

Reduction in Area of Radial Gates and their Effect on Safety – A Comparative Study

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Abstract: This article discusses the very common types of spillway radial gates and develops a program based on Excel, for Optimum design of Radial Gate. The main aim will be to reduce the weight of the gate and its other parts without losing the strength of the gate at any point. To attain the aim of the present study following proposed steps are involved. Study of relevant codes and other literature related to the Radial Gate design. Development of a computer aided design procedure through spread sheet computations. Discuss the results in the context of economical Radial Gate. To discuss the conclusion from observed result.

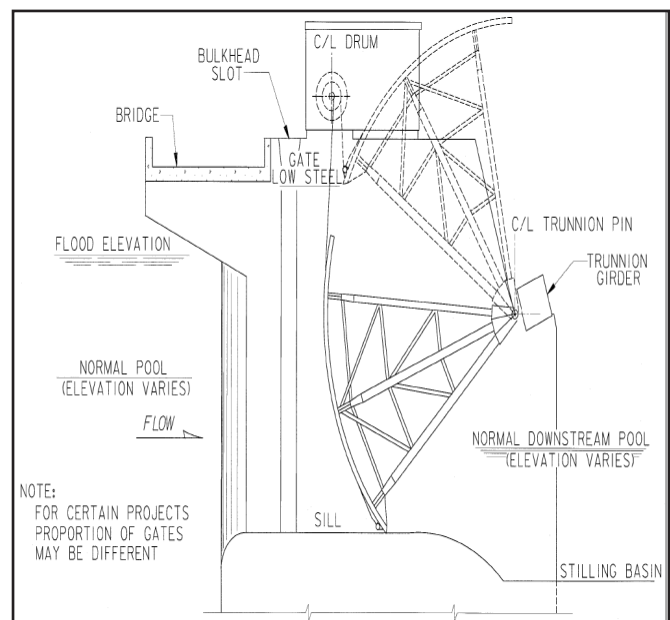
Keywords: Girder, Stiffeners, Trunnion.

I. INTRODUCTION

A Hydraulic (radial) Gate is defined as, A (Radial) gate on the spillway crest to regulate the discharge or water level. A radial gate plays a role which is similar to a drum section. Water thrust is transferred from the (skin plate) through the horizontal girder to the arms at the sides of the opening. The arms act as columns and transfer water thrust to a common bearing located on either side of the gate opening.

Water flow is underneath the skin plate as the gate is opened. This design results in a lightweight, economical radial gate that can be lift and closed with minimum effort. According: I.S. CODE 4623:2000 “the radial gate has a skin plate bent to an arc with convex surface of the arc on the upstream” side. The centre of the arc is at the centre of the trunnion pins, about which the radial gate rotates. The curve plate is supported by suitably spaced ribs either horizontal or vertical or both. If horizontal stiffeners are used, these are supported by suitably spaced vertical diaphragms which are connected together by horizontal girders transferring the water load to two end vertical diaphragms. The end beams are supported by arms, emanating from the trunnion hubs located at the axis of the skin plate cylinder. If vertical ribs are used; these are supported by suitably spaced horizontal girders which are supported by arms. The arms transmit the water thrust to the trunnion girder/yoke

girder. Suitable seals are provided along the curved (skin plate) ends of the gate and along the bottom. If used as a regulating gate in tunnels or conduits, a horizontal seal fixed to the civil structures, seals with the top horizontal edge of the gate, in the closed position. The BIS code IS 13623: 1993 “Criteria for choice of gates and hoists.”



II. CASE PROBLEM

- The design of gate involves tedious procedure. To decide the dimension of various element of radial gate one study problem has to be chosen. To analyze the radial gate designs we are going to consider a problem having following data analyze.
- In this study the gate consist of curved skin plate supported on suitably spaced vertical stiffeners from ½ cut ISMB .and the stiffener rest on 2 horizontal girders, which are supported by inclined arms at each end.

