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Monitoring of special construction using 3D laser scanning

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Abstract—Strong economy has resulted in the construction of imposing constructions. Many of special buildings (cooling towers, dams, nuclear, etc.) require special attention in terms of data quality service without danger, through time, monitoring the movements and deformations of buildings or their components.

In context of urban development recorded in Romania with the development of major construction such as: dams, bridges, silos, blast furnaces, chimneys, cooling towers, tall buildings etc., we can say that they draw after some deformations that many arise both during construction and after their completion. Their systematic measurement has great practical and scientific importance.

Through continuous collaboration of the engineering branches, the construction activity it is correlated and completed very often completed with the adoption and application of some geodetic methods and technologies that are coming to record, to process and to represent the behavior of the buildings subject to different perturbation factors.

The progresses made in the last years in geodesy and topography fields have seen a giant step by implementing modern surveying technology and surveying methods adapted in the civil engineering at the to track of the behavior in time some objectives importance.

Engineering structures (such as dams, bridges, high rise buildings, etc.) are subject to deformation due to factors such as changes of ground water level, tidal phenomena, tectonic phenomena, etc. Cost is more than offset by savings and by improvements in safety both during and after constructions. As a result, the design, execution and analysis of such surveys are a matter of considerable practical importance. Deformation refers to the changes of a deformable body (natural or man-made objects) undergoes in its shapes, dimension and position. Therefore it is important to measure this movements for the purpose of safety assessment and as well as preventing any disaster in the future.

The advantage of a real prognosis determination is the fact that in time the investments in these types of areas can be made on time and with maximum efficiency.

Practice has demonstrated that by using 3D modeling and the analysis of the movements of the areas located in mining areas, the experts in the field have better tools to perform a good prognosis in time and a good monitoring in time of the techniques used for land protection and for the protection of the existing constructions in the affected areas.

Keywords—monitoring, construction, 3D modeling, urban, environment, movement, deformation, laser scanning

1. INTRODUCTION

Engineering structures (such as dams, bridges, high rise buildings, etc.) are subject to deformation due to factors such as changes of ground water level, tidal phenomena, tectonic phenomena, etc. Cost is more than offset by savings and by improvements in safety both during and after constructions. As a result, the design, execution and analysis of such surveys are a matter of considerable practical importance. Deformation refers to the changes of a deformable body (natural or man-made objects) undergoes in its shapes, dimension and position. Therefore it is important to measure this movements for the purpose of safety assessment and as well as preventing any disaster in the future.

The development of measuring techniques has permitted and created the possibility to observe and emphasize the behavior of the studied buildings. There are loads of classification criteria, methods of research and observation of buildings and structures.

Taking this into consideration, there have been criteria developed, made by types of deformations, types of equipments and place where the equipments are situated during the observations.

By the place where equipment are located during the observations process there are two possibilities to determine the movements and deformations:

Physical methods: with the equipment located inside the building; in this case the equipment move at the same time with the building so relative movements and deformations can be evaluated.

Geometric methods: in this case, the equipments are placed outside the building or outside of its deformation area, the measurements will be linked to a network of fixed points situated outside of the deformation area and of the factors that can affect the building or the foundation ground that it is situated on [2].

Through this process there will be established absolute values of the horizontal or vertical movement. The topographic-geodetic methods belong to this category of determination of movements and deformations.

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Monitoring the dynamic behavior of large structures has been always a topic of great relevance, due to the impact that these structures have on the landscape where they have been built.

In our paper, in order to sustain our point of view, we are going to present an eloquent example, i.e.: cooling tower within the enclosure of CET Timişoara South.

Fig. 1 The cooling tower from the area of CET Timişoara South

SC Colterm SA – C.E.T Timişoara South is located in the south of Timişoara municipal, in a densely populated area.

Fig. 2 Satellite Imagine with the area C.E.T Timişoara South

2. MONITORING COOLING TOWER, WITHIN THE ENCLOSURE CET SUD TIMIŞOARA, USING TERRESTRIAL LASER SCANNING TECHNOLOGIES

The advantage of a real prognosis determination is the fact that in time the investments in these types of areas can be made on time and with maximum efficiency.

