GEODESY AND GEOTECHNICAL ASSESSMENTS FOR IMPROVING EL-ZAYAT DRAINAGE LAKE

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1. ABSTRACT

During the last decade, the closed drainage systems have been used extensively in the drainage engineering in Egypt especially in the oasis area. El-Wady El-Gdid and Marse Matroh governorates are examples of the regions of such applications. El-Zayat drainage lake of area 450 feddans in El-Wady El-Gdid governorate is surrounded from the north by series of hills while the rest of borders are earth–fill embankments. Due to the increase in population, the sustainability activities increased and consequently, the drainage water supplied to the lake increased results in the raising of water level which in turn deteriorates the earth embankment. In this research, geodetic control network in El-zayat drainage lake using Global Positioning System (GPS) was established to produce topographical maps and estimated the capacity of this lake at different levels. The rehabilitation of the embankments was also redesigned to cope with the new working conditions. Recommendations of the precautions to deal with such systems in the future were also explained.

Keywords: El-Zayat Lake- Geodetic Network- GPS - Stability of Embankment.

2. TNTRODCTION

In an effort to develop El-Wady El-Gdid governorate and attract more people to move into, the egyptian government started a huge reclamation projects in this region. Since there are not any open channels (river or sea) near El Wady EL-Gdid region to use as drainage facility, the closed drainage system was chosen. In this system, the drainage process depends on the water surface evaporation and the seepage of water through soil layers [1]. El-Zayat drainage lake is one of these closed drainage system.
The drainage lake is far from Sahl- El-Zayat village in western direction for 3 km and in north direction for 1 km. Sahl- El -Zayat village lays between Kharga and Dakhla oasis, 90 km far from El-kharga city in El- Wadi El Gadid governorate. El-Zayat drainage lake is surrounded from the north by series of hills while the rest of borders are earth–fill embankments [2]. The length of these earth fill embankments is 3.5 Km. A cutting drain parallel to the El-Zayat embankment in all directions except the northern side was constructed. There is a pump station to left up the drainage water from the cutting drain to the lake. The embankments of this lake consisted of clay

loam soil. The total soluble salts content in this soil reaches to about 18% of the dry weight soil. The main part of these salts is sodium chloride salt which is able to dissolve in water quickly, so sodium ions cause soil dispersion, consequently the shear parameters of the soil decrease with time and the void ratios increase. This causes unstability of the side slope of embankment. In year 2007, parts of the earth embankment of the lake deteriorated [3].

In this research, geodesy network for El- Zayat drainage lake using GPS techniques producing contour topographic map was carried out. The volume and surface areas of the drainage storage water at different levels in the lake were calculated. Basing on the geodesy studies and the requirement of the capacity of the lake, which is equal to 1.2 million cubic meters, the embankment level of El-Zayat drainage lake was determined and the stability of slopes of the embankment was investigated**.** In the stability study the seepage force, the waves, and surge action were taken into consideration. The protections of the lake side slopes against these forces as well as the protection of the drain side slops against the migration of the fine soil particles were considered in the study.

3. GEODESY STUDIES

3.1 Geodesy Field Works

The study area was first discovered and the best positions of putting marks to locate the topography details of the study area were chosen. Second, the land boundary points using GPS static technique were determined and stakes of iron were installed on the embankment boundaries which divided to lengths (250 m) that face the drainage lake. For high accuracy results, static relative positioning method was utilized. GPS observation times about 3 hours were used and the observations was depended on two GPS units, network of intersect of triangles was composed and it was analyzed using computer program TGO. Go and stop method was also used in this survey work of the study area. The accuracy of this method reaches to 1ppm to 0.1ppm. Precise leveling network relative to bench mark and precise leveling to the embankment (350 m) with determination of boreholes levels of the embankment were done. Finally, the GPS observations were connected with precise levels results. Figure 1 shows sketch the El-Zayat drainage lake embankment and the location of the boreholes.

