Analysis of Spillway Radial Gate of Dam for Gate Openings at Various Distances

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Abstract— Present work has carried out a methodology to design a radial gate with a high strength low alloy steel to analyze its strength and deformation using Ansys software. In order to evaluate the effectiveness of high strength low alloy steel static analysis is performed on these steel spillway gate using FEA. The Total deformation, Von misses stresses were found for these materials of spillway gate and compare their graphical representation. When partial gate openings, hydrostatic balance is broken and pressure falls on gate reduces and flow velocities increases. According to Bernoulli's principle as the speed of fluids increases, at the same time with a decrease in pressure or a decrease in the fluid's potential energy occurs.

Key words: Spillway Radial Gate of Dam, FEA

I. INTRODUCTION

When dimensioning a gate, the first step is to calculate the water thrust acting on the skin plate for the various gate-opening positions. Its maximum value occurs with the gate closed and subjected to the maximum head water level. When a gate is totally closed and the water is at rest, the pressures obey the hydrostatic laws and the hydraulic forces are easily determined by analytical methods. In the absence of any flow, the calculation of the vertical component of the hydraulic forces on the gate comprises solely the determination of its buoyancy. This static condition is considered by a uniform value of the piezometric head. When the gate is partly open, the hydrostatic balance is broken and a non-uniform distribution of the piezometric head in the conduit, near the gate, is observed. The high flow velocities at the bottom surface of the gate, which reduces the local pressure, cause this phenomenon.

II. METHODOLOGY

A. CAD Model

In every design optimization the primary thing is the design of the model. Once the design part is ready the further processing is carried out with the set value and boundary conditions. This is the basic geometry file which comprises of nodes, surface and solid entities. They are arranged in the particular manner so that the analysis process which will be carried out on it will have systematic path to solution. 3D modeling of the radial gate is done using CATIA Software and saved in a neutral format such as .igs format.

B. FE Model

Import the CAD geometry into the ANSYS. In ANSYS tool add the material and material properties. For meshing, tria meshing is used. The main load acting on the skin plate of radial gate and at the end of trunnion, fixed support is provided.

– The Segment gate in the Fig.1 is shown partly open.

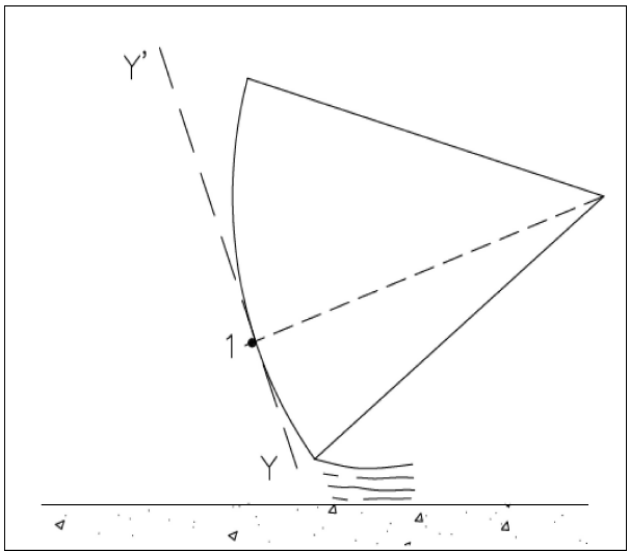

Fig. 1: Radial gate partly open

III. MATHEMATICAL CALCULATIONS FOR GATE OPENINGS

Applying the Bernoulli equation to points 1 and 2, we get:

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 \quad (1)$$

Where
v is the fluid flow speed ,
g is the acceleration due to gravity,
z is the elevation of the point above a reference plane,
P is the pressure at the chosen point, and
ρ is the density of the fluid at all points in the fluid.
Assuming that the water is at rest at the point 2, $V_2 = 0$.
As Z_1 is practically equal to Z_2, Equation (I) becomes

$$\gamma \frac{V_1^2}{2g} = P_2 - P_1$$

As the left side of the equation is positive, there is a pressure difference between points 1 and 2, which increases with the velocity of the water flowing under the gate.
Gate Opening at Various Distances like 0.5 m, 1 m, 2 m, 4 m-

