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ANALYSIS OF CRACK PROPAGATION IN A CONCRETE GRAVITY DAM

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ABSTRACT

A concrete gravity dam is a dam constructed from concrete and designed to hold back water. A crack may be induced in the dam due to [1]temperature effects, [2]earthquake, [3] hit by debris, [4]human errors, [5]settlement of base etc., Hence, it becomes important to study the crack behavior and the stress induced around the crack and the allowable limit up to which it can be propagated . Hence, a study of the crack and crack propagation at different water levels in the dam is done using fracture mechanics. In this paper FEM based software FRANC 2D is used to analyze the problem.

Keywords: Crack propagation; Fracture Mechanics; concrete gravity dams, Finite element analysis; Franc 2D

I. INTRODUCTION

A gravity dam is dam constructed from concrete or stone masonry and designed to hold back water by primarily utilizing the weight of the material alone to resist the horizontal pressure of water pushing against it. Gravity dams are designed so that each section of the dam is stable, independent of any other dam section. Gravity dams generally require stiff rock foundations of high bearing strength (slightly weathered to fresh); although they have been built on soil foundations in rare cases. The bearing strength of the foundation limits the allowable position of the resultant which influences the overall stability. Also, the stiff nature of the gravity dam structure is unforgiving to differential foundation settlement, which can induce cracking of the dam structure. A concrete gravity dam has been modeled in a finite element framework [1] .A fracture mechanics based crack propagated has been carried out using Franc 2D [1].During construction, the setting concrete produces a exothermic reaction. This heat expands the plastic concrete and can take up to several decades to cool. When cooling, the concrete is in a stiff state and is susceptible to cracking. It is the designer's task to ensure this doesn't occur.

II. ANALYSIS

The height and width is considered to be taken as 110 meter and 75.64 meter respectively. All the slopes are inclined at 60 degree and 45 degree for toe and heel respectively. Three various cases of water levels are considered for crack propagation analysis they are [1] when the water is at one third height of the total height of the dam, [2] when the water is at the equal height as that of dam, [3]when the water is overflowing at the height greater than three meter of the dam. The dam is fixed at the base in XY axis and then uniformly varying loads (i.e., water pressure on the structure) are applied at the different levels as mentioned above .The dead load of the structure is applied as a body force[1]. Material properties of M60 grade concrete are used[2] i.e., the elasticity modulus of the concrete as per the formula given in IS456 2000 was calculated and is taken as 38729.83346 N/(mm)2 ,Poison's ratio is taken as 0.25 [3], the thickness of the dam was assumed to be unit , density is taken as 0.000024 N/(mm)3[4] ,toughness value as 1.4[3] . All the data is taken from the references used. Further the edge crack was applied in the region of maximum deformation and it was propagated and the deformed shape was found out for all the three cases[5] as shown in the figures. Also, the value of effective stress for variations in water level was determined.

Figure2.1. shows the finite element mesh of the dam profile.

Figure 2.2. ,2.3. , 2.4. , 2.5., shows the deformed mesh and effective stress for the case 1 and case 2 respectively as mentioned in the abstract.

Figure 2.6. , 2.7., 2.8. , 2.9. , shows the deformed mesh and the values of the effective stresses before and after the application of the crack repectively.

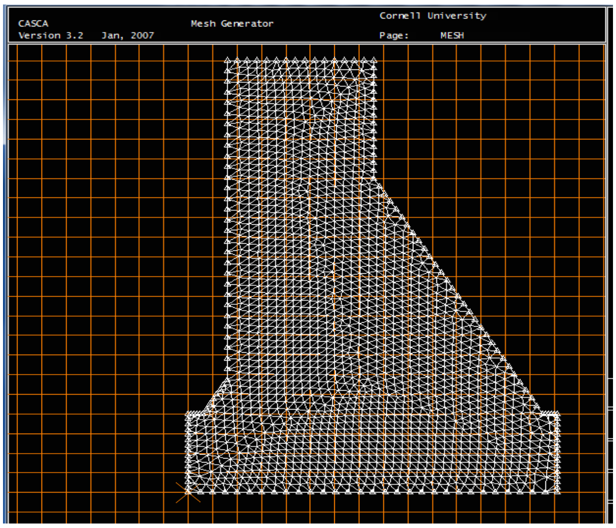

Fig 2.1. Finite Element Mesh of concrete gravity dam profile

Fig. 2.2. Deformed mesh of the fem dam profile after application of the crack for the water level at the one third height of the dam height.

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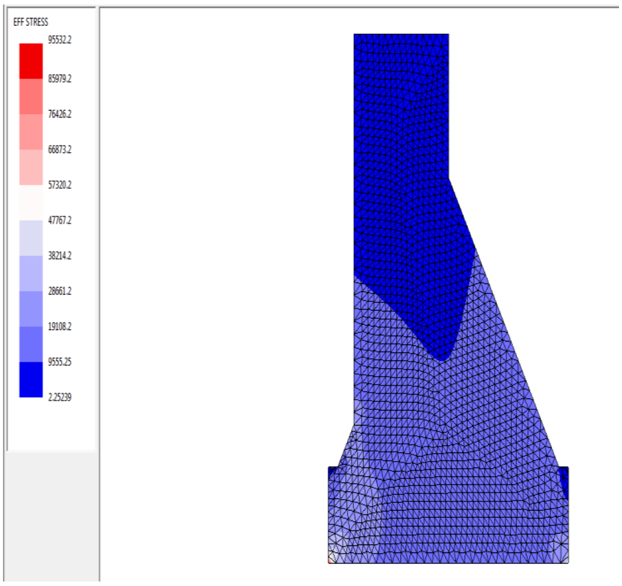

Fig. 2.3. Effective stress values when the water is at the one third height to the height of the dam.

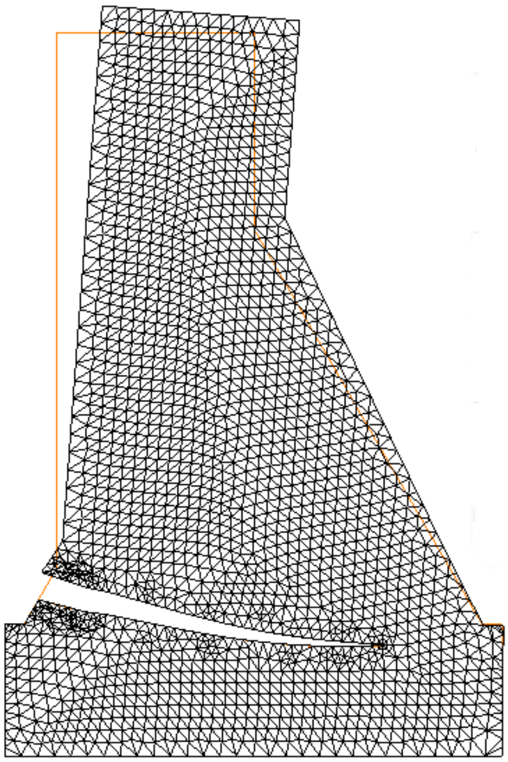

Fig. 2.4. . Deformed mesh of the fem dam profile after application of the crack for the water level at the height equal to the height of the dam.

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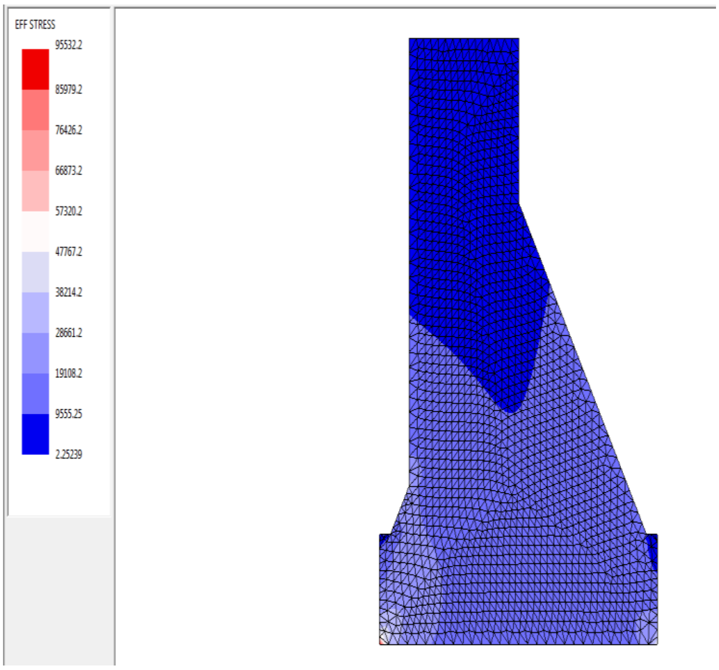

Fig. 2.5. Effective stress values when the water is at the equal level to the height of the dam. wateris at the one third height to the height of the dam.

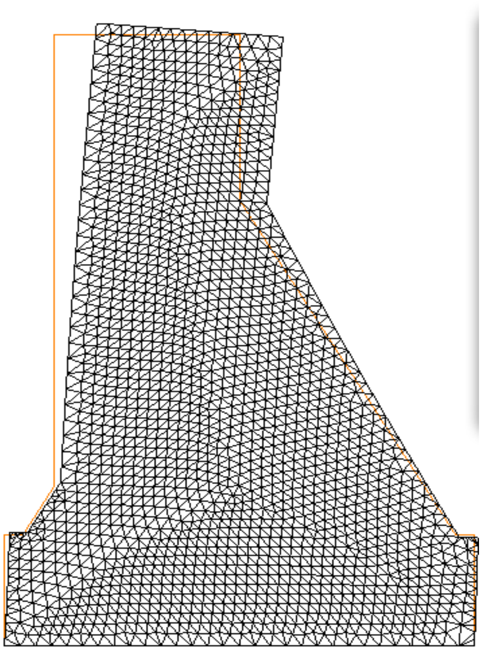

Fig. 2.6. Deformed mesh of the fem dam profile For the case three

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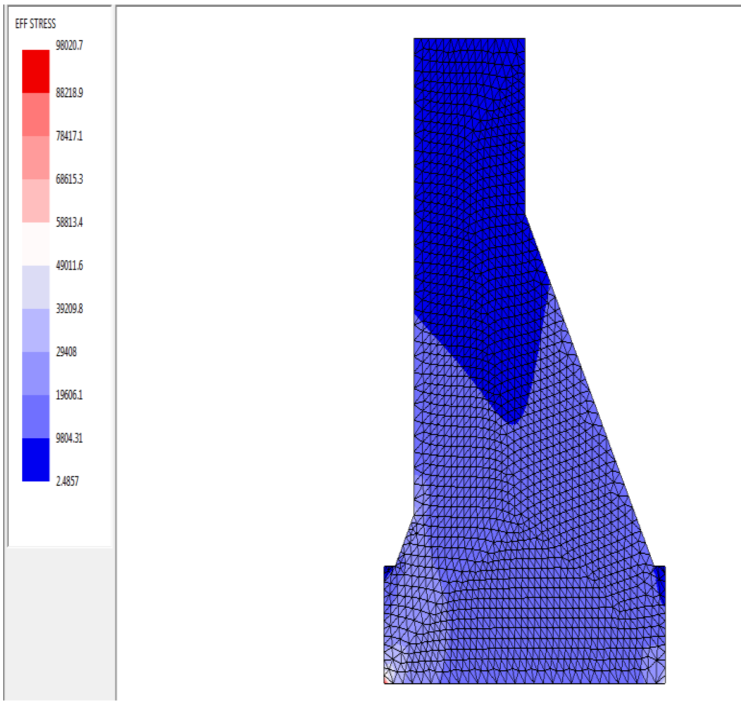

Fig. 2.7. Effective stress values for the water overflowing at three meter greater than the height of the dam.