- These are braced and terminate on trunnion hub which rotated about the fixed trunnion pin mounted on trunnion bracket

III. DESIGN OF EMBEDDED PARTS

THE LOAD ANCHORAGE SYSTEM IS DESIGNED FOR THE FOLLOWING CONDITION

Frl+ Effect Of Sill Reaction		463.87T
Frl Load+ Hoist Reaction		488.54T

THE ANCHORAGE ASSEMBLY IS AT INCLINATION TO HORIZONTAL 9.59 DEGREE

The max load on the anchor	(.5(488.546 sec9.59)	246.7024249
		250t

Water Level	Case and Condition	Bottom H.g			Top H.g.		
		B.M kg cm	SF kg	Reac-tion	BM kgcm	SF kg	Reac-tion
Frl	Gate is Just Lifted	3749	111.7	185	4876	85.5	132
	Gate Resting On Sill	4889	111.7	197	4876	85.5	132

A. Case 1

a. Design of Skin (Curve) Plate

THE CURVE PLATE IS STIFFENED WITH VERTICAL RIBS/STIFFENERS AT 420MM C/C AT MIDDLE AND 335MM C/C AT END

Skin Plate Thickness cm	Effective Thickness cm	Section Modulus cm ³	Head cm	End Span cm		Mid Span cm		Permissible Stress
				BM kgcm	SF kg	BM kgcm	SF kg	
1.4	1.25	.26	780	242	929	253	967	1020 kg/cm ²

b. Design of Vertical Stiffeners at Bottom Horizontal Girder at Point a Proposed Section its Tee Cut of ISMB 450 *150

C/C Spacing of Stiffeners cm	Area Cm ²	Ixx cm ⁴	Z1 cm ³	Z2 cm ³	Z3 cm ³	SF kg	BM Kgcm
42	92.3	9033	994	1152	625	4691.3	205338

Skin Plate Stress $389.177 < 1020 \text{ kg/cm}^2$

Bending Stress on U/S of Skin Plate $206.5 < 1020 \text{ kg/cm}^2$

Shear Stress $223.8 < 765 \text{ kg/cm}^2$

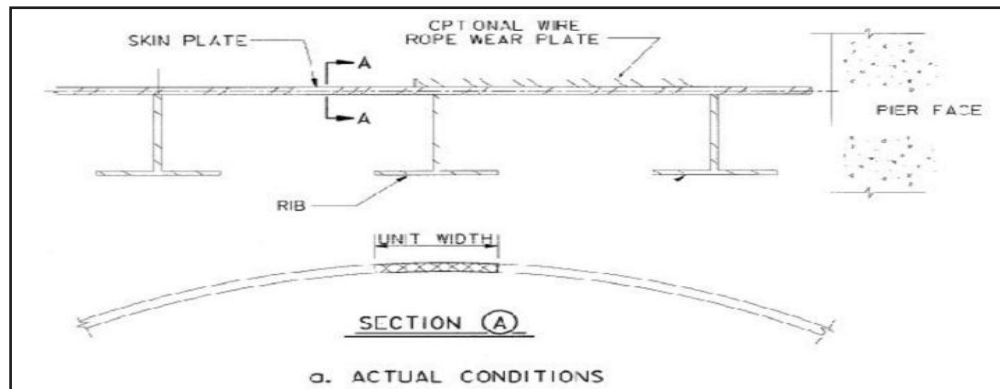
c. Design of Vertical Stiffeners at Top Horizontal Girder

C/C Spacing of Stiffeners	Area Cm ²	Ixx Cm ⁴	Z1 Cm ³	Z2 Cm ³	Z3 cm ³	SF kg	BM Kgcm
42	92.3	9033	994	1152	625	3591.84	204792

Skin Plate Stress $167.4919355 < 1020 \text{ kg/cm}^2$

Bending Stress on U/S of Skin Plate $206.028169 < 1020 \text{ kg/cm}^2$

Shear Stress $171.350062 < 765 \text{ kg/cm}^2$



d. Design of Bottom Horizontal Girder

- Design of Section at Point C and B

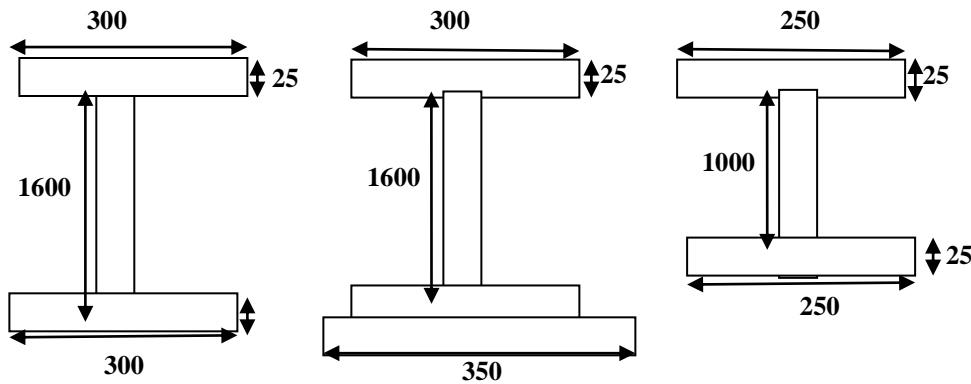
Area cm ²	Ixx Cm ⁴	Zxx Cm ³	Max BM Kgcm	Max SF kg	Bending Stress	Shear Stress
310	1331646	16141	10479933	70176	649.< 1102 kg/cm ²	438.6 <892 kg/cm ²

