IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 14, Issue 5 Ver. IV (Sep. - Oct. 2017), PP 26-32
www.iosrjournals.org

An Evaluation for the Rehabilitated Old Aswan Dam Including Hydrodynamic Water Pressure

Sahar Abd-Elfatah
(Lecturer in Construction and building department, High Institute for Engineering & Technology (HIET)– Bihira, Egypt)

Abstract: *An evaluation for the Old Aswan dam has been prompted by occurrence of a magnitude 5.3 earthquake in November 1981, on Kalabsha fault which is about 55 kilometres southwest of the High dam. This paper evaluates the response of the rehabilitated Old Aswan dam including soil structure and hydrodynamic interactions subjected to earthquake signal have Magnitude 6.3. One of the basic parameters in estimating the earthquake response of the dam is its fundamental natural period. Therefore, this value is determined for the coupled reservoir-dam system. It is apparent that under steady state harmonic vibration, presence of the reservoir results in an added mass for the dam whereas the dam stiffness is unaffected. The natural period of the coupled system will, be longer than that for the dam. Results reflect the necessity and importance of integrating hydrodynamic interaction to analyze dynamic response of earth dams with impervious up stream face. The response of the Old Aswan Dam subjected to The San Fernando earthquake signal used in the this article including dam water and foundation interactions cause resonance after 0.351 seconds at the crest of the dam..*

Keywords: *Aswan Old dam, Dynamic analysis, Earth dams, , Hydrodynamic*

Date of Submission: 10-10-2017 Date of acceptance: 27-10-2017

I. Introduction

Recent studies on dynamic behaviors of embankment dams during earthquakes revealed that the lowest few earthquake response of earthworks and foundations is an important problem in earthquake engineering. This is because damage of structures is related closely to ground or soil. Study in this branch of earthquake engineering has been active for several decades. The study of sites seismic response characterizes the relation between ground surface and "bedrock" and the behavior of the ground surface itself. The ground or soil has two features compared with structures, strong non linearity and an infinite or no boundary, or half space, which has the important property of geometric damping or high energy-absorbing capacity [1], [2], [3]. The Aswan Old Dam in Egypt is located at 6 kilometres to the south of Aswan city crossing river Nile in a straight line at shallal region. The total length the dam is 2142 m (2342.51 yd) [4]. The foundation stone of the original Aswan Old Dam was laid on the 8th of February 1898, completed in 1902, and filled for first time in 1902–1903. The dam extended across the Nile valley in a straight line at the head of the Aswan cataract where the width of the valley is about 2000 m. The granite rocks at this cataract though one of the hardest and most resistant rocks, were traversed by joints and crushed planes of softer igneous materials. These materials detracted considerably from its quality as an excellent foundation stratum. When operations were begun on site, deep layers of varying depth of rotten granite were also found and were dug down before a sufficiently good rock for foundation had been obtained [5]. Figure 1 shows the Aswan Old Dam [5] and figure 2 shows the cross section of the Aswan Old Dam [5]. The original Aswan Old Dam was constructed to store one milliard cubic meters of water. Since it was originally constructed, the dam was twice increased in capacity to store more water. The first during the years 1908-1912 to store capacity 2.5 milliard cubic meters, the second in 1929-1933 to increase the total capacity to 5 milliard cubic meters. The original dam was founded on solid granite rock with 22 m high block of granite masonry set in 4 to 1 cement mortar with no construction joints. The crest level of the dam was at River Level 109.00 m and capable of impounding water up to River Level 106.00 m. The first heightening of the dam crest level was at the River Level 114 m; impound water up to River Level 113 m. The second heightening of the dam crest level was to the River Level 123 m, the impounding water up to River Level 121 m. [5]. A conceptual proposal solution for rehabilitation of the Old Aswan Dam was presented by constructing a new layer of geomembrane on the upstream face of the Old Aswan dam. It is highly recommended to impose a waterproof condition at the dam upstream face to provide and maintain full protection against water ingress and at the same time reduce the acting water pressure and increase the dam period and natural frequency [6], [7]. Integrating soil structure interaction with the dynamic analysis of the earth dams of impervious upstream face reduces the hydrodynamic pressure force on the upstream face of the dam [8], [9]. A seismic stability of the rehabilitated Old Aswan dam is evaluated by the San Fernando Earthquake (S11.4o E), magnitude M= 6.3 max acceleration

1.2g and frequency 9.6 rad./sec. Hydrodynamic interaction causes a water volume to move with the dam which represents an added mass of value and shape varies according to the dam response. This added mass is thus expected to vary according to the dam construction material. Results reflect the necessity and importance of integrating hydrodynamic interaction to analyze dynamic response of earth dams with impervious up stream face. The analysis includes Dam, water and foundation interactions considering compressibility of water.