1) At d =0.5 m Gate Opening-
   ΔH = 6 m, V= √ 2gh
   $P_2 - P_1$ = 58750 N/m^2
2) At d =1 m Gate Opening-
   ΔH = 5.5m, V= √ 2gh
   $P_2 - P_1$ = 53950 N/m^2
3) At d =2 m Gate Opening-
   ΔH = 4.5 m, V= √ 2gh
   $P_2 - P_1$ = 44086 N/m^2
4) At d =4 m Gate Opening-
   ΔH = 2.5 m, V= √ 2gh
   $P_2 - P_1$ = 24500 N/m^2

IV. RADIAL GATE MODEL DETAILS

width of Gate	12 m
Gate height (above sill to FRL)	6.5 m
Radius of skin plate	8.2 m
Sill level	EL 93.70 m
Trunnion level	EL 102.033 m
Top of gate	EL 106.70 m
Design head (FRL – SILL)	6.5 m

Table 1: Radial Gate Specifications

V. SIMULATION OF MODEL

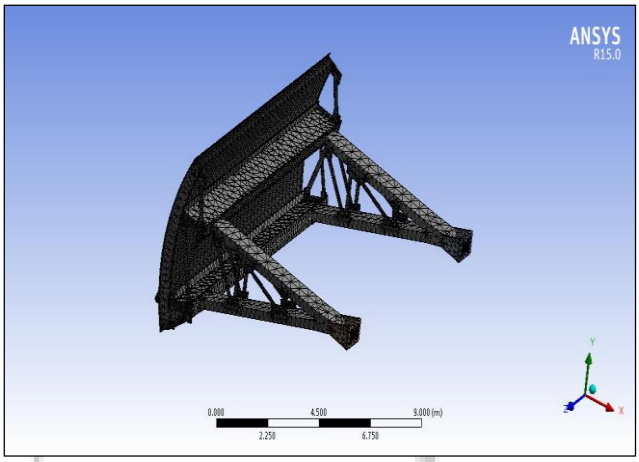

Fig. 2: Meshing

A. Stresses of Radial gate at Various Gate Openings-

1) High Strength Low Alloy Steel (HSLA) –

Below Fig. shows Von mises Stress of Radial Gate at different Gate Openings.