- Design of Section at S

Area cm ²	Ixx Cm ⁴	Zxx cm ³	Max BM kgcm	Max SF kg	Bending Stress	Shear Stress
461.5	1965592	19980	12569711	86688	629.< 1148 kg/cm ²	541.8<892kg/cm ²

- Design of Section at A

Area cm ²	Ixx cm ⁴	Zxx cm ³	Max BM kgcm	Max SF Kg	Bending Stress	Shear Stress
265	445052	8477	1925336	40229	227.1<1102kg/cm ²	402.2<892kg/cm ²



Section B, S and A (all dimension in mm)

e. Design of Top Horizontal Girder

- Design of Section at Point C and B

Area cm ²	Ixx cm ⁴	Zxx cm ³	Max BM kgcm	Max SF kg	Bending Stress	Shear Stress
300	1265625	15341	6968127	47158	454< 1102 kg/cm ²	294.7375<892 kg/cm ²

- Design of Section at S

Area cm ²	Ixx cm ⁴	Zxx cm ³	Max BM kgcm	Max SF kg	Bending Stress	Shear Stress
397	1667211	24836	5556484	58254	334< 1148 kg/cm ²	364<892kg/cm ²

- Design of Section at A

Area cm ²	Ixx cm ⁴	Zxx cm ³	Max BM kgcm	MaxSF kg	Bending Stress	Shear Stress
220	398583	7592	571024	15324	75.21390938<1102kg/cm ²	153.24<892kg/cm ²

f. Design Bottom Arm

THE FOLLOWING SECTION IS PROPOSED COLUMN SECTION UC 305*305*198

Load On Column kg	Inclination Of Arm	Cantilever Moment kgcm	FEM Kgcm	Area Cm ²	Ixx cm ⁴	Zxx cm ³	Ixx Mean cm ⁴
151596	19.86 Degree	8268.44	12402845.44	252	50900	2995	1550248.0

Actual Bending Stress 79.26 < 1102 kg/cm²

Actual Compressive Stress 601.1 < 992kg/cm²

g. Design Top Arm

THE FOLLOWING SECTION IS PROPOSED COLUMN SECTION UC 305*305*118

Load On Column kg	Inclination Of Arm	Cantilever Moment kgcm	FEM kgcm	Area Cm2	Ixx Cm4	Zxx Cm3	Ixx Mean Cm4
101870	19.86 Degree	5556.484	8339.69812	150	27670	1760	653483.6897

Actual Bending Stress $90 < 1102 \text{ kg/cm}^2$

Actual Compressive Stress $679.1 < 904 \text{ kg/cm}^2$

h. Design of Horizontal Girder Bracing

The design for the down stream flange of horizontal girders are designed for the following:

- 1/2 The weight of horizontal girders
- 2.5% of axial force in D/S flange of girders

PROPOSED SECTION 2L OF 100*100*6

Area Cm2	L/rxx	Permissible Stress	Actual Compressive Stress
23.3	105.3<180	528.5kg/cm2	175.92<528.5 kg/cm2

i. Design of Arm Bracing

PROPOSED SECTION 2 No ISMC 125*65

Area cm2	L/rxx	Permissible Stress	Actual Compressive Stress
33.3	64.3<180	876kg/cm2	320<876 kg/cm2

B. CASE 2

a. Design of Skin Plate

THE SKIN PLATE IS STIFFENED WITH VERTICAL STIFFENERS AT 400MM C/C AT MIDDLE AND 520MM C/C AT END

Skin Plate Thickness cm	Effective Thickness Cm	Section Modulus cm3	Head cm	End Span cm		Mid Span cm		Permissible Stress
				B kgcm	M SF kg	B kgcm	M SF kg	
1	.85	.1204	780	88	734.2	112	930	1020 kg/cm2

*b. Design of Vertical Stiffeners at Bottom Horizontal Girder at Point A Proposed Section its Tee Cut of ISMB 350 *140*

C/C Spacing of Stiffeners cm	Area cm2	Ixx cm4	Z1 cm3	Z2 cm3	Z3 cm3	SF kg	BM Kgem
52	88.45	5013.38	842	1114.2	588.6	5808.4	254228

Skin Plate Stress $1290.239203 < 1020 \text{ kg/cm}^2$ **FAIL**

IV. CