Static Structural Analysis of Concrete Gravity Dam Using Drainage Gallery In Ansys Workbench 14

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Abstract- *A gravity dam is a solid structure, made of concrete or masonry, built throughout a river to create a reservoir on its upstream. In this study analysis of dam is achieved the use of Ansys software program. Ansys is extensively used for multi-storied homes with beam and columns. But Ansys can examine any form of element which include, plate, shell or strong further to beam individuals. So, in the software with appropriate facts, dam is modelled with stable factors. Result of stresses and pressure contours are defined in this study. The goal of study is to have a course of analysis of dam thinking about solid elements using Ansys and conventional methods. Ansys is computer software, which is used for stability and stress analysis of structures. Dam is such a massive structure; to evaluate such structure manually is very tedious and long timing process so it's easy to evaluate the dam stability Ansys.*

Keywords- Gravity dam, concrete, moments, frictional force, stability, Ansys.

I. INTRODUCTION

Gravity dams are very important structures. The collapse of a gravity dam due to earthquake ground motion may cause an extensive damage to property and life losses. Therefore, the proper design of gravity dams is an important issue in dam engineering. An integral part of this procedure is to accurately estimate the dam earthquake response. The prediction of the actual response of a gravity dam subjected to earthquake is a very complicated problem. It depends on several factors such as dam-foundation interaction, dam-water interaction, material model used and the analytical model employed. In fluid-structure interaction one of the main problems is the identification of the hydrodynamic pressure applied on the dam body during earthquake excitation. The analysis of dam reservoir system is complicated more than that of the dam itself due to the difference between the characteristics of fluid and dam's concrete on one side and the interaction between reservoir and dam on the other side. The earthquake response of concrete gravity dam-reservoir-foundation system has been addressed to study the effect of foundation flexibility and reservoir water body on the seismic response of concrete gravity dams. Safety evaluation of dynamic response of dams is important for most of researchers. When such system is subjected to an earthquake, hydrodynamic pressures are developed on upstream face of the dam due to the vibration of the dam and reservoir water. Consequently, the prediction of the dynamic response of dam to earthquake loadings is a complicated problem and depends on several factors, such as interaction of the dam with rock foundation and reservoir, the computer modelling and material properties used in the analysis.

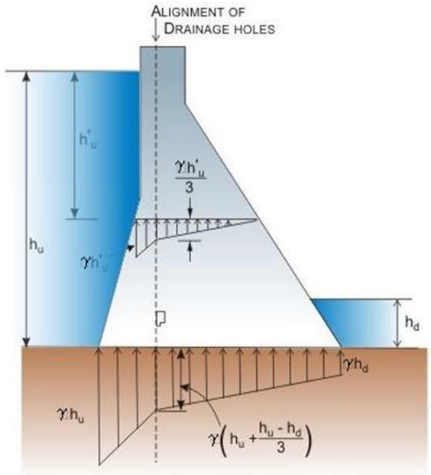

Figure 1: Assumed uplift pressure considering presence of drainage holes

II. FINITE ELEMENT MODELLING

FEM modelling of concrete gravity dams is a method with a lot of advantages compared to traditional structural dynamics and scale modelling. Compared to scale modelling the time and cost issue is the main factor, it is a lot cheaper to construct a virtual model than a physical one. Also, the convenience of computer-based models compared to the location and rarity of scale models provide a significant advantage. Compared to structural mechanics FEM has a big advantage in the alteration of both construction and external loads. Once a dam has been modelled in FEM it is possible to experiment and change details about it without the need to restart the whole process [25]. This is still just an analysis of a single section in a static state of a dam; a lot of aspect is because of that limitation not dealt with at all. Examples of these aspects are: discharge capacity, temperature changes, cracks, earthquakes and fatigue of the concrete. FEM means Finite Element Method and it is a way of turning real life objects, such as a dam construction, to a computable model. In the FEM the object is divided into smaller elements which are calculated separately, preferably by a computer. It is the density and shapes of these elements that determines the accuracy of the FEM-model.

III. MODELLING OF GRAVITY DAM STRUCTURE

In the present work two types of opening shapes are considered, one is Rectangular and second is circular. Different sizes of the openings are also considered in the present work. Three different sizes for Rectangular opening and three different sizes of circular opening are considered.

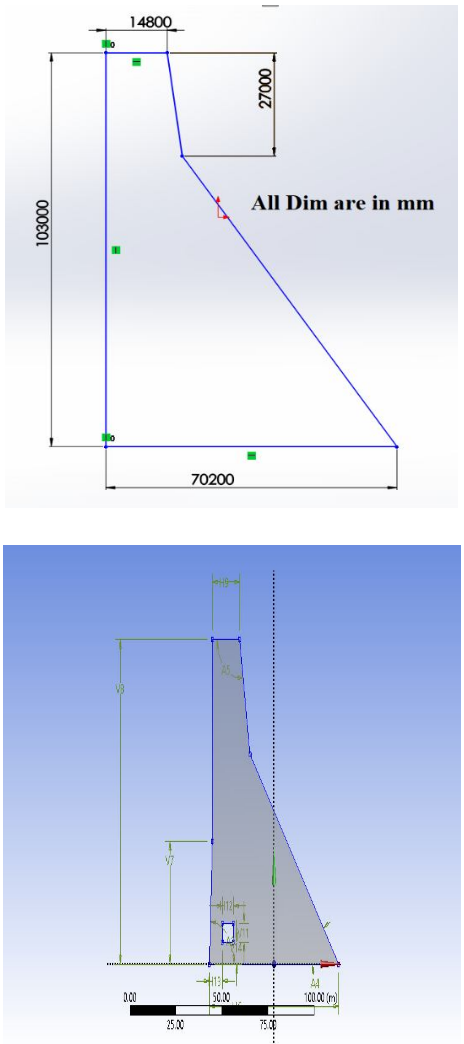

Figure 2: Geometry of the dam with opening

Table 1: Dimensions of the openings

Rectangular openings dimensions		Circular openings dimension	
Width × Height	4.2 mm × 4.2 mm	Radius	4.2 mm
Width × Height	6 mm × 6 mm	Radius	6 mm
Width × Height	8.3 mm ×8.3 mm	Radius	8.3 mm

IV. BOUNDARY CONDITIONS

Figure 3.12 shows the applied boundary condition on the dam. These boundary conditions have been taken from the literature. Pressure of 630 and 900 have been applied on the horizontal and vertical boundaries of the dam. While the two sides of the dam have been kept fixed.

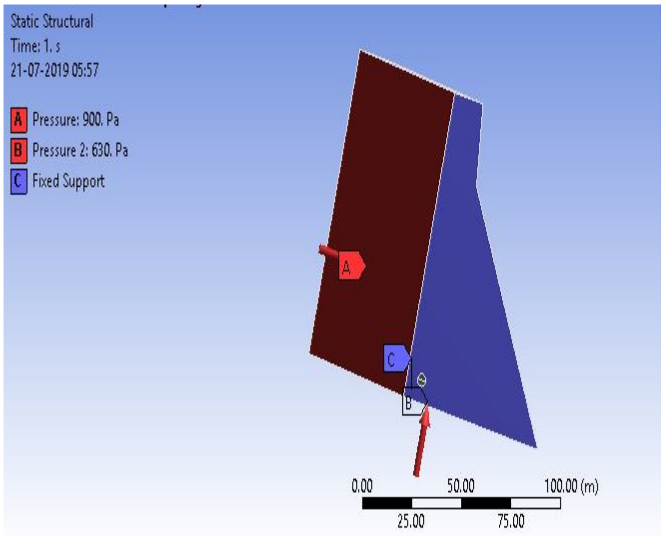

Figure 3: Boundary conditions

V. TEST RESULTS AND DISCUSSION

In this paper comparative analysis of X-directional deformation, Y-directional deformation, and equivalent von-mises stress are conducted. On bottom and vertical side of the dam force is applied while left and right side of dam are kept fixed. To analyses the effect of opening two shapes of openings are considered circular and Rectangular. Dimension of the opening are also varied to study its effect on the stress and deformation generated on the dam.