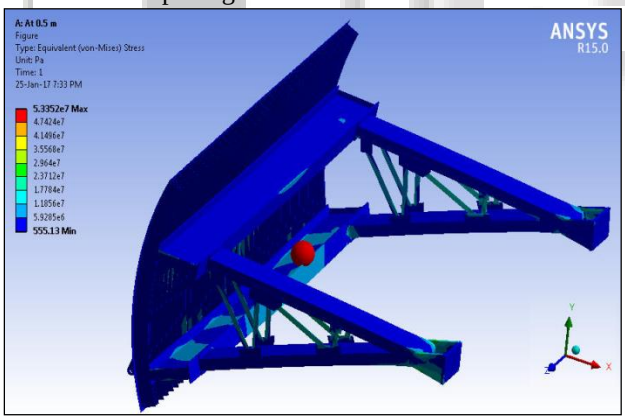

Fig. 3: at 0.5 m Gate Opening

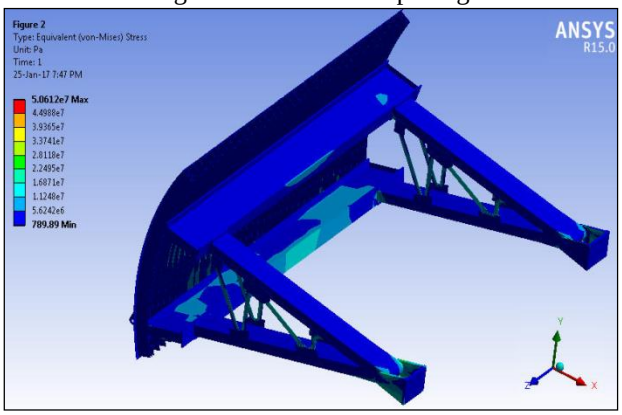

Fig. 4: at 1m Gate Opening

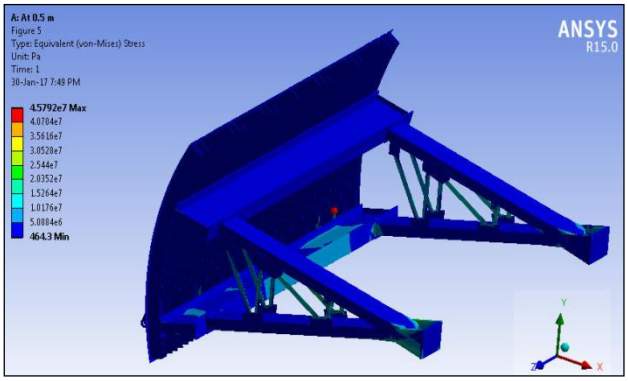

Fig. 5: at 2 m Gate Opening

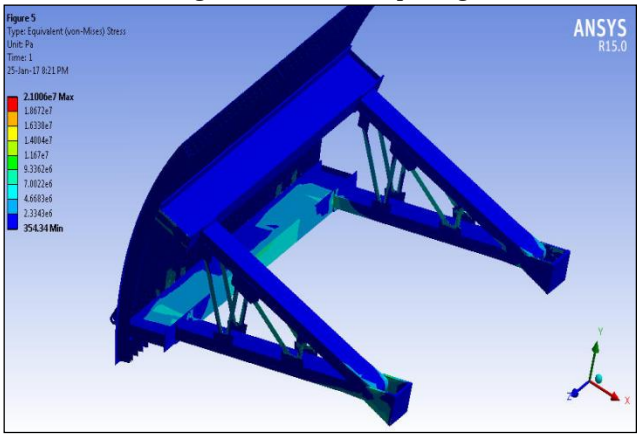

Fig. 6: at 4 m Gate Opening

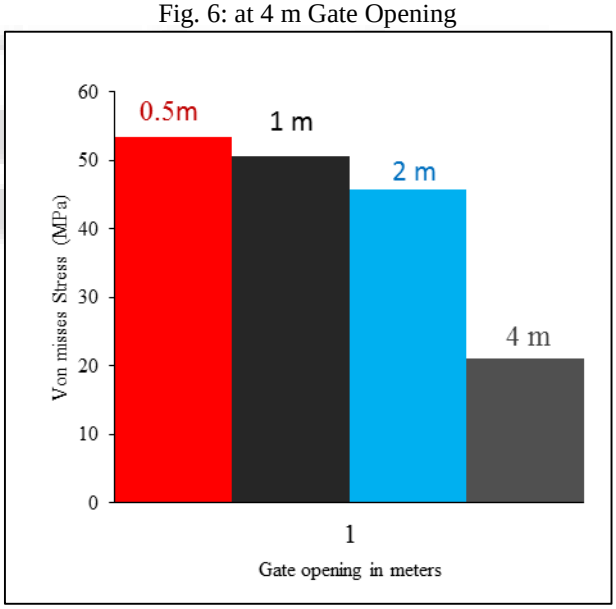

Fig. 7: Comparison between Von mises Stress for various Gate Opening

As the Gate open at higher distance(m), the von mises stress is reduced. At 4m gate opening stress obtained on a gate is very less as compared to gate openings at 0.5m, 2m, and 4m.

