FROM 2D MONGEAN PROJECTION
TO 3D MODEL IN AUTOCAD

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Abstract. The aim of this paper is to present some examples of problems, which can be implemented within the course of descriptive geometry. A computer assistance for solving the problems through the use of AutoCAD software has been utilized. Firstly, each task will be solved in a classic Mongean layout. Later, some elements of the solution are used to create a 3D model. Finally, the solution will be graphically represented in Mongean projection. The method has been illustrated by two examples.

Keywords: shadows construction, topographic projection, topographic mapping, AutoCAD applications, descriptive geometry problems

1   Introduction to a case study of CAD application

Geometrical problems can be easily solved with the use of a manual technique of representation of 3D problems on a 2D medium of a hand-made drawing. However, the solutions we get very often play "tricks' with our ability to think in three dimensions and what's more with our ability to communicate design ideas on the 2D medium, which is a cardboard paper. Representation of the task solution becomes neither unique nor easy to present. Thus, the aid provided by computer software makes it easier to transfer the ideas into a 2D medium. The authors of this paper will present below 2 examples showing how AutoCAD can help better understand the solutions of two specific problems [2].
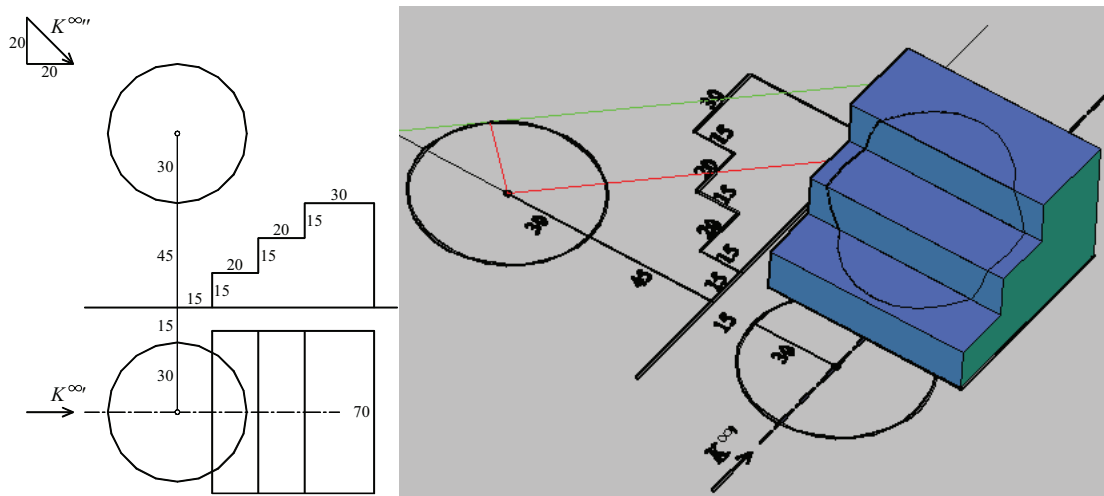
2   Shadow construction

Figure 1: Sphere's shadow cast on the stairs

Example 1

Task: Construct horizontal and vertical views of the shadow cast by a sphere by a spotlight onto the stairs. Illustrate the solution in 3D (Fig. 1).

Solution: Let us first draw two orthographic views of the stairs and the sphere in Mongean projection method. Let us assume that the source of light is a spotlight located at infinite distance from the sphere. The axis of the cylinder of revolution, whose generators are the light-rays, will be parallel to the frontal picture plane π_2. We have enough information to create the appropriate cylinder of light-rays (as a block) in AutoCAD software. We can also create a model of the stairs as the sum of relevant boxes. It is easy to find now a common part of the cylinder and the block of stairs. The intersecting part represents the shadow of a sphere cast on the stairs.

3   Cut and fill embankments construction – a case study of CAD application

Example 2

Task: Construct a topographic projection of a road determined by a certain road profile, its width and slope, when the data for a cut and fill embankments and their two profiles are given. Illustrate the solution in 3D (Fig.2).
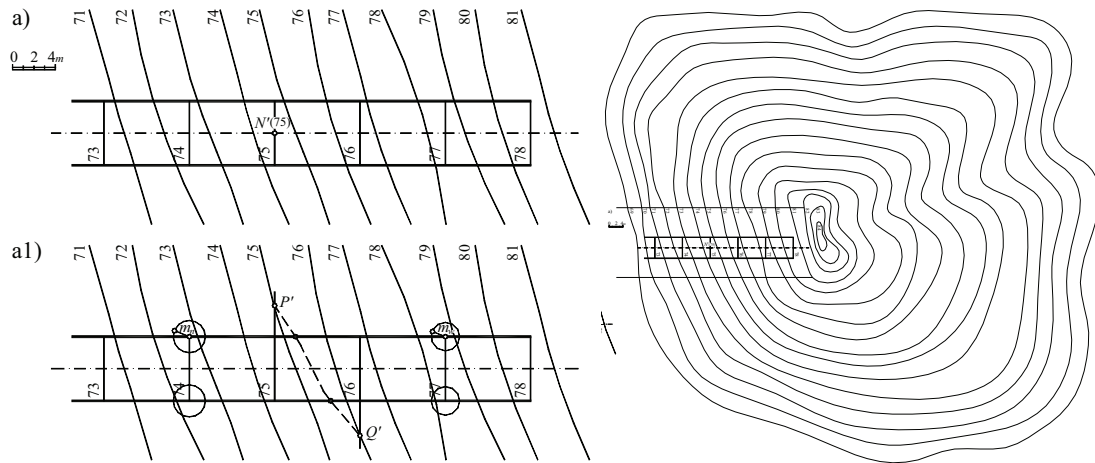

Figure 2: Two-dimensional closed terrain mapping contour created on the basis of the existing 2D projection by the use of spline curves (=splines) and a 3D model of the terrain created by changing elevations of the existing contours
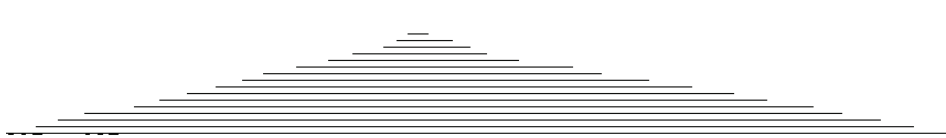

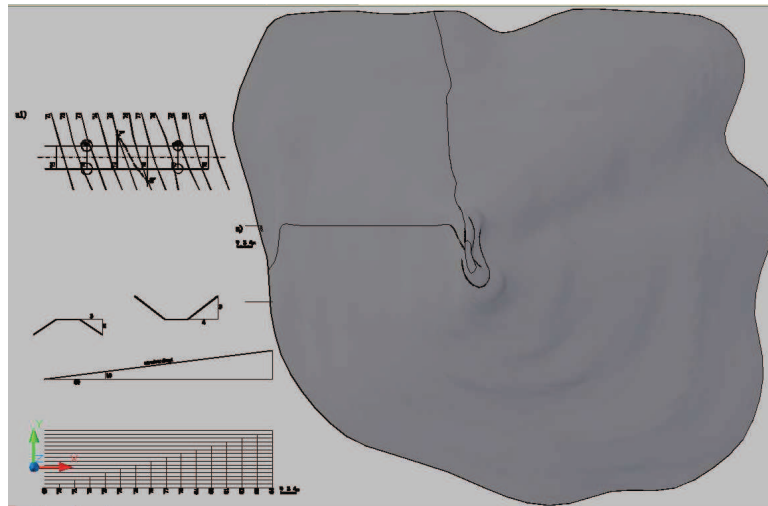Figure 2-1: Cross section through the contours of the land

Figure 2-2: Top view of 3D ground surfaces (created by removing the horizontal cross-sections)

Figure 2-3: Front-view of the 3D ground surface profile (created by removing the horizontal cross-sections)
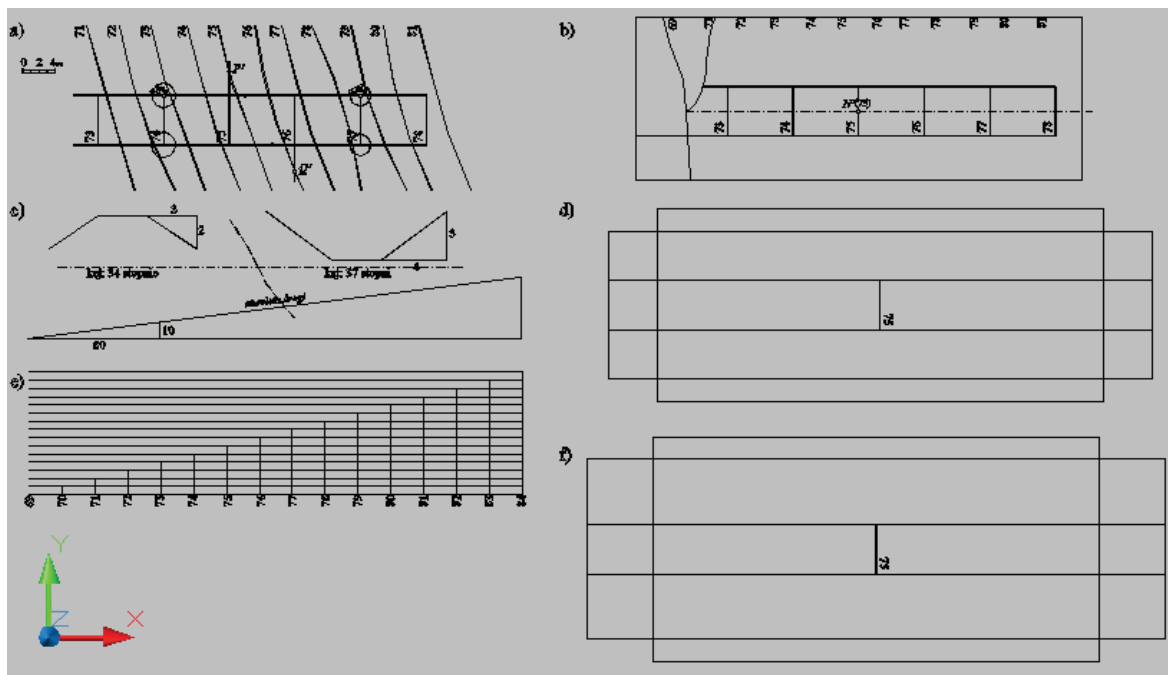

Figure 2-4: Elements of creating a model of the road: a) localization of a 2D contour, b) create a solid model with the base of a rectangular area presented in Fig. 2-4a), cut the solid with the use of a Boolean operator, c) slope angles of the embankments of the cut and the fill parts, d) assumptions to create the embankments: two rectangles will be extruded: one with an angle of extrusion of 56° to the height of 20, the other one vertically to the height of 20, e) diagram of contour heights f) assumptions to create the foundation of excavation: two rectangles will be extruded: one with an angle of 53° to the height of 30, while the other one will be extruded vertically to the height of 30. In AutoCAD software all the rectangles are drawn with a closed polyline
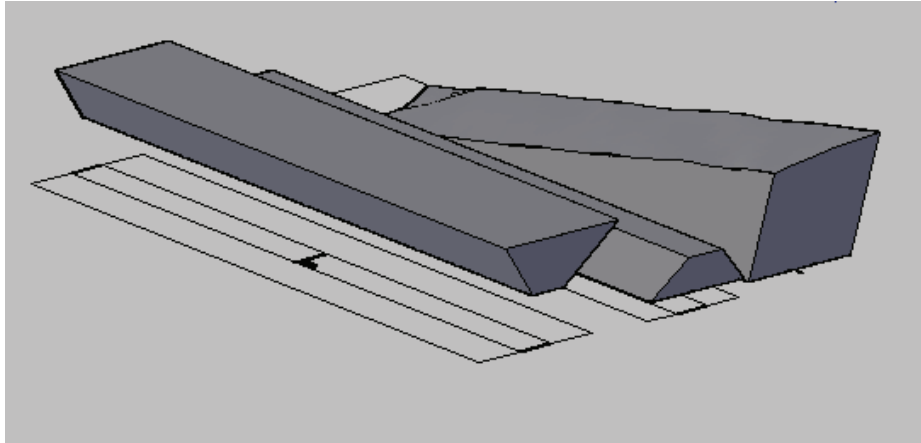
Figure 2-5: Creation of a fragment of the land-area with two types of the embankments: a cut and a fill (reflected symmetrically with 3D operations)

Solution: After solving the task in topographic projection (see: Fig. 2a1, a2, 3a4, 3a5 [1]) we create respective polylines using indirectly the functions of creating the splines. At first we create a closed 2D terrain mapping contour based on the existing 2D closed splines as created by applying an "extension" command on the existing contours. We change the elevations of the 2D contour lines of the site to the appropriate heights of 5, 10, 15, 20, ... (now in 3D). Later we can create the grade line of the road inclined at 7° to the horizontal plane and we add the embankments with the respective slopes: 34° for a fill and 37° for a cut area (see Fig. 2, on the right side). Finally we can extrude the horizontal cross-sections to form the solid.
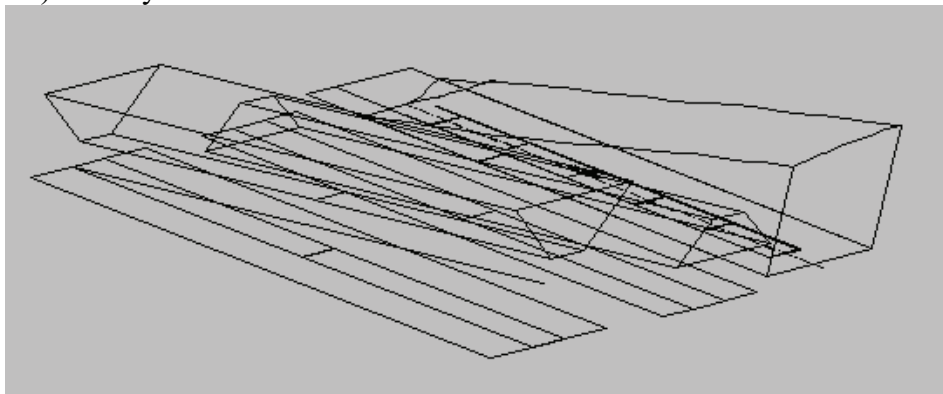