Practice has demonstrated that by using 3D terrestrial laser scanning and the analysis of the movements of the construction, the experts in the field have better tools to perform a good prognosis in time and a good monitoring in time of the techniques used for land protection and for the protection of the existing constructions in the affected areas.

Modeling 3D constitutes a first reference for geo-3D modeling and the data analysis, being able to be used for studies on many important directions and in various fields, such as: geophysics, mining, hydrology, environmental protection, constructions, archeology, meteorology, etc.

To confirm the possibility to building high follow-up analysis was performed poaching cooling tower using terrestrial laser scanning technologies. The cooling tower scans were performed using laser scanning Scan Station C10, manufactured by Leica. This is a terrestrial scanning system that uses static measurement that can be used in a wide range of topography engineering works.

Fig.3 C10 ScanStation scanning system

The instrument used to measure distances of time measurement principle for measuring angle oscillating mirror principle and has a 3600 scan field horiyontally and vertically. Scanning was performed with cooling tower on the benchmark RN11 closing of leveling network, using three prisms of view of circular type Leica.

Fig.4 Scanning prism pole with tripod mounting

Fig.5 Basic benchmark leveling RN11 network CET Sud Timişoara

Scans were made at a resolution of 5 cm to 50 m, with fine scanning targets that are placed on the pole with tripod attachment to 2 mm at 50 m resolution. Scan mode was chosen “target all” entails 3600 both horizontally and vertically. The scan was obtained a file with a cloud of points in local coordinate system. This file contains the 3D position of points, the name of which the scanning station, the name of the points that have set targets and the position

coordinate system [6].

3. ANALYZING DATA RESULTING FROM SCANNING

Postprocessing data from measurements with the scanning ScanStation C10 were made with Cyclone software v 6.0. If the results meet such registration, in terms of geometric and considers acceptable, that is deviations results are within the accuracy required, resulting cloud of points unwrough a single coordinated system.

Fig.6 Cloud points resulting unwrought

The next operation is in the process of filtering the resulting data post processing, which requires the removal of items not covered by the area scanned, removing items that contain noise generated by the influence of weak relection of the scanned surface, obstacles or people in the scan, the scanning resolution, etc.

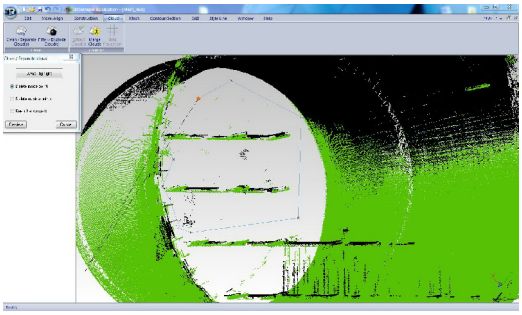

Fig.7 Cleaning the cloud of points by drawing a contour

It's recommended that the points taken extra tool to be removed manually by the operator, it can identify them easily by analyzing the scanned area. Operation for removal of the points can be implemented with the five standard control nodes "Point cloud density" without reduction, reduce the minimum average cut, high cut and cut very high.

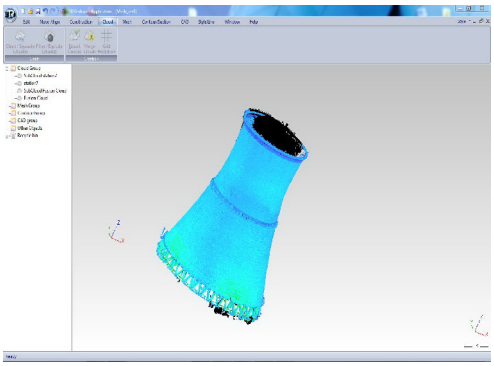

Fig.8 Point cloud ready to achieve the final product

After filtering and setting these operations will move to data modelling for obtaining 3D modelling a colling tower no. 1 . For this operation will create a 3D mesh to achieve the objective scanned.