3.2 Analysis of Field Data

Analysis and manipulation of field data for observations correction and adjustment were carried out. Horizontal coordinates (East, North) were calculated. After analyzed the precise leveling data and calculated levels different, the final adjustments were done. Contour map of the El-Zayat lake (450 feddans) with interval 50 cm using using surfer software was produced. Three dimensions model of El-Zayat lake was carried out using GIS environmental**.** The contour map and three dimensions model of El-Zayat lake are shown in Figure 2 and Figure 3 consequently. These figures indicated that the bed level is not flat but it has various levels, the lowest bed level is (164.00m) and the highest hill level is (170.50m). The relation between level of water and estimated capacity of the lake is shown in Figure 4. The value of the surface area in 2 dimensions (2D), 3 dimensions (3D) and the volume of the lake corresponding to the different level were determined and presented in Table 1. This data is essential for estimating the evaporation water quantity during the year and the capacity of the lake. The requirement of maximum water level corresponding to the capacity of the lake is (166.5m) as shown in Figure 4 and Table 1.

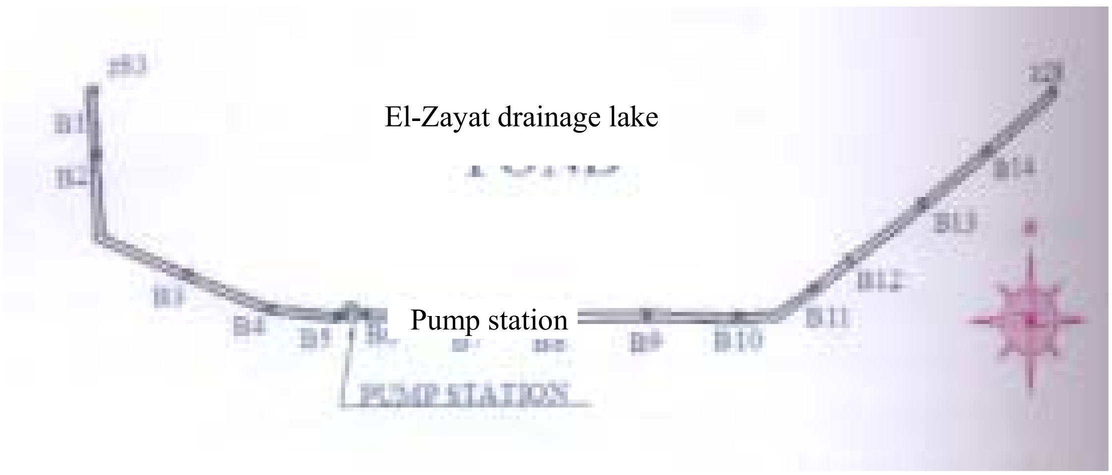

Fig. 1 Sketch of earth fill embankments of El-Zayat drainage lake and the location of the boreholes

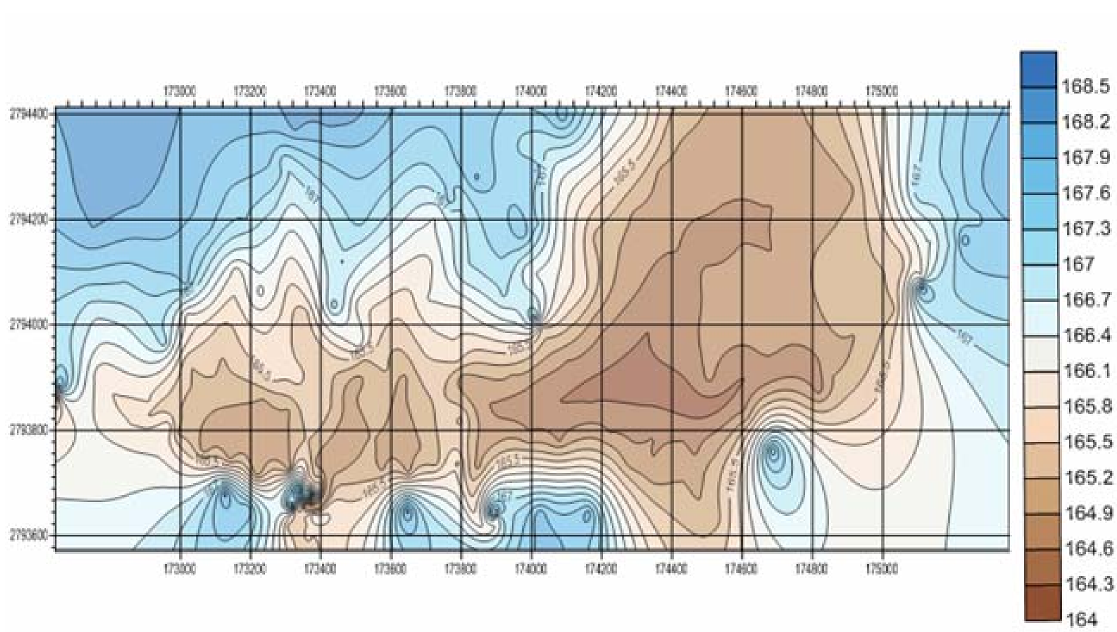

Fig. 2 Contour map of El- Zayat Lake

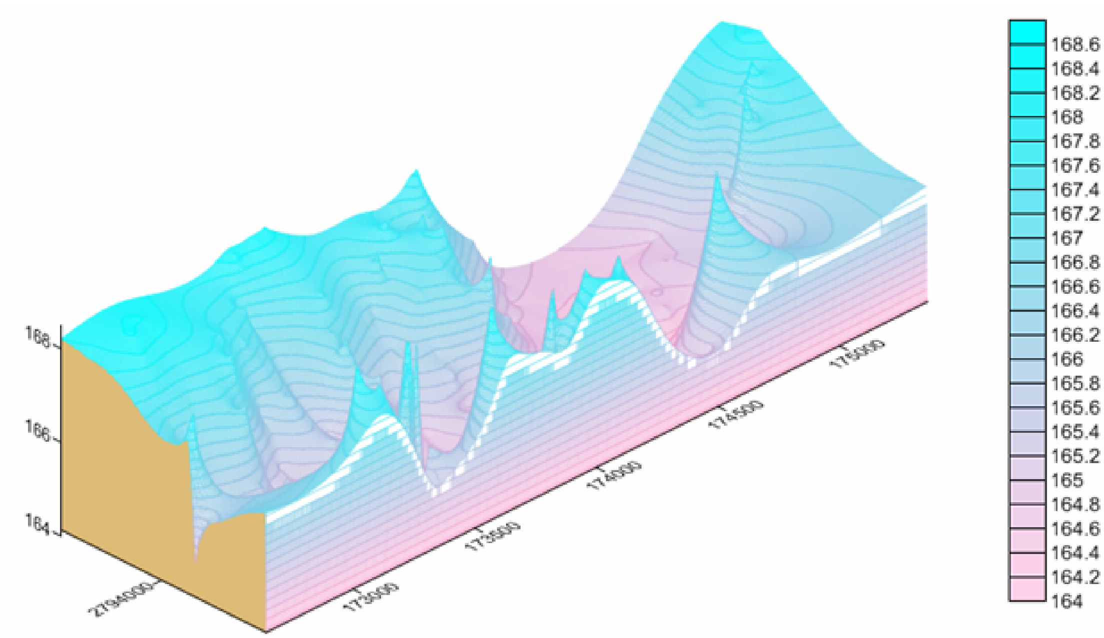

Fig. 3 Three dimensions model of El-Zayat Lake

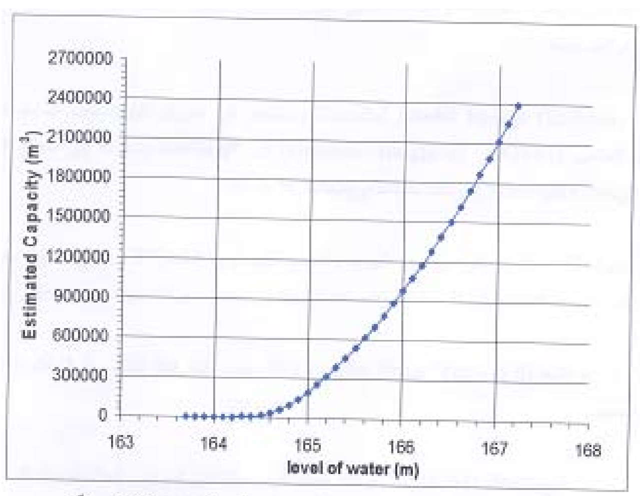

Fig. 4 The relation between level of water and estimated capacity

4. GEOTECHNICAL STUDIES

4.1 Soil Investigation

Using mechanical controlled drilled (PILCON), fourteen boreholes along the east, west, and north embankment of El-Zayat lake were carried out. The locations of these boreholes are shown in Figure 1. The boreholes were drilled down to depth 15 meters. The laboratory tests were performed to determine the physical and mechanical properties of the soil layers [4]. According to the results of the field and laboratory tests, the soil profiles consistent mainly of clayey loam interpreted with lenses of sandy loam. The undrained shear strength (cohesion) of this clay deposit according to unconfined shear test is varied from 0.34 Kg/cm^2 to 0.53 Kg/cm^2. The plastic limit is varied from 18% to 23%, while the liquid limit varies from 48 % to 58%. The natural density varies from 1.79t/m^3 to 1.88t/m^3, free swelling of this clay is less than 50%. According to chemical analysis results the total soluble salts in the clay loam soil varies from 5171 p.p.m. to 18304 p.p.m. The concentration of sodium chloride varies from 2904 to 10112 p.p.m. The soil is classified as high degree of dispersion according to dispersion test.

Table 1 2D area (m^2), 3D area (m^2), volume (m^3) of El-Zayat lake for different levels (interval 0.5m)

Plane levels ,m	2D area, m^2	3D area, m^2	Volume, m^3
164.00	0.00	0.00	0.00
164.5	107249.93	107251.18	15200
165.0	550656.47	550668.21	178562.86
165.5	840956.84	840988.48	530947.57
166.0	1092618.49	1092675.44	1012507.03
