palabras clave: Estabilidad, cauces antiguos, diques de protección, SIG, ingeniería geológica.

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1. INTRODUCTION

At the town Ostrava as a consequence of the catastrophic floods, during which the real flow rates in many waterways in the basin of the Odra River considerably exceeded the flow rates corresponding to the theoretical level Q100 years, damage to the right riverbank flood-control dam happened in the year 1997. In the framework of exploratory works done, among other matters, causes of the failure of the protection dam were examined with the aim to make a prognosis of a possibility of failure reoccurrence in the case of extreme loading the protection dams due high water. The methodology applied had not been used in solving similar problems yet.

All information presented in this article is a part of an engineering geological project of considering the right river levee of the Odra river in a section km 8,600 - 21,995 between Ostrava - Jih and Pudlov. It was elaborated by firm ALGOMAN s.r.o. with the town Opava as the place of business for a requirement of Povodí Odry, a.s.

2. GOALS AND METHODOLOGY FOR ENGINEERING GEOLOGICAL WORKS ON FLOOD CONTROL DAMS

2.1. Goals of exploratory works

The designed and realised geological exploratory works were executed for the following purposes:

a) To determine the material composition of the dam in the stretch under study and the division of the dam embankment into individual units being quasihomogeneous from the point of view of their granulometric composition

b) To evaluate foundation conditions for the part of the right riverbank protection dam under study

c) To evaluate stability conditions of the dam embankment and dam bedrock

d) To analyse possible causes of dam damage in the course of the floods in the year 1997.

The goal of the executed works is thus the overall evaluation of engineering geological quality of the dam - bedrock system in the sense of dam embankment stability in case of embankment loading due to high water corresponding to the theoretical level Q100.

2.2. Methodology for exploratory works

When executing engineering geological works we used a methodology designed for this project. In principle, it was the case of combination of geophysical works (resistivity profiling) and boreholes supplemented by penetration sounding, laboratory analyses, cameral works, etc. In the article, merely information about the observation of intersections of old riverbeds with flood control dams by means of GISs is provided. These old riverbeds are often filled with highly compressible soils that affect stability conditions.

3. OBSERVATION OF INTERSECTIONS OF OLD RIVERBEDS WITH FLOOD CONTROL DAMS

Generally, causes of local destructions of dams may be divided into the two following fundamental categories:

a) Causes associated with the material composition and dam construction,

b) Causes associated with the foundation conditions for dams.

The analysis of foundation conditions for dams, especially then dams built in the space of altered streams, must begin with the study of natural historical development in the waterway and of methods (Marschalko *et al.*, 2000), or impacts of anthropogenic interferences into this development (improvement, dam building). By the example of the right bank part of the dam on the Odra River, a possibility of geographic information system (GIS) application may be documented when solving the problems of dam stabilisation.

In the framework of the above-mentioned project, individual time stages of the development of the Odra River and its flood plain by comparing aerial photos in the long time series (since the year 1946) with topographical documents and engineering geological maps were observed. In this connection, GIS uses have shown to be very useful.

Changes found are very marked.. This is related to the improvement of the river for planned canalisation, the building of flood control protection dams, the landfilling of cut-offs, etc.

For processing by the GIS the following methods were employed:

Geometrical transformation

Geometrical transformations (sometimes numerical transformations in contrast to analytical ones) ensure the attachment of the coordination system to maps, layers, or make it possible to coordinate the positions of layers in relation to one reference layer. This procedure is designated as registration, or georeferencing, or warping. Data layers in one area were usually unified (related to the only coordinate system) so that it could be possible to work with them.

In the 1st step, points with known locations were selected (control points, check points, identical points), and in the 2nd step, layer transformation was done. For raster transformation, affine and polynomial transformations are used most commonly (Horák, 1996).

Registration by relative position

Registration by relative position was used for the attachment of aerial photos. In this procedure, one data layer was designated as secondary (slave), "registered" to the reference layer (master).

The first step was the selection of elements (small objects, points, line intersections) that were displayed on both the layers. These elements are designated as control points in both the layers (always 1 point of the reference layer and the corresponding point of the secondary layer). The more control points and more regular point distribution in the whole area of the layer, the better the result of transformation. On the basis of control points the transformation function was calculated that then performed the proper transformation of the whole secondary layer.

As a consequence of this registration, positional errors from the reference layer are transferred to the secondary layers.

This operation is also designated as rubber sheeting (Horák, J. 1996).

Registration by absolute position

Registration by absolute position was used for the attachment of the topographical, Quaternary, engineering geological and hydrogeological maps. In this procedure, each layer is attached separately to the chosen coordinate system.

The advantage of this procedure is the fact that a positional error does not propagate from the reference layer to other layers. Moreover, the accuracy of each layer may be independently assessed.

On the contrary, the disadvantage is the fact that small positional errors in individual layers will be independent, and thus the boundaries of objects at their overlapping are not always identical. These discrepancies may be removed by another procedure - conflation. Horák J. (1996).

Regulation of the Odra River made mostly from year 1960 until year 1970 consisted above all in a straightening of the stream by building new river channel and the flood banks. This regulation caused a shortening of the original stream almost 5 km in examined area in comparison with year 1946. This prominent shortening of the river stream contributed to an increase of rectilinearity from 35 % in 1946 to 15 % in the present times (TABLE 1).

Formula for the rectilinearity of the river stream c_p:

$$c_p = \frac{L - L_p}{L} \cdot 100\%$$

, where L means a length of the water course [km] and Lp is a straight distance between initial and terminal point of that water course [km].

TABLE 1. Comparision of rectilinearity of the course.

Year	L [km]	L_p [km]	c_p [%]
1946	22,3	14,4	35,4
The present	17,6	14,9	15,3

In TABLE No. 2 are described the meanders and the river bends (FIGURE 1) recorded on air photographs from year 1946 and which are contemporary out of the active river channel. There is also listed younger and older generation of the oxbow lakes. Those two generations were separated by visual evaluation of their relicts such as an arrangement of the trees in the peripheral lines, terrain topography, geometrical limitation and a lot configuration.

State of the year 1946 (TABLE 2):

Width of the neck of the meander lobes ranges from about 200 to 400 m.

Width of the neck of the largest meander is 1100 m in the section km 7,95 - 9,05 in a place of an active gravel pit in Vrbice.

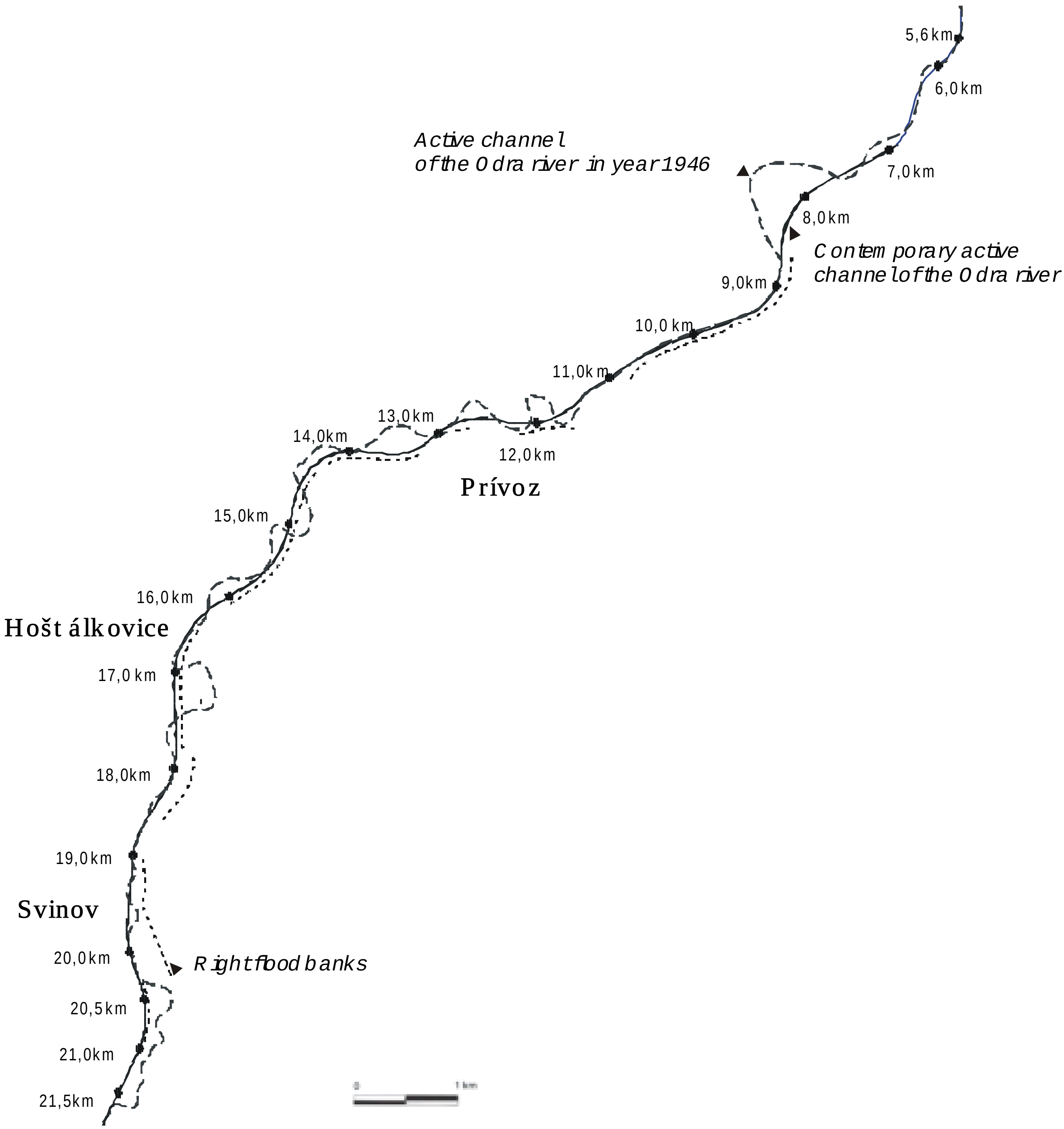

FIGURE 1. Points of intersection of old stream chanel of Odra River (1946 - from air photo) with flood protection dams

TABLE 2. Morphology analysis of the water course.

Stretch of the Odry [km]	*map sheet*	*formation*	*neck width [m]*	*amplitude [m]*	*topography*	*active channel*	*Detailed description*
6,0 – 6,5	*1*	*L former bend*	*500*	*150*	*in place of old exploated gravel pit in Antošovice*	*before 1946*	*gravel pit is used as a swimming pool*
6,5 – 7,3	*1*	*R former bend*	*800*	*700*	*in place of an active gravel pit in Vrbice*	*before 1946*	*the Struž ka stream flows in its N arm nowadays*
7,3 – 7,75	*1*	*L former bend*	*450*	*400*	*in place of an active gravel pit in Vrbice*	*before 1946*	
7,75 – 7,95	*1*	*R meander*	*200*	*400*	*in place of an active gravel pit in Vrbice*	*in 1946*	*the water flows in channel nowadays, it is becoming the oxbow lake*
7,95 – 9,05	*1*	*L meander*	*1100*	*650*	*in place of an active gravel pit in Vrbice*	*in 1946*	
9,05 – 9,85	*2*	*R bend*	*800*	*200*	*S from CD Koblov*	*after 1946*	
11,4 – 11,8	*2-3*	*R bend*	*400*	*120*	*about 500 m in front of the confluence with the Ostravice river*	*in 1946*	*the ? erný potok stream flows in its NW arm nowadays*
11,8 – 12,05	*3*	*L meander*	*250*	*250*	*SE from the Anselm mine*	*in 1946*	*it is the oxbow lake under the S slope of the Landek nowadays*
12,05 – 12,4	*3*	*R meander*	*350*	*150*	*S from the Anselm mine*	*in 1946*	
12,4 – 12,8	*3*	*L bend*	*400*	*200*	*S from the Anselm*	*in 1946*	
12,8 – 13,2	*3*	*L bend*	*400*	*100*	*SW from the Anselm mine*	*in 1946*	
13,2 – 14,0	*3*	*R bend*	*200*	*50*	*SW from the Anselm mine*	*in 1946*	
14,0 – 14,65	*3*	*L bend*	*650*	*250*	*E form CD Lhotka*	*in 1946*	
14,65 – 15,0	*3*	*R meander*	*350*	*200*	*SE from CD Lhotka*	*in 1946*	
15,0 – 15,2	*3*	*L meander*	*200*	*150*	*SE from CD Lhotka*	*in 1946*	*perceptible continuing silting up of the concave bank of the meander*
15,2 – 15,4	*3*	*R bend*	*200*	*100*	*S from CD Lhotka*	*in 1946*	
15,4 – 15,6	*3-4*	*L bend*	*200*	*100*	*E form CD Hoš? álkovice*	*in 1946*	
15,6 – 15,8	*4*	*R bend*	*200*	*150*	*E from CD Hoš? álkovice*	*in 1946*	
15,8 – 16,2	*4*	*L bend*	*400*	*150*	*SE from CD Hoš? álkovice*	*in 1946*	
16,4 – 17,0	*4*	*L bend*	*600*	*200*	*SE from CD Hoš? álkovice*	*in 1946*	
17,0 – 17,4	*4*	*R meander*	*400*	*300*	*NE from the confluence with the Opava river*	*in 1946*	
17,4 – 17,8	*4*	*L bend*	*400*	*200*	*close to the confluence with the Opava river*	*in 1946*	
20,3 – 20,45	*5*	*L oxbow lake*	*200*	*200*	*about 600m under the confluence with the Porubka stream*	*before 1946*	*perceptible dead channel*
20,3 – 20,7	*5-6*	*R bend*	*400*	*300*	*NE from CD Ostrava-Jih*	*in 1946*	*perceptible dead channel*

Amplitude of the meanders ranges from about 150 to 400 m.

Maximum amplitude of the meander was found in the section km 7,95 - 9,05 and that is 650 m from the place of the active gravel pit in Vrbice.

Width of the neck of the river bends ranges from about 200 to 650 m.

Width of the neck of the largest river bend is 800 m in the section km 9,05 - 9,85 E from the Koblov city district.

Amplitude of the river bends ranges from about 50 to 250 m.

Maximum amplitude of the river bend was found in the section km 20,3 - 20,7 300 m NE from the present Ostrava-Jih city district (former Výškovice municipality).

Width of the oxbow lakes ranges from about 200 to 500 m.

Width of the largest oxbow laker is 800 in the section km km 6,5 - 7,3 in the place of the active gravel pit in Vrbice.

Amplitude of the oxbow lakes ranges from about 150 to 400 m.

Maximum amplitude of the oxbow lake was found in the section km 6,5 - 7,3 in the place of the active gravel pit in Vrbice.

4. CONCLUSION

The methodology used by us saves a considerable amount of money and may be employed for solving many similar problems. As for the stability of protection dams, especially from the point of view of the filtration stability of their bedrocks, the most critical points may be just places of the intersecting of the dam embankment with the initial riverbed and cut-offs. Those parts are often difficult to identify during the common terrain reconnaissance, above all in agricultural areas. These points may be, altogether, reliably delimited and spatially defined by the analysis of map underlying documents and aerial photos from various time periods. To process them clearly, GIS tools and methods should be used. In the next stages of the analysis of dam stability, great attention should be paid, where appropriate, just to these spatially exactly defined parts of the intersections of protection dams with the original riverbeds.

5. REFERENCES

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