Figure 2-6: Making the rotation of the solid embankments: a cut and a fill area at the angle of 7°. 3D rotation was performed in 2D of the Oxy plane (see the symbol of the coordinate axes of the local User Coordinate System, which was introduced perpendicular to the model's base). The section showing the contour 75 of the road has been previously copied to the central section of the base of the cut area and similarly inside the top section of the fill embankment
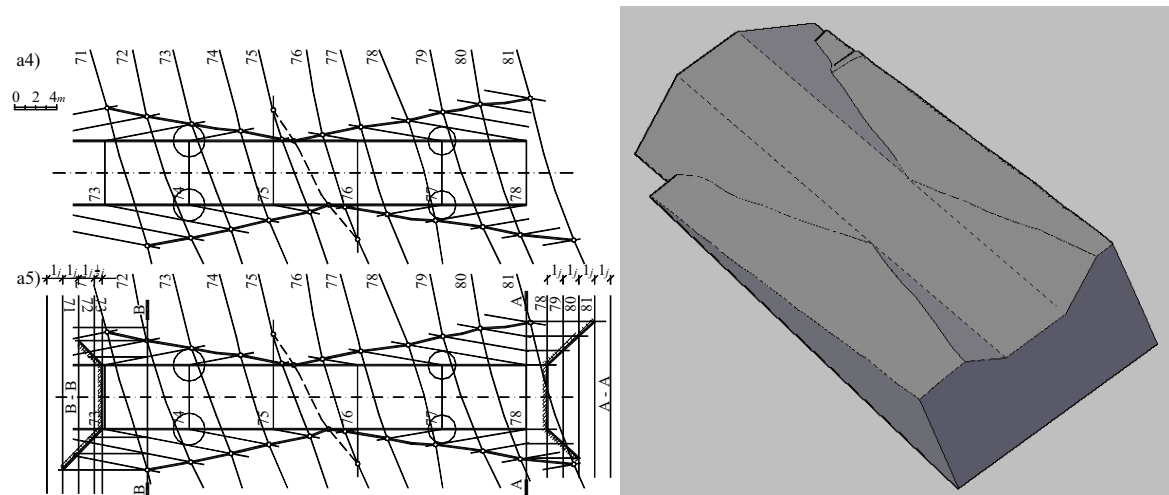
Figure 3: Planar solution (a4, a5) and 3D topographic profile of the road

From the main solid we subtract the piece of land by intersecting it with the appropriate parallelepiped**.** Then we create a solid embankment of cut and fill by extruding polylines at appropriate angles. After making the rotation with a specified angle of 7°, then moving and creating the union we obtain a 3D topographic profile of the road.

References:
[1] Koźniewski E.: *Rzut cechowany*. Wykład 7, Ćwiczenie droga_2D3D. Preskrypt. Politechnika Białostocka, Białystok 2011. http://wb.pb.edu.pl/Materialy-do-zajec.html (w07.pdf).
[2] Pikoń A.: *AutoCAD* 2007. Helion, Gliwice 2007.

OD RZUTÓW MONGE'A DO MODELU WIRTUALNEGO W 3D W PROGRAMIE AUTOCAD

Na przykładzie dwu zadań przedstawiono nową koncepcję rozwiązywania zagadnień geometrycznych, która może być zrealizowana w kursie geometrii wykreślnej z użyciem oprogramowania AutoCAD. Każde zadanie jest najpierw rozwiązywane na płaszczyźnie klasyczną metodą Monge'a ale za pomocą programu AutoCAD, by następnie pewne elementy założeń i rozwiązania wykorzystać do utworzenia wirtualnego modelu 3D za pomocą tegoż programu. Graficzne przedstawienie, w celu porównania wyników konstrukcji zrealizowanych w obu przypadkach, kończy proces rozwiązania zagadnienia.