166.5	1430399.23	1430483.18	1640399.68
167.0	1703266.56	1703377.51	2430707.01
167.5	1935690.68	1935823.39	3340055.26
168.0	2163134.85	2163278.85	4369826.56
168.5	2282264.21	2282409.78	5486406.18

4.2 Stability of Side Slope

Using computer program "Geo-slope" [5] based on Janbu's method [6] the stability of slops of the existing El-Zayat lake embankments was investigated. Figure 5 shows the actual cross section of the lake embankment and cutting draine. The side slope of the embankment is 2:1 (2 horizontal and 1 vertical). The minimum bed level is (164.00m). The bed level and the embankment level of the cutting drain are (161.3m) and (164.5m) respectively. In the analysis of stability of slope study, the action of seepage force, waves, and surges were taken into consideration. The factor of safety against sliding is 0.9 at the critical case (both lake and cutting drain full with water). This value is considered unsafe according to Egyptian Code of Soil Mechanics and Design and Execution of Foundations (ECSMDEF) [7]. Egyptian code requires that the factor of safety against sliding of slops should be ≥ 1.5. To get this requirement factor of safety, new rigid embankment is constructed inside the existing embankment as shown in Figure 6. This suggestion is more economic than removes the existing embankment and rebuilding new embankment. According to maximum future capacity of the lake, which is 1.2 million cubic meters per year, the designed water level of lake is (166.5 m) and by adding 0.5 m to avoid the water wave motion and 0.5 m free board, so the embankment level is (167.5m). The side slope of the new embankment is 6:1 to verify the stability requirement factor of safety and in the same time creating a big surface area which leads to increase the evaporation of the drainage water.