II. Displacement Response Of The Rehabilitated Old Aswan Dam

The response of the selected earth dam model subjected to the horizontal component of earthquake record propagating at velocity V is determined by the computer program written in FORTRAN. The program evaluates numerically the responses of earth dams, including Soil-Structure Interaction and Hydrodynamic Interaction considering the compressibility of water. The analysis is based on the lumped mass model. To evaluate the response of the rehabilitated Old Aswan dam including soil structure and hydrodynamic interactions subjected to another earthquake signal has Magnitude= 6.3. The signal has the following properties, the component (S11.4o E), has Magnitude= 6.3, with a max acceleration of 1.2g, and frequency of 9.6 rad./sec. The system is subjected only to horizontal earthquake force perpendicular to the longitudinal dam section. The response of the Old Aswan Dams due to earthquake shaking is investigated theoretically considering Soil Structure Interaction, and hydrodynamic interaction including compressibility of water.

III. Flow Chart Of The Computer Program

The complete system is decomposed to three substructures; the dam is modeled by lumped masses, the water domain is treated as a continuum of infinite length in the upstream direction and the foundation soil region is analyzed as a semi-infinite half-space. The effects of water are represented by added force and added mass moving with the dam [8]. The procedure described is an extension of the shear-wedge theory with the application of the lumped mass method. The procedure facilitates generating vibration modes for earth dam including soil - structure - hydrodynamic interactions and compressibility of water by involving a small number of degrees of freedom in the analysis [8]. A computer program written in FORTRAN 77 language to evaluate numerically the response of earth dam [8] has been modified to evaluate numerically the response of the Old Aswan Dam. Figure (3) shows the Flow Chart of the modified computer program. The dam base and body is divided into 10 segments with 11 slices vertically. The dam body is divided into 3 layers horizontally. The current model produces results using 44 degrees of freedom. The analysis includes effects arising from dam-water and foundation interactions. The analysis is based on the lumped mass model. The model deals with the fundamental mode shape for each slice along the dam length to calculate the added mass of water moving with the dam (Dam water interaction). The complete system is considered composed of three substructures, the earth dam represented as a lumped mass model, the fluid domain, as a continuum of infinite length in the upstream direction and the rock foundation region as a semi-infinite half-space. The development of the necessary algorithm for the linear and nonlinear multi degree-of-freedom systems by the step-by-step linear acceleration method parallels the presentation for the single degree-of-freedom system [1], [2].

IV. Results And Discussion

The response of earth dams due to earthquake shaking is investigated theoretically considering soil structure interaction, and hydrodynamic interaction including compressibility of water. Figure 4 through 6 shows time history of displacement response for different points at dam bottom length. Figure 7 shows the time history of displacement response at dam crest (slice 4). Figure 8 shows the time history of displacement response at dam bottom (slice 4). Figure 9 shows that the displacement response of the dam increases along the dam height with maximum values at dam crest which is in agreement to Chopra and Chakrabarti [10]. The maximum amplitude of the earthquake force used in this article is less than one second (t<1 sec). The results show that the response of the rehabilitated Aswan Old Dam including dam hydrodynamic interaction causes resonance after 0.351 seconds at the crest of the dam. Results reflect the necessity and importance of integrating hydrodynamic interaction to analyze dynamic response of earth dams with impervious up stream face.

V. Conclusions And Recommendations

1. The response of the rehabilitated Aswan Old Dam subjected to earthquake signal has Magnitude = 6.3 including dam- hydrodynamic interaction causes resonance after 0.351 seconds at the crest of the dam.
2. The hydrodynamic interaction increases the displacement response along the dam height with maximum influence at the dam crest.
3. It is necessary to include dam water interaction in the analysis of earth fill dams of impervious upstream conditions.

4. The added mass of water interacts with the dam movement depends on the shape of the fundamental mode of vibration of the earth dam.
5. It is recommended to reduce river level (R.L.) of the impounding water behind the Aswan Old Dam.
6. It is recommended to use other earthquake signals with magnitudes more than 5.3 and less than 6.3 to examine the stability of the rehabilitated Aswan Old Dam.
7. Determine the safe river level (R.L.) of the impounding water behind the Aswan Old Dam.