VI. DEFLECTIONS OF RADIAL GATE AT VARIOUS GATE OPENINGS-

A. High Strength Low Alloy Steel (HSLA) –

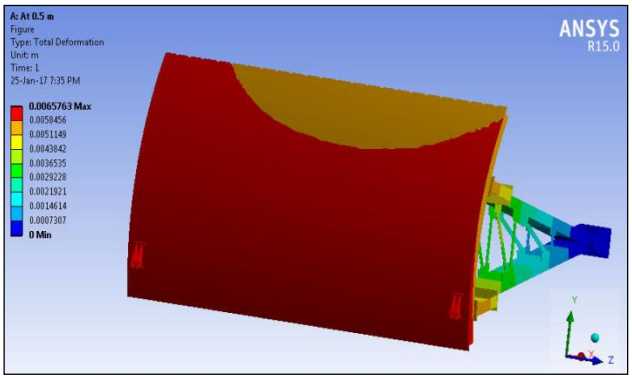

Fig. 8: At 0.5 m Gate Opening

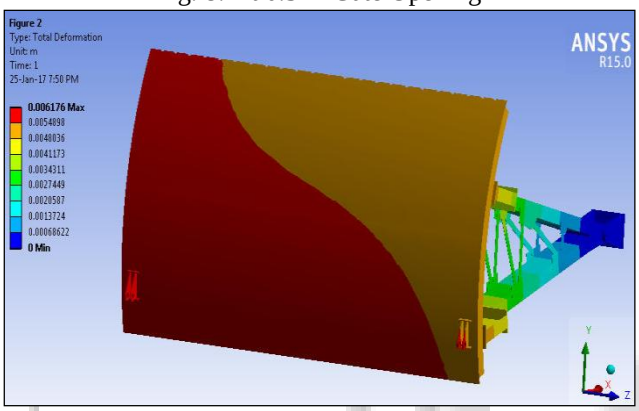

Fig. 9: At 1 m Gate Opening

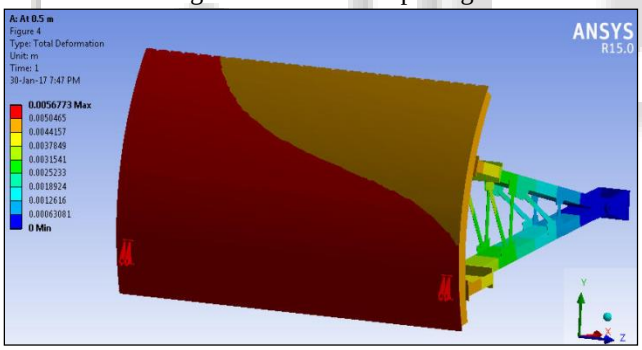

Fig. 10: At 2 m Gate Opening

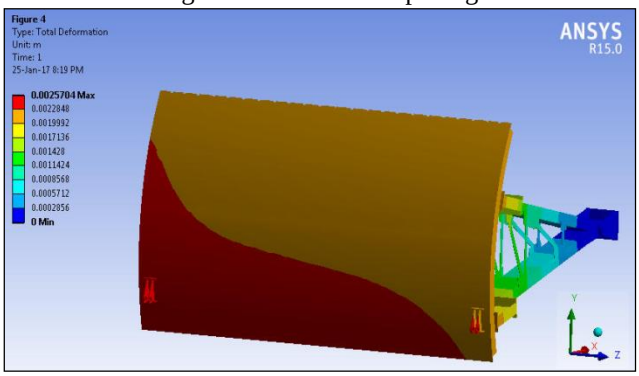

Fig. 11: At 4 m Gate Opening

As the Gate open at higher distance(m), the deflection is reduced. At 4m gate opening deflection on skin plate is very less as compared to gate openings at 0.5m, 2m, and 4m.

VII. CONCLUSION

1) As the Gate open at higher distance(m), the von mises stress is reduced.
2) At 4m gate opening stress obtained on a gate is very less as compared to gate openings at 0.5m, 2m, and 4m.
3) 3.As the Gate open at higher distance(m), the deflection is reduced.
4) At 4m gate opening deflection on skin plate is very less as compared to gate openings at 0.5m, 2m, and 4m.

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