The new embankment will be built from siliceous sandy soil which has total soluble salt not more than 300 p.p.m. These siliceous sandy soils are placed in layers each 0.3m thick and these layers should compact to reach dry density 1.87t/m^3 and water content 13% according to the modified compaction test in laboratory. The grain size distribution of the sandy soil is shown in Figure 7. Bituminous cutoff with length of 9.00 meter could be inserted to prevent piping through the embankment and controlling the seepage line and the dissolving of salts in the natural base soil. This cutoff consists of intersect bentonite slurry piles. The piles have a diameter of 60 cm and the intersection between them is 15cm. The bentonite slurry mix consists of 38 kilogram cement, 16 kilogram bentonite, 100 kilogram water and 6 kilogram silicafum [8]. The finite element mesh and seepage vectors of the new embankment are shown in Figure 8 and Figure 9 respectively. The stability factor of safety increases to value 1.634 at the critical case as shown in Figure 10.

4.3 Lining and Protection Works

The protection works along the slops of El-Zayat lake should be done to reduce the force actions of waves under the effect of winds and surges. In addition, this filter prevent the migration of the fine soil particles of the embankment. Figure 11 shows the detail of the lining and protection works of the drain lake slope. The lake slope is protected by filter consists of two layers; each one is 0.5 m thick. First layer is gravelly sand soil which should be compacted according to Egyptian Code (ECSMDEF) to reach 70% of its relative density. The second layer consists of broken dolomite stone. The grain size distribution of the gravelly sand and the broken dolomite stone are shown in Figure 7.

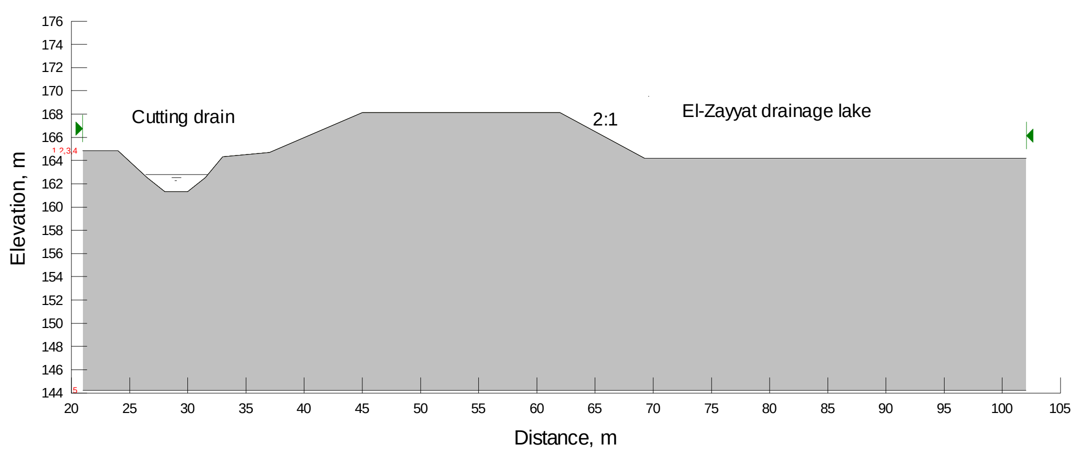

Fig. 5 The actual cross section of the lake embankment and cutting drain.