References

[1] M. Paz, *Structural dynamics theory and computation* (Van Nostrand Reinhold Company, 1979).
[2] R.W. Clough, and J. Penzien, *Dynamics of structures 2nd Ed* (Mc Graw-Hill Book Company, 1993).
[3] Y. X. Hu, S.C. Liu, W. Dong, *Earthquake engineering* (E&FN Spon, 1991).
[4] Ministry of Irrigation, High and Aswan Dams Authority, *Request for technical proposal seismic stability evaluation of the Old Aswan Dam* (Aswan, July 1986).
[5] H. Zaki, Heightening of the Aswan Dam, *Sixieme Congres Des Grands Barrages*, New York, 1958.
[6] L.El-Hifnawy, H. Abdelmohsen, E. Elkordi , S. Abdelfatah, Hydrodynamic water pressure for the Old Aswan Dam with impervious upstream face, *International Conference on Earthquake Geotechnical Engineering*, Istanbul, Turkey, Boğaziçi University June 2013.
[7] S. Abdelfatah, A shrinkage reduced concrete mix design for rehabilitation of old dams, *IOSR Journal of Mechanical and civil Engineering (IOSR-JMCE)*, e-ISSN:2320-334X, 14(2), Ver. II Mar. - Apr. 2017, 06-13.
[8] L.El-Hifnawy, H. Abdelmohsen, E. Elkordi , S. Abdelfatah, Seismic analysis of earth dam including dam-water and foundation interactions, International Conference on Earthquake Geotechnical Engineering, Istanbul, Turkey, Boğaziçi University, June 2013.
[9] Fenves G., and Chopra A. K., Simplified earthquake analysis of concrete gravity dams, *ASCE, Journal of Structural Engineering*, 113(8), 1988.
[10] Chopra A. K., and Chakrabarti P., Earthquake analysis of concrete gravity dam-water-foundation-rock interaction, *International Journal of Earthquake Engineering and Structural Dynamics*, 9, 1981, 363-383.

Figures

List of Figures:

Figure 1 Aswan Old Dam

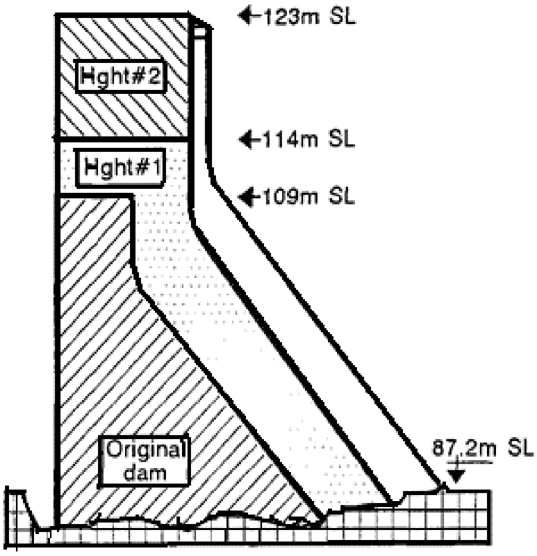


Figure 2 Cross section of the Aswan Old Dam [5]

