

3D REPRESENTATION OF THE TOPOGRAPHICAL SURFACES FOR THE REHABILITATION AND DEVELOPMENT OF THE STOCK PONDS

REPREZENTAREA 3D A SUPRAFEȚELOR TOPOGRAFICE PENTRU REABILITAREA ȘI REAMENAJAREA IAZURILOR PISCICOLE

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Abstract. *This article presents the methodology for creating the terrain 3D digital model based on topographic surveys and also for using it to carry out some preliminary calculations of the design process, to reduce the damage caused by floods and land arrangement occupied by water. The 3D digital terrain model allows users to perform a series of operations such as viewing, analyzing, measuring, querying and others.*

Key words: Delauney triangulation, 3D model, volumes, surfaces

Rezumat. *Articolul prezintă metodologia de creare a modelului digital 3D al terenului pe baza ridicărilor topografice, precum și utilizarea acestuia în vederea efectuării unor calcule preliminare procesului de proiectare. pentru reducerea pagubelor produse de inundații și amenajării terenurilor ocupate de ape. Modelul 3D digital al terenului permite utilizatorilor să efectueze o serie de operații, cum ar fi: vizualizarea, analizarea, măsurarea, interogarea și altele.*

Cuvinte cheie: triangulația Delauney, model 3D, volume, suprafețe

INTRODUCERE

Starting with few years ago, more and more designers and architects around the world have approached this relatively new field of three-dimensional modeling preferring 3D design systems instead of traditional 2D representation (Cosmin, 2007). The 3D model can be easily manipulated, viewed, analysed and modified according to various requirements and demands. Designing on a 3D model is faster than a traditional design in 2D space. The advantage is that by viewing the model, it eliminates the difficult task of three-dimensional thinking, as compared to classical design plans.

The first parts of the paper approach a brief review of the triangulation method with linear interpolation used by the TopoLT program to represent the topographic surfaces in 3D (Raković et. al, 2004). In this paper were treated some aspects related to the data collection based on land surveying methods and to the areas and volumes calculations used to represent the characteristic curves of the Ibaneasa III lake, situated in Ungureni commune territory, Botosani county, both through practical methods and using the TopoLT software.

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MATERIAL ANF METHODS

1. Accumulation's characteristics and hydrology

The stoke pond Ibaneasa III is situated in the Prut river's hydrographic basin, having the land code XIII-1.15.11 and is part of a chain of stoke ponds on the upstream of Ibaneasa river (Prisaca, Slobozia, Vorniceni, Ibaneasa I and II). The Ibaneasa III lake was inaugurated in 1958, having at the maximum retention level a 17.38 ha water surface, with a total volume of 0.214 m^3 , of which an utilization volume of 0.145 m^3 . The dam has a spillway with a surge front with a wide threshold. The spillway has 30.50 m in length and 1.00 m in height. On the front overflow there are metallic guides for mounting the piscicultural grillages and walkway passages. According to STAS 4273/83, the stoke ponds fit to the fourth class of importance. Aquaculture activities are carried out on 18.43 ha. The water volume of the lake at the maximum retention level (104.80 m) is $270,000 \text{ m}^3$ according to an average depth $H_{med.} = 1.70 \text{ m}$.

2. The Delauney triangulation principle

There are several methods, more simple or more complex, to generate 3D terrain models using various tools (Zăvoianu et al., 2002). Modeling functions or geometrical models are used in order to create the digital terrain model (Grid, contour lines and TIN-Triangulated Irregular network). The TIN model reduces redundant data from grid model especially in regions where the land is bump. TIN model accuracy is higher than any other models of terrain surface representation because, this model uses 3D triangles to represent the 3D surface (Savu, 2010). TIN network elements can be generated by Delaunay triangulation method which creates a family of triangles for all the points characterised by the X, Y and Z coordinates. The triangles have the surface greater than zero, share a vertex or edge and the circle circumcircle of each triangle does not contain another vertex.

RESULTS AND DISCUSSIONS

1. Surfaces and water volumes calculation, using practical formulas and graphical representation of the characteristic curves

To achieve the necessary calculations, an accumulation levelling site plan was drawn using a topographic survey, with AutoCad software.

The water surfaces of the lake, corresponding to different rates of the dam water level, were determined by planymetry process on the site contour plan of the stoke pond Ibăneasa III, in which case, the water surface was considered horizontally (Giurma et al, 2006). Such areas were measured on the contour curves with 5 m equidistance, from 102.00 m elevation above sea level (thalweg elevation), the area at this elevation being considered null, up to 106.00 m above sea level (dam crown elevation). The water volume variation in an accumulation is given by the functional dependence $V = f(H)$.