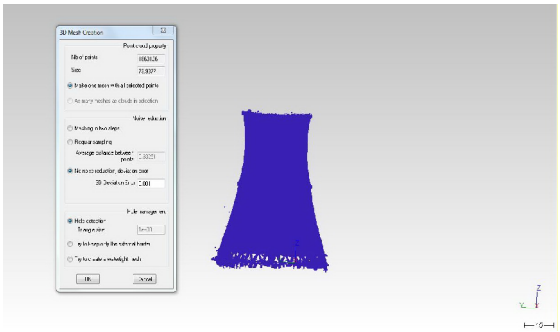

Fig.9 Setting options for creating meshes them a colling tower

Fig.10 3D model of a cooling tower

Based on the 3d model of cooling tower and a reference plane can calculate the cooling tower and finding differences between the surfaces measured at different times.

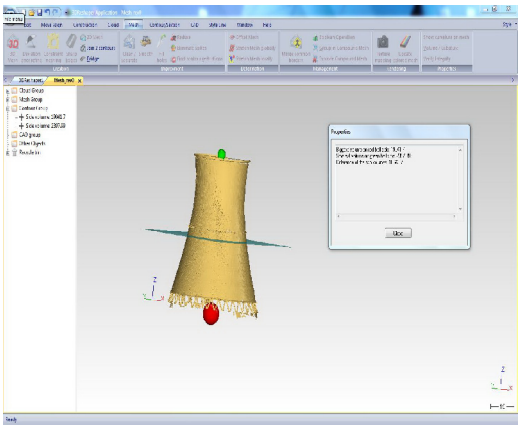

Fig.10 Return values of volumetric

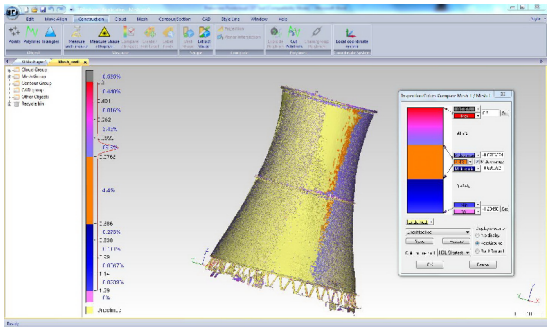

Fig.11 Distortion analysis using measurements of the cooling tower at any given time

On the basis of we conclude that terrestrial laser scanning technology can be used to analyze the possibilities of tracking behavior in time of major construction in our country such as: dams, bridges, silos, blast furnaces, chimneys, cooling towers, tall buildings, etc., they result in some strain both during construction and after their completion.

4. CONCLUSION

The application of the modern topo-geodetic methods to the study of the behavior of different types of constructions represents an essential condition in the real highlighting of the evolution in time of a part of the construction or of whole structure as a whole.

The measurement, the processing, the calculation and the representation of the settlements, horizontal movements or inclinations of the tall buildings can be done today with modern topo-geodetic technologies, automated, which associated with the correct application of some specific methods, gives the guarantee of a fair highlights of the phenomenon of the buildings instability. With the help of the new geodesic methods and technologies with high degree of automation, the field of construction observation behavior submitted to different disturbance factors becomes a branch of topical with applicability to various types of civil engineering, in close connection with the requirements of urban development and environmental protection.

The results obtained after a 2-year study confirm the need to:

- Implement this new technology to monitor the high constructions;
- Using topo-geodetic measurements as well as 3D modeling, as a system which can provide a permanent control, and which will be able to monitor the behavior in time of the construction movement phenomenon. A system able to signal efficiently, in real time any modification that can lead to potential damages to the environment.

In context of evolving technology, more and more potential domains for 3D laser scanning applicability appeared, starting from its obvious advantages: measurements without direct contact, high precision, quickness data acquisition, results delivery in a shorter time, etc.

Laser scanning technology represents a first reference for 3D modeling and data analysis, being able to be used for studies on many important directions and in various fields, such as: geophysics, mining, hydrology, environmental protection, constructions, archeology, meteorology, etc.

These are some of the reasons for which a possible prognosis in time of the movement of special constructions can make the investments in these areas continuous and made with maximum efficiency.

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