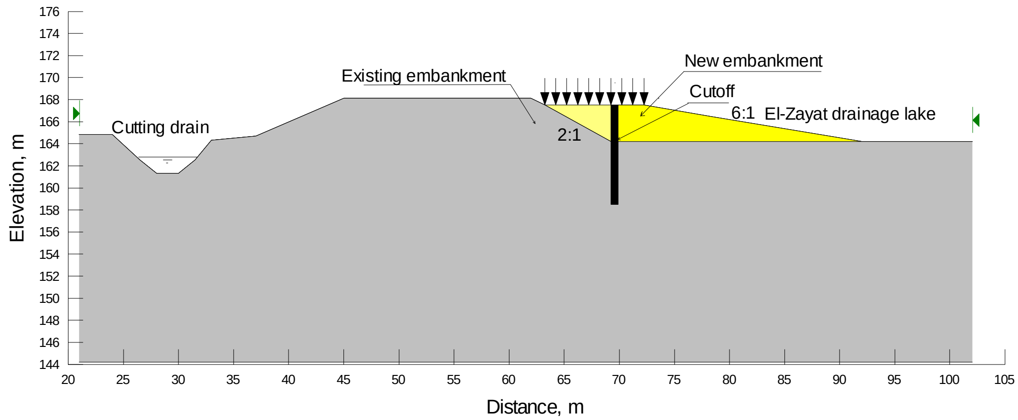

Fig. 6 Configuration of the new embankment of El-Zayat lake

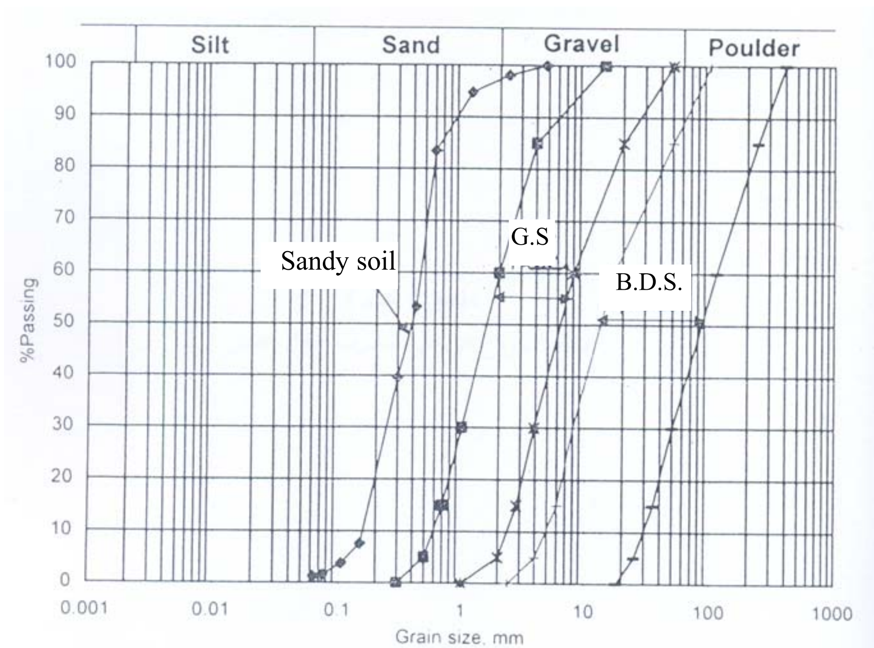

Fig. 7 Grain size distribution of sandy soil, gravelly sand (G.S) and broken dolomite stones (B.D.S.)