- **Analyse effect of Gravity Dam Circular channel opening**

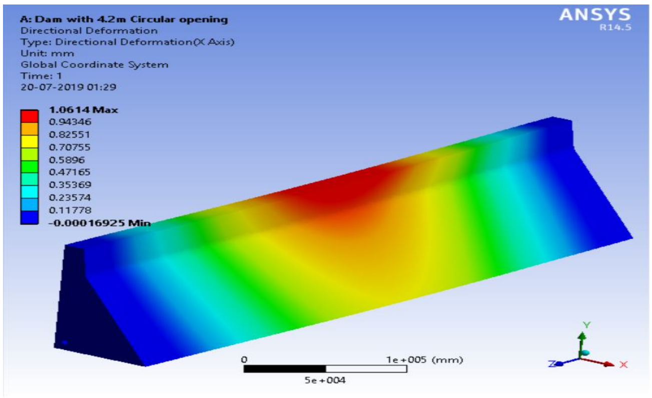

Figure 4: X-directional deformation for 4.2 mm radius circular opening

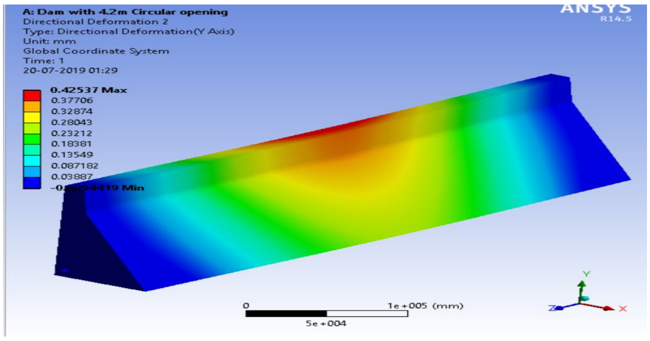

Figure 5:Y-directional deformation for 4.2 mm radius circular opening

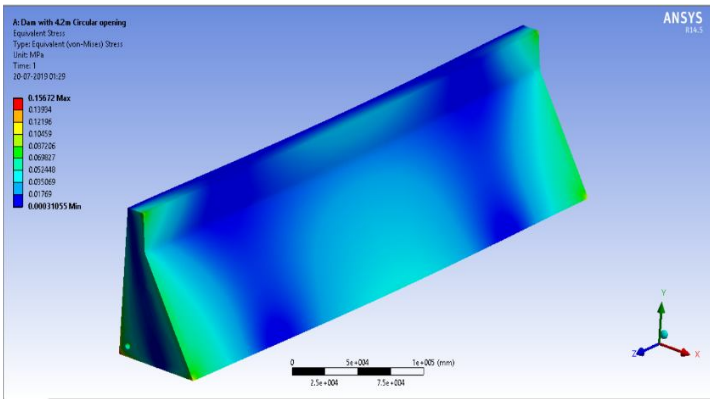

Figure 6: Equivalent stress for 4.2 mm radius circular opening

Figure 4 - 6 shows the results for circular opening of 4.2 mm radius. X-directional deformation, Y-directional deformation and equivalent von-mises stress are shown in the figures. Red colour shows the regions where highest values of stress and deformation generated while blue colour shows regions where least values of stress and deformation generated. It can be observed from the figure 4 and 5 that at the centre of the dam maximum amount of deformation is generating and it gradually decreasing towards the corner of the dam.

Table 2: Results of Gravity Dam with circular opening

Gravity Dam with Circular Opening			
Openings in Metre	Equivalent Stress (MPa)	Deformations in X (mm)	Deformations in Y (mm)
4.2	0.156	1.061	0.425
6	0.158	1.071	0.432
8.3	0.16	1.09	0.444

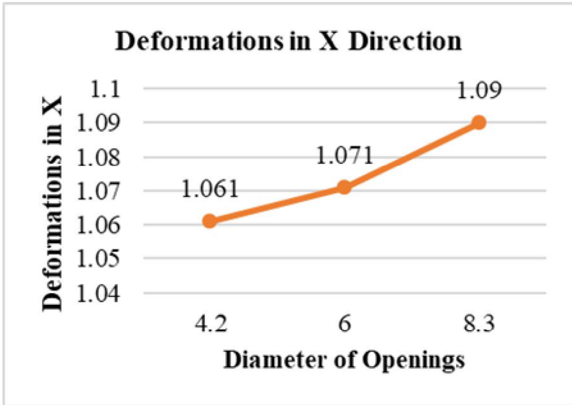

Figure 7: X-deformation vs radius of opening

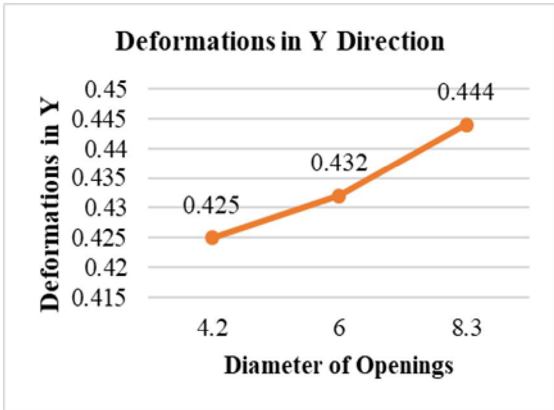

Figure 8: Y-deformation vs radius of opening

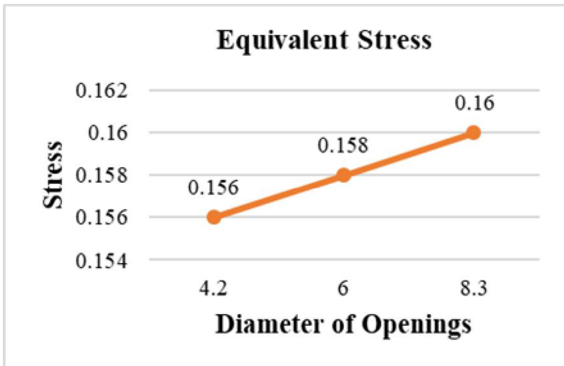

Figure 9: Equivalent stress vs radius of opening

Figure 7- 9 shows the effect of radius of the circular opening. Three radiuses considered are 4.2, 6 and 8.3-mm. X-directional deformation, Y-directional deformation and

equivalent von-mises stress are shown in the figures. It can be observed from the figures that with increment in the size of the opening amount of deformations and stresses generated in the dam are increasing which shows large stress concentration for large opening values which results in the failure of the dam.

- **Analyse effect of Gravity Dam Rectangular channel opening**

To analyses the effect of Rectangular opening different dimension are considered (4.2×4.2, 6×6 and 8.3×8.3). Dimension of the Rectangular is considered in such a way that cross-sectional area of Rectangular opening matches well with the cross-sectional are of the circular opening). Study of stress and deformation generated on the dam are studied for different Rectangular opening dimensions.