For this case study area has been used the average surfaces of the horizontal sections method. For this purpose the volume of water in the lake was divided into nine distinct sections separated by horizontal sections at different water levels (Giurma I. et al, 2006), resulting a total of eight partial volumes (table 1), calculated with the following formula:

$$\Delta V_{i-1,i} = \frac{S_{i-1} + S_i}{2} \cdot \Delta H \quad [m^3]$$

where: S_{i-1} - the area closed on the lower level curve,

S_i - the area closed on the upper level curve,

ΔH - difference of altitude between two successive curves (0.50 m).

The cumulative volumes were then calculated (table 1), using the relation:

$$V_i = V_{i-1} + \Delta V_{i-1,i} \quad [m^3]$$

Table 1

Ibaneasa III accumulation characteristic curves					
Elevation [m]	Equidistance between the curves [m]	Surfaces		Volumes	
		Partials	Averages	Partials	Cumulatives
		[m ²]	[m ²]	[10 ³ m ³]	[10 ³ m ³]
102.0		0.00			0.00
102.5	0.50	4609	2305	1.15	1.15
103.0	0.50	55940	30275	15.14	15.14
103.5	0.50	123730	89835	44.92	60.05
104.0	0.50	162850	143290	71.65	131.70
104.5	0.50	174050	168450	84.23	215.92
105.0	0.50	192840	183445	91.72	307.65
105.5	0.50	211350	202095	101.05	408.69
106.0	0.50	226450	218900	109.45	518.14

The pairs of values (S, H) and (V, H) were graphically represented, in an rectangular axis system, achieving the lake surfaces and water volumes variation curves (figure 1).

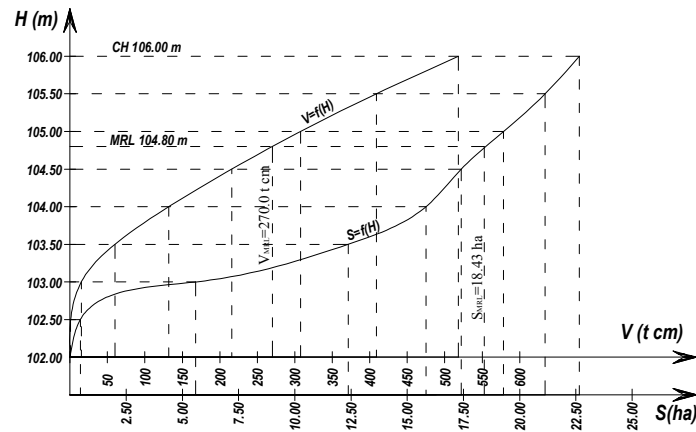


Fig. 1 – Ibaneasa III accumulation characteristic curves: $S = f(H)$ - variation curve of the

lake water surface, $V = f(H)$ - variation curve of the lake water volumes

2. Surfaces and water volumes calculation using the TopoLT software

TopoLT is software that works under the AutoCAD or IntelliCAD platform. The TopoLT software constitutes a help for those who carry out topographical or cadastral plans in a digital format (Balaneanu and Oprea, 2007).

The first step was to create the 3D terrain model of Ibaneasa III acumulation (as Delaunay triangulation network) in a gradual colors ranging from a minimum (thalweg elevation) up to a maximum (crown height), using the M3D command. In order to create the 3D terrain model was used the X, Y, and Z coordinates inventory, as well as space lines and polylines, which represent a forced slope change. The 3D terrain model can be viewed by running the VM3D command from CAD software (fig. 3).