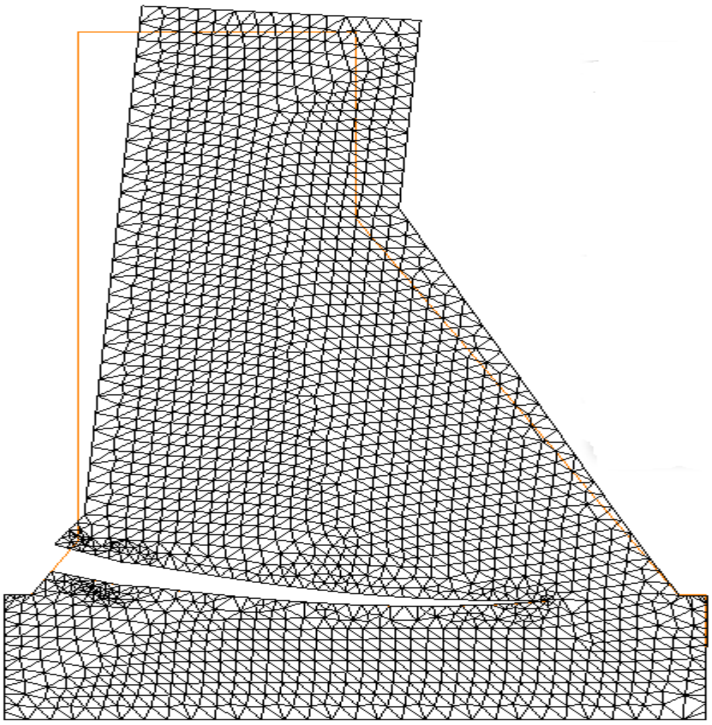

Fig.2.8. Deformed mesh after the application of crack for the water flowing at three meter height greater than that of the dam

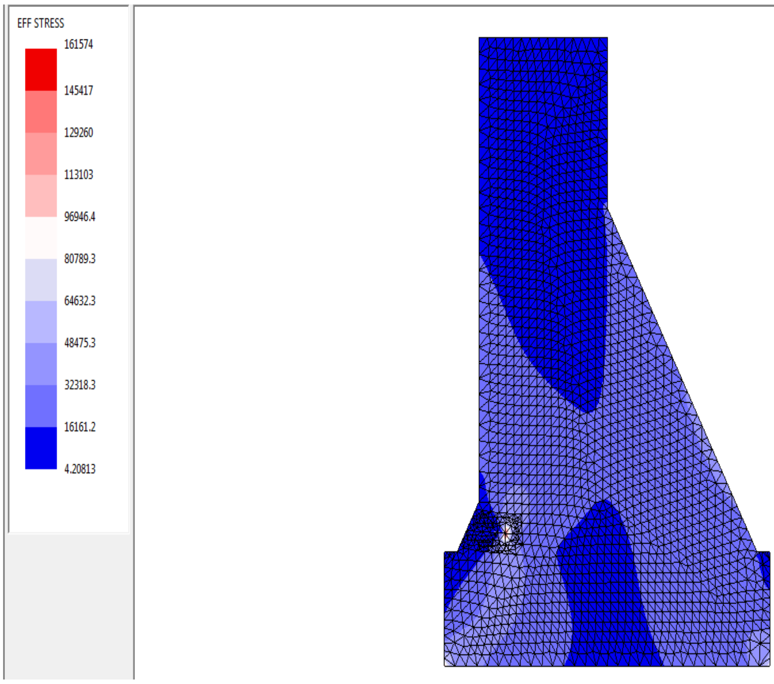

Fig. 2.9. Effective stress values after the application of the crack for water flowing at the height three meter greater than that of the height of the dam.

III. CONCLUSION

A concrete gravity dam has been analyzed using finite element method incorporate mechanics using Franc 2D.Stresses around the crack and the crack propagation were studied using FRANC2D and results were obtained succesfully.. Fracture based analysis should be adopted in the design procedure for clearer description of crack propagation and estimation of life of such concrete gravity dams.As observed the crack propagation through the dam body can be very well simulated.

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