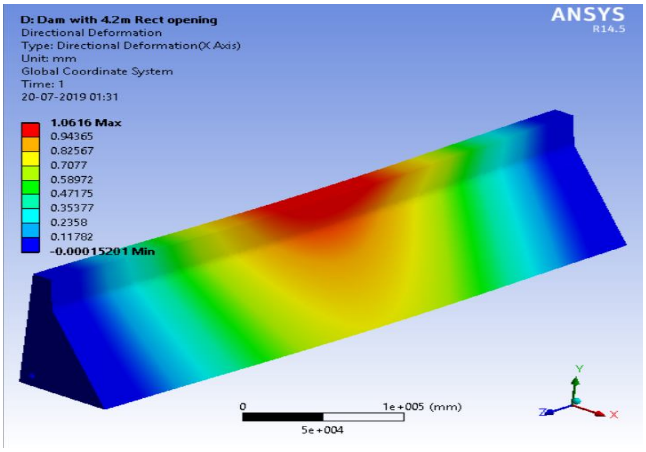

Figure 10: X-directional deformation for 4.2×4.2 Rectangular opening

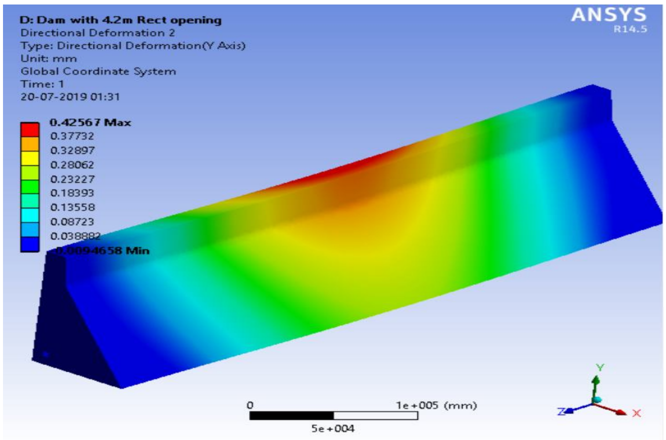

Figure 11: Y-directional deformation for 4.2×4.2 Rectangular opening

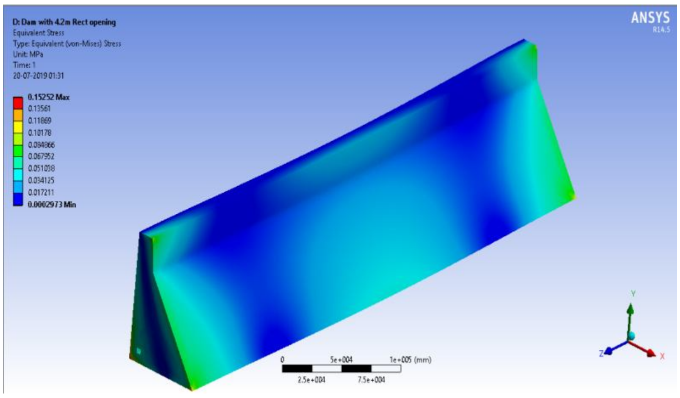

Figure 12: Equivalent stress for 4.2×4.2 Rectangular opening

Figure 10 - 12 shows the results for Rectangular opening of 6×6 dimension. X-directional deformation, Y-directional deformation and equivalent von-mises stress are shown in the figures. Red colour shows the regions where highest values of stress and deformation generated while blue colour shows regions where least values of stress and deformation generated. It can be observed from the figure 10 and 11 that at the centre of the dam maximum amount of deformation is generating and it gradually decreasing towards the corner of the dam.

Table 3: Results of Gravity Dam with Rectangular opening

Gravity Dam with Rectangular Opening			
Openings in Metre	**Equivalent Stress (MPa)**	**Deformations in X (mm)**	**Deformations in Y (mm)**
4.2	0.152	1.061	0.431
6	0.156	1.07	0.431
8.3	0.158	1.083	0.441

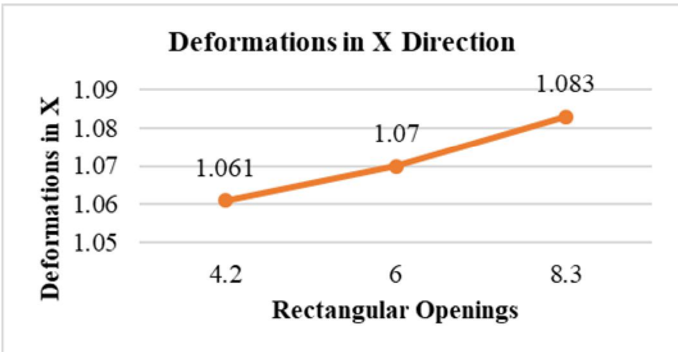

Figure 13: X-direction deformation vs dimension of Rectangular opening

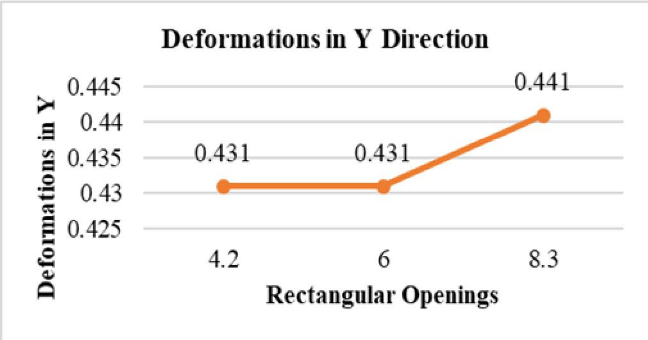

Figure 14: Y-direction deformation vs dimension of Rectangular opening

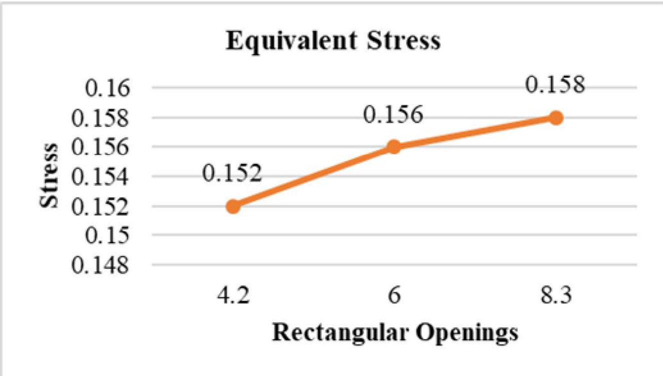

Figure 15: Equivalent stress vs dimension of Rectangular opening

Figure 13 - 15 shows the effect of radius of the circular opening. Three radiuses considered are 4.2×4.2, 6×6 and 8.3×8.3. X-directional deformation, Y-directional deformation and equivalent von-mises stress are shown in the figures. It can be observed from the figures that with increment in the size of the opening amount of deformations and stresses generated in the dam are increasing which shows large stress concentration for large opening values which results in the failure of the dam.

Figure 16 - 18 shows the comparison of the X-direction deformation, Y-direction deformation and equivalent stress between Rectangular and circular opening. The cross-sectional of the Rectangular and circular opening are considered to be same. Three cases have been studied in the present work in first case dimension of circular and Rectangular opening is 4.2 mm, in case-2 dimension of circular and Rectangular opening is 6 mm and in case-3 dimension of circular and Rectangular opening is and 8.3 mm respectively.