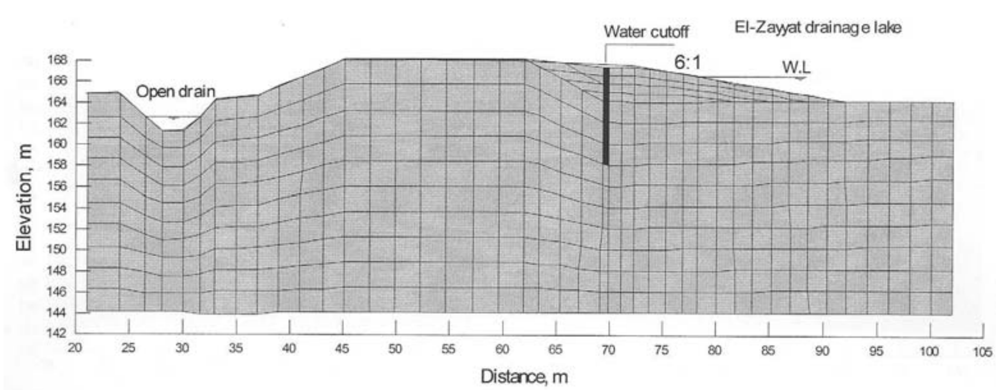

Fig. 8 Finite element mesh of the El-Zayat embankment

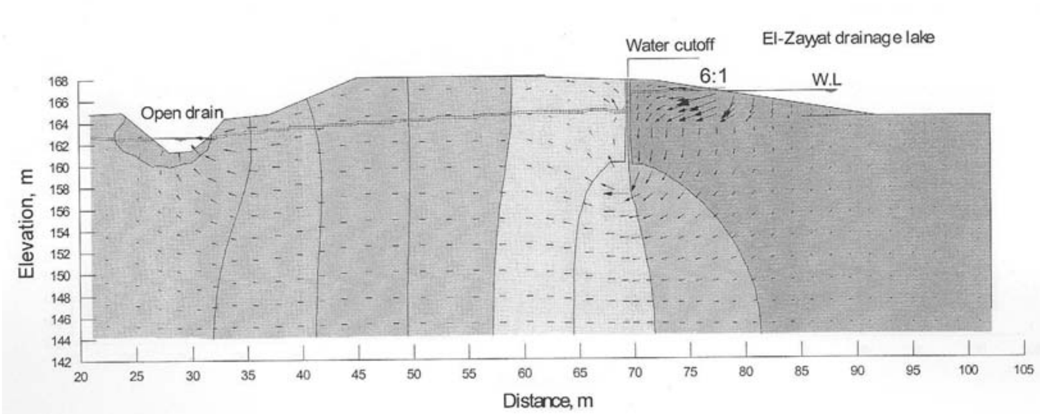

Fig. 9 Seepage vectors of the El-Zayat embankment

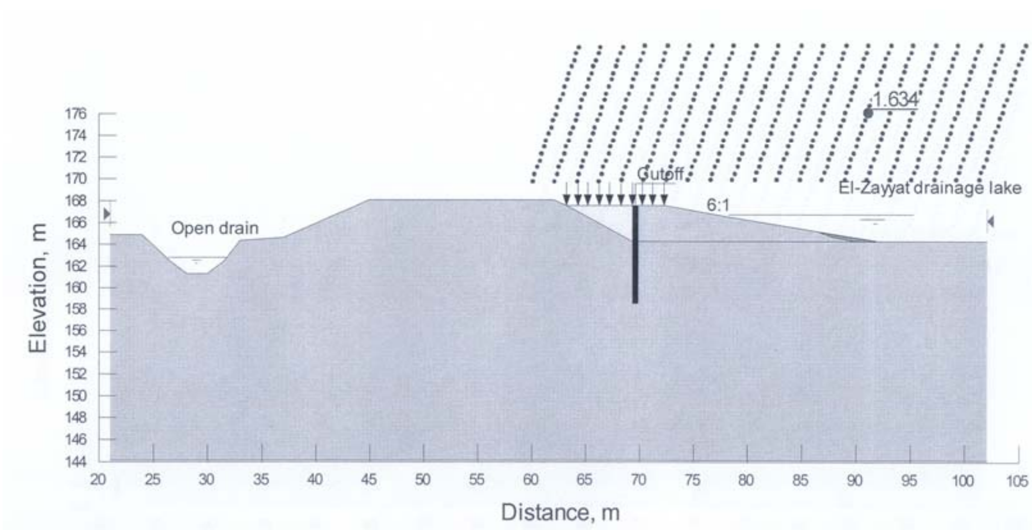

Fig. 10 Factor of safety against sliding for the new embankment

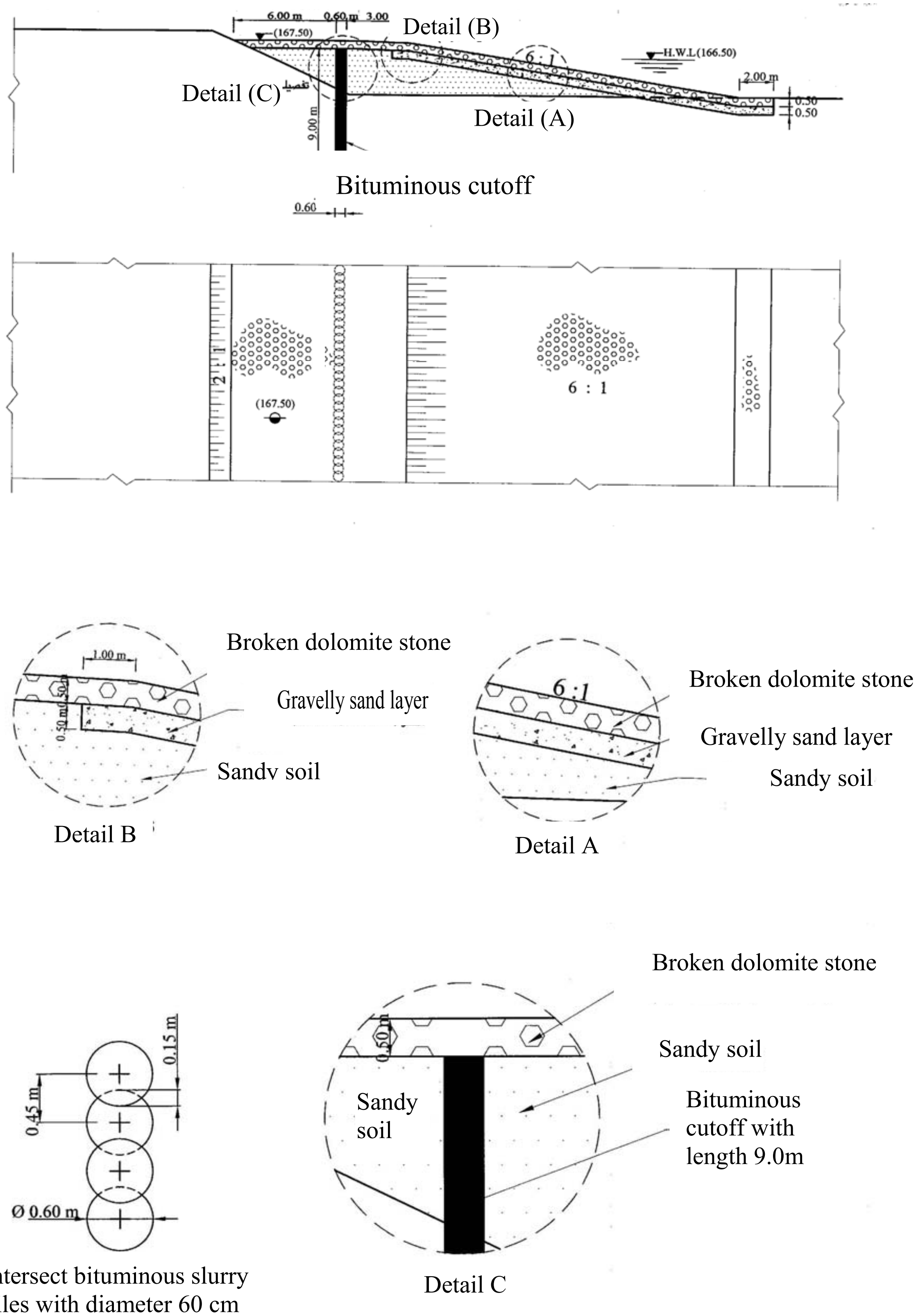

Fig. 11 Layout and details of the suggested cross section of the El-Zayat lake

5. CONCLUTIONS

Surveying work integrating GPS and leveling techniques is considered as powerful techniques for speed and accuracy enhancement. According to the contour topographic map, the capacity and the surface area of the lake at different water levels are estimated. Consequently, the maximum water level corresponding to the requirement storage capacity of the lake could be predicted.

Rehabilitation and redesigning of El-Zayat lake are necessary to overcome the deterioration of embankments**.** Building new embankments inside the existing embankments is economic suggestion. The required safe side slope of the lake is 6:1. Filters, which consist of gravelly sand and graded broken dolomite stones are necessary to protect the slopes of the lake against the waves, surges actions and the migration of the fine soil particles.

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