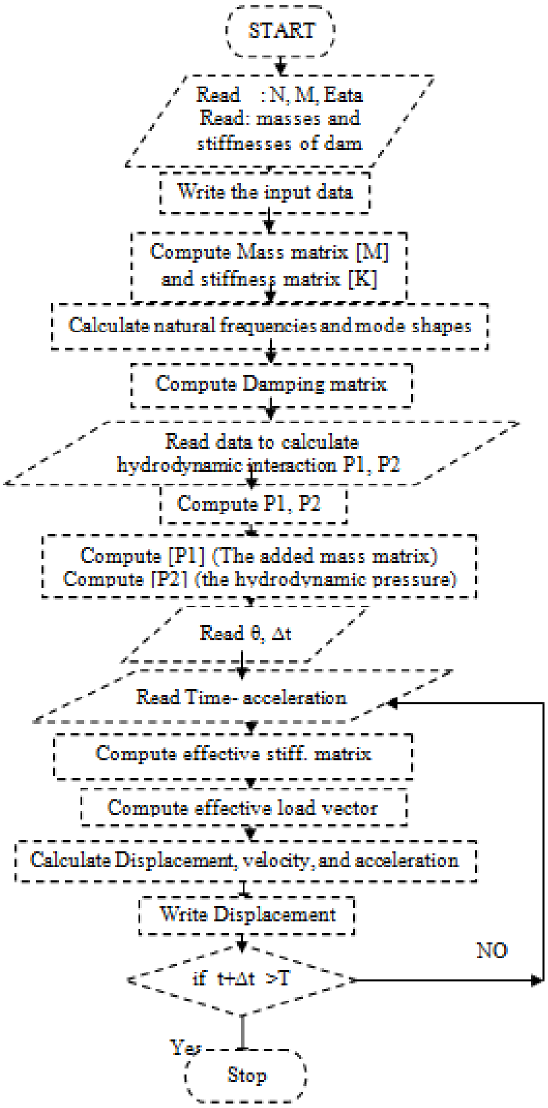
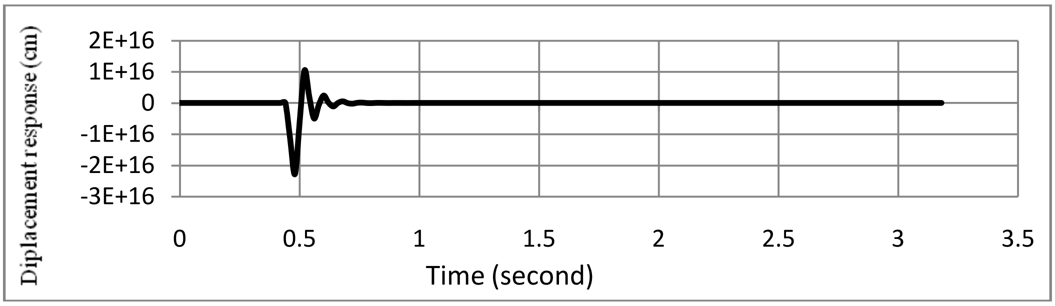
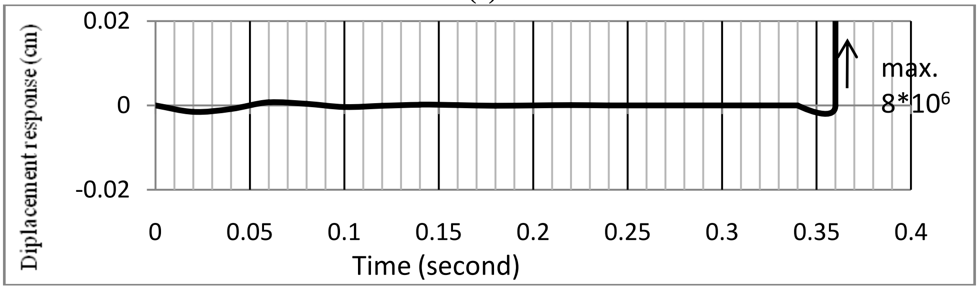


Figure 3 Flow Chart of the computer program

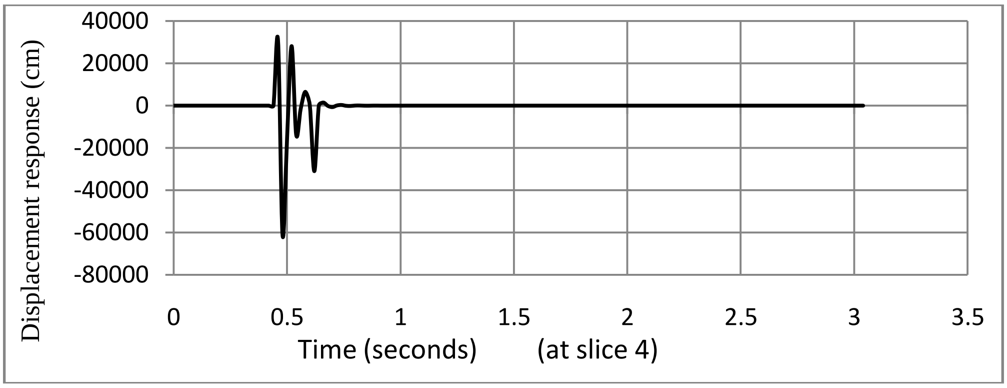


(a)

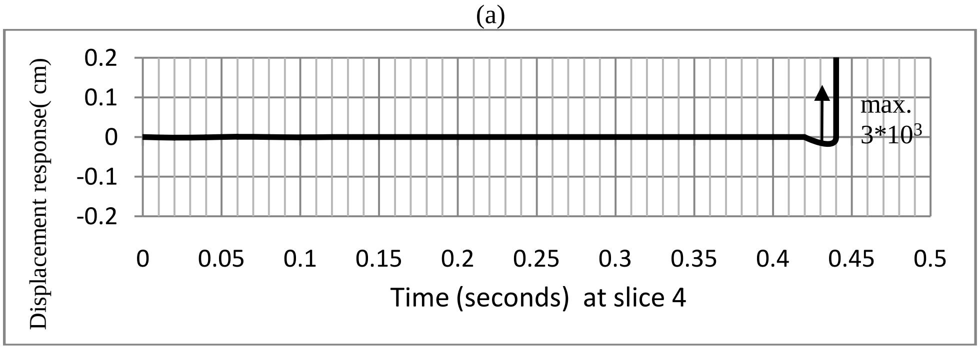


(b)

Figure 4 (a), (b) Time history of displacement response at (slice 1)

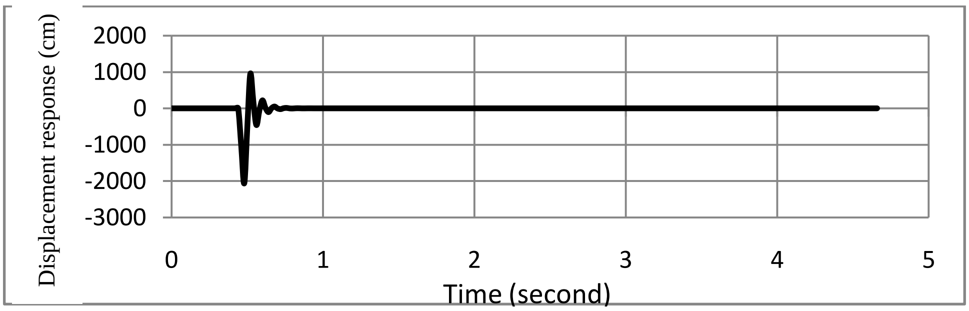


(a)

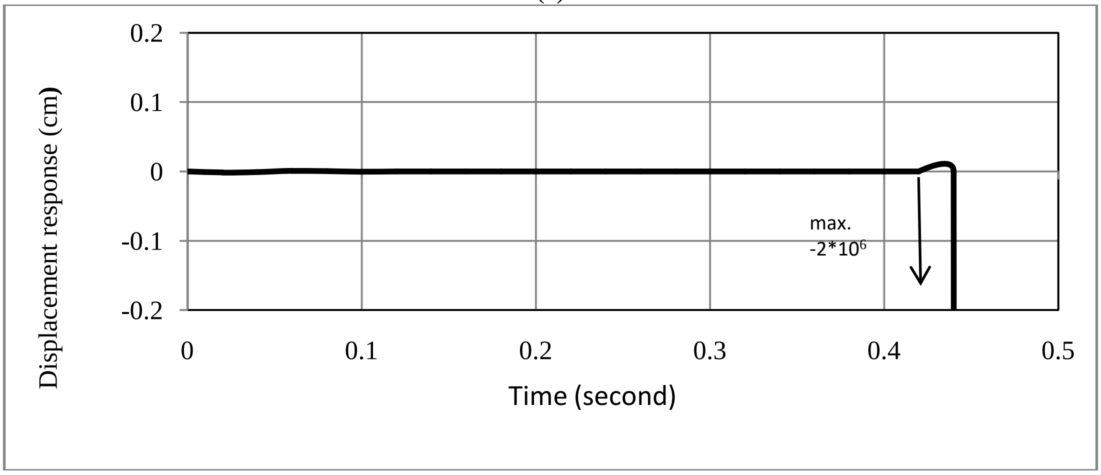


(b)

Figure 5 (a), (b) Time history of displacement response at (slice 4)



(a)



(b)

Figure 6 (a), (b) Time history of displacement response at (slice 8)

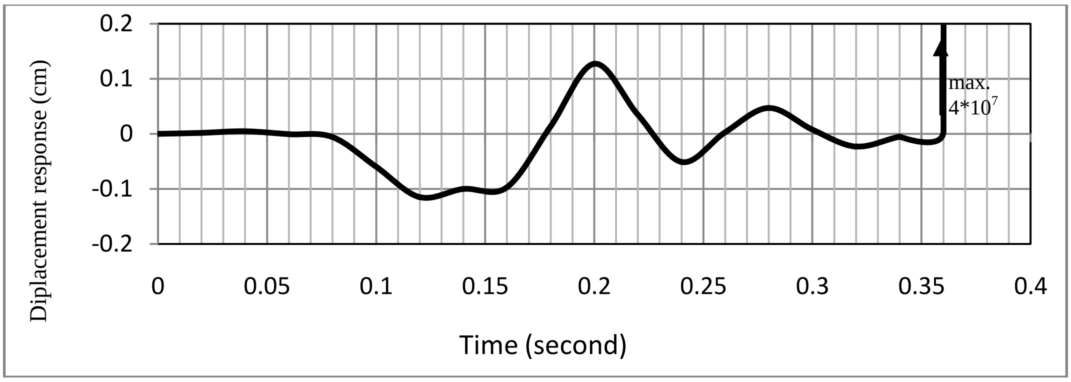


Figure 7 Time history of displacement response at dam crest (slice 4)

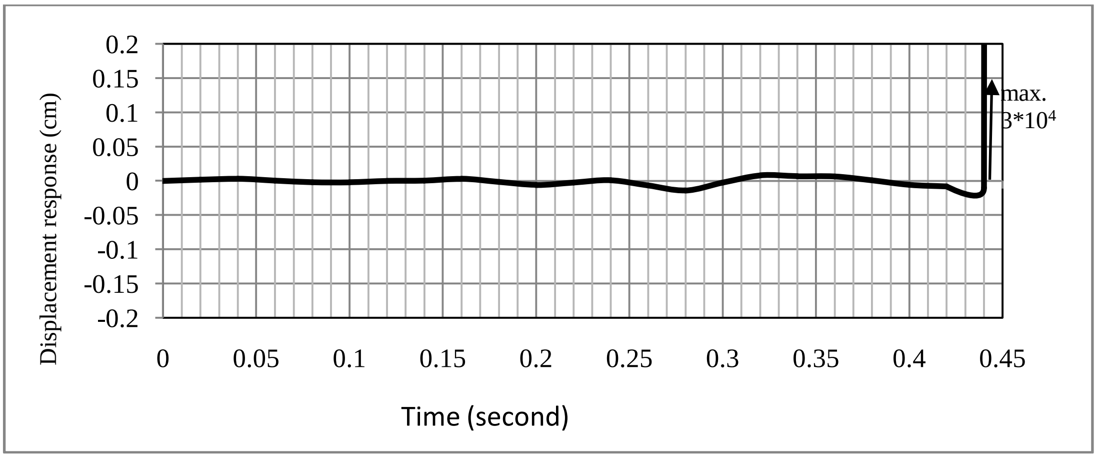


Figure 8 Time history of displacement response at dam bottom (slice 4)

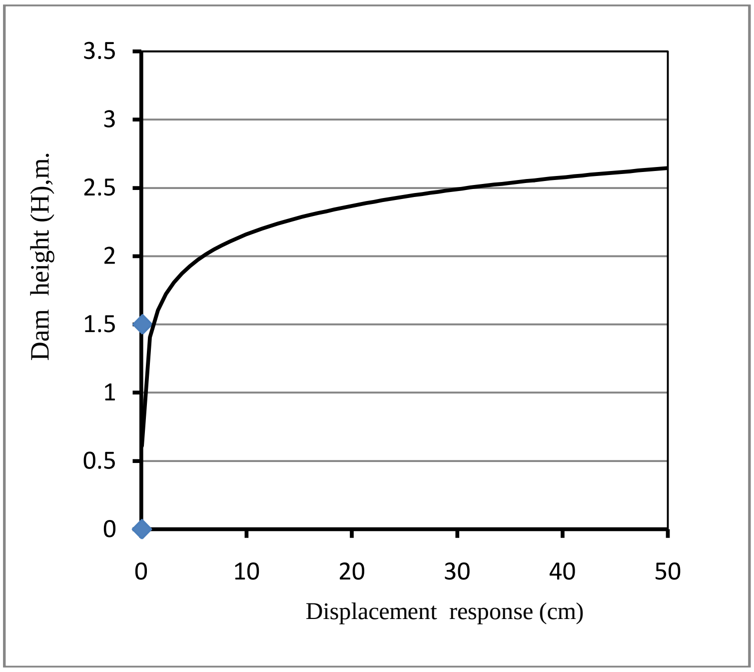


Figure 9 Displacement response along the dam height at (slice 4), t = 38 sec.

Sahar Abd-Elfatah . "An Evaluation for the Rehabilitated Old Aswan Dam Including Hydrodynamic Water Pressure ." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 14, no. 5, 2017, pp. 26–32.