



Study of the terrain deformation examinations in the town Tuzla using geodetic methods.

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The problem which the town Tuzla in Bosnia and Herzegovina meets with is unique in this country, but also in the counties of the Balkan region. Tuzla is very well known town after its salt mine, because the salts has been exploiting at this location since the Roman time. After the year 1880, the exploitation begins more intensive. So, the deformations on the buildings were noticed in the northern part of the town, at the early forties of the twentieth century.

After some time, the problem of the deformation begun more serious. The fractures and the gaps appeared on the many buildings. The first systematic program with the purpose to do the readjustment was implemented at the late forties of the twentieth century. The problem persisted, and even, begin more serious.

For that reason, the examination of the deformations started to be more extensive in the early fifties. The local authorities made the decision to investigate and to follow the deformations using geodetic measuring. After 1950, the local geodetic networks were established in the town and the surroundings, as follows: triangulation, traverses, detailed geodetic profiles and leveling networks. Subsequently, the program of the geodetics works started to be implemented yearly. The accuracy of the 10-20 mm achieved for the horizontal positions, and 1mm/km for the leveling. These accuracies were more than enough good, because the velocities were very large. The largest (cumulative) vertical velocities in the center of the terrain deformation appear to be as much as about 10 m, but even horizontal velocities were about 5 m.

Geodetic data were collecting systematically over the period longer than 50 year. Now, this geodetic data set is a very valuable one, and relevant to present adequately, very

serious deformations and the local geodynamics. It is appropriate enough to describe the behavior of the terrain and its deformations, very precisely.

As the consequence of the deformations, the northern part of the old town Tuzla was destroyed heavily and many buildings disappeared totally. During the time, several center of the deformation appeared, and the different velocities trends can be recognize, for the different time intervals. The curiosity is that the local authorities decided to make an artificial salt lake and the center for the recreation and tourism, called "Pannonia Sea". This tourist attraction is located in the northern part of the town, exactly on the same place where the destroyed, old town centers use to be.

As though, the salts mine stopped the exploitation, and the terrain deformations are experiencing the subsidence. Beside that, the problem is still difficult, especially for the experts of urbanism and architecture as well as for the civil engineers. They are faced to the problems of the maintaining the towns, the building, the roads, and the utilities. Spatial planning is extremely problematic, because the deformation is located in the center of town.

So, during the geodetic project of determining the deformations, in the summer of 2007, the triangulation network was observed by GPS method. Traverses and the detailed geodetics profiles were observed by the total stations, whereas two leveling network were observed by digital leveling instruments.

GPS data were processed by Trimble Geomatics Office and Trimble Total Control software. Connection to ETRS89 made using observation on the three EUREF stations: STOL, TURI, and SRJV. The coordinates of the old trigonometric network resulted in the WGS84 and ETRS 89, as well as in Gauss-Krüger's sixth zone system. Free network adjustment of the traverses network (as the densification of the triangulation) and the leveling were processed using the software developed at Geodesy Department -Faculty of Civil Engineering-University of Sarajevo.

The final adjustment made as the 3D combined solution of the GPS data together with the terrestrial data (the traverses and the leveling) using the software Neptan.

The interesting geodetic problems of the transformations of the coordinates in the local coordinate system appeared. The coordinates in ETRS89 system and Gauss-Krüger's sixth zone system need to be transformed to the local system, as the velocities had to be defined.

The local datum was defined for the purpose of the investigation of this problem in the early 1950, using the Bessel ellipsoid, but, on the average height of Tuzla above the Adriatic Sea, i.e. 230 m. The additional problem with the local datum appeared because the deformations location experienced expansion, and stability of the points

defining local datum was problematic.

The horizontal and the vertical velocities were calculated for the different epoch, and also the cumulative velocities for the period 1956-2007. Also, the differences of the lengths were calculated from the coordinates of the points on the detailed geodetic profiles, and had been compared with corresponding ones from the different epoch.

Interesting interpretations of the velocities were calculated, and the different graphical interpretations were made, as the maps of the horizontal and the vertical deformations, and similar.

The local geodynamic problem is presented, numerically and graphically, in this paper. Some recommendation for the futures observations series are given in the conclusion.