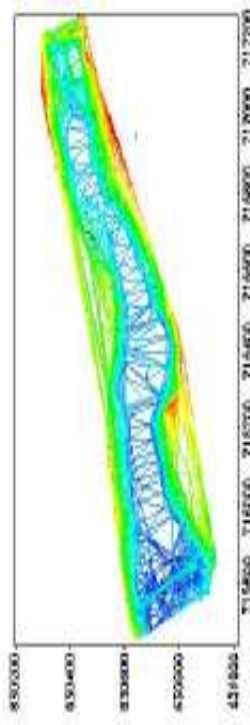


Fig. 2 – The triangles network for the 3D terrain model representation

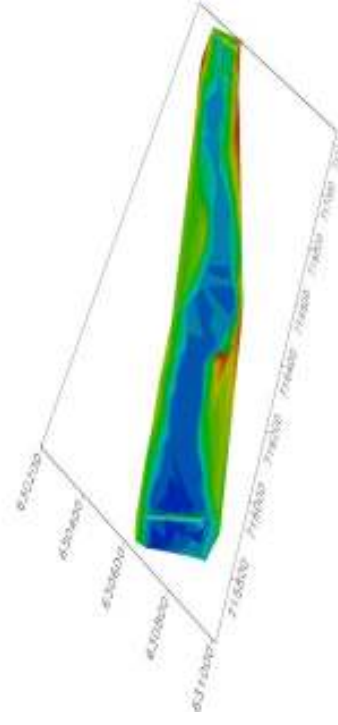


Fig. 3 – The Ibaneasa III accumulation 3D model, created by TopoLT software

The water volumes are calculated as a sum of 3D objects (block prism), which are obtained by spatial intersections between the 3D model and the constant elevation plan or by intersections between two 3D models using the **Vol** command. The calculation method is purely geometrical, approximation methods are not used, so the 3D models to be used should describe the surface as accurate as possible.

For this case study were calculated a total of eight volumes, defined by the 3D model and the plans with known Z elevation, from 102.50 m above sea level and continuing with the appropriate equidistance of 0.5 m, up to 106.00 m above sea level, dam crown height (tab. 2).

The volumes can be viewed or not, this setting is made using the Om3D command and using the **Vol** command the flat and sloping surfaces are calculated, corresponding to the objects that make up this volume. The areas for 0.5 m equidistance contour lines (areas in the plan), determined with TopoLT software, are listed in tab. 2.

The comparative analysis of the horizontal surfaces defined by contour lines with 0.5 m equidistance, resultated from measurements on the site plan in the CAD software and those calculated with TopoLT software, revealed differences between the areas up to 1.95% in range, which are within the statistical limit of error.

Table 2

The surfaces resultated from measurements and those calculated withTopoLT

Elevation [m]	Surfaces		Differences	
	Measured	TopoLT	[m ²]	%
	[m ²]	[m ²]		
102.0	0	0	-	-
102.5	4609	4697	-88.29	-1.92
103.0	55940	54848	1092.34	1.95
103.5	123730	122512	1218.21	0.98
104.0	158323	158253	69.81	0.04
104.5	174050	174213	-162.81	-0.09
105.0	192840	192061	778.90	0.40
105.5	211350	211405	-55.33	-0.03
106.0	226450	227719	-1268.55	-0.56

Table 3 show a comparative analysis of the water volumes calculated with the average areas practical formula and of those calculated by TopoLT software. The volumes differences range up to 4.20%, statistical was fitting in the error's limits, except for the first two volumes that correspond to the 102.50 m and 103.00 m elevation above sea level contour line, for which there were differences of 73.22% and 13.36% respectively.

Since in practice is used a simplified formula of the volume, the result is a volume approximated to reality. The TopoLT software calculates the water volumes as a sum of 3D objects (trunks prism) which are obtained by spatial intersections of the 3D model with the constant elevation plan, thereby achieving values much closer to reality.

This is obvious for the first volume in part because throught the simplified formula of the volume, the geometric body is considered a pyramid (the thalweg elevation surface is considered null), which in reality it is impossible, resulting a gross error (73.22%). For the other partial volumes, the

errors due to approximation with a regular geometric body are not removed, but are relatively minor.

Table 3

The water volumes calculated using practical formulas and TopoLT software

Elevation [m]	Water volumes		Differences	
	Calculated [m ³]	TopoLT [m ³]	[m ³]	%
102.0	0	0	-	-
102.5	1152.25	309	843.64	73.22
103.0	15137.25	17159	-2021.75	-13.36
103.5	60054.75	62579	-2524.21	-4.20
104.0	131699.75	133628	-1927.82	-1.46
104.5	215924.75	216662	-737.10	-0.34
105.0	307647.25	308340	-692.33	-0.23
105.5	408694.75	409608	-913.50	-0.22
106.0	518144.75	519511	-1366.37	-0.26

CONCLUSIONS

1. The TopoLT software creates 3D terrain models that can be easily manipulated, viewed, analyzed and modified according to various requirements and demands.

2. The 3D model can be successfully used to perform calculations needed in the design process; because it offers a very good accuracy and the design process can be performed in a rapid way directly on the 3D model, comparative to the traditional design process in 2D space.

3. This modern computer system implementation will lead to high economic efficiency and obtaining high precise results comparing with the classical methods.

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