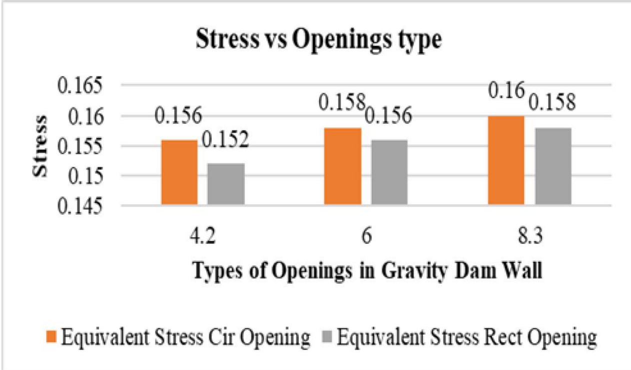

Figure 16: Comparison of equivalent stress between circular and Rectangular opening

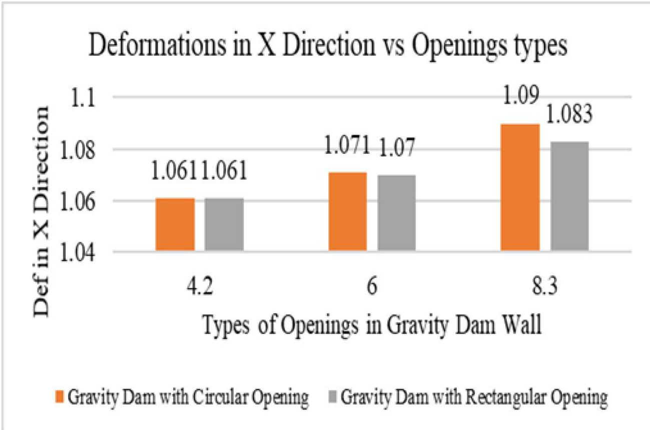

Figure 17: Comparison of X-directional deformation between circular and Rectangular opening

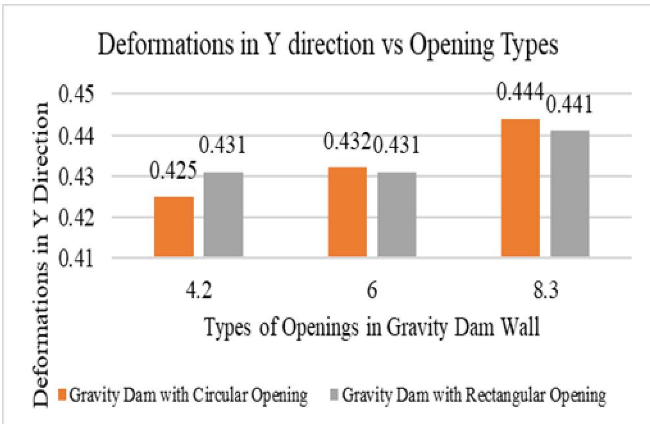

Figure 18: Comparison of Y-directional deformation between circular and Rectangular opening

From the figures 16 - 18 it can be observed that deformation generated in Rectangular and circular opening are of same order for small size (case-1) and with increment in the opening size deformation generating is increasing in case of Rectangular opening but the different is very small. It can also be observed from the figure 16 that stress generated in case of Rectangular opening is large compared to stress generated in case of circular opening for small size of opening (case-1 and case-2). But for largest opening size considered in the present study Rectangular opening shows less stress generation compared to stress generation in case of circular opening.

VI. CONCLUSION

The first step of simulation is by finite element Analysis 14, a three-dimensional finite element model of Koyna gravity dam is proposed using ANSYS 14. Dams with full reservoir and empty reservoir condition are analysed. In this study, normal stress shear stress and deflection along X and Y direction is observed. The rectangular opening of 6x6 mm is more effective than circular opening of same size. The stresses and deformation are less in case of rectangular opening and to reduce the deflection rectangular opening should be at bottom near hill of gravity dam.

- With increment in the size of opening deformation generated in the dam is increasing.
- With increment in the size of opening stress generated in the dam is increasing.
- Circular opening shows less stress generation compared to Rectangular opening for small opening size.
- Deformation generated for small size of opening are same for both opening shapes considered.
- Rectangular opening shows less stress generation compare to circular opening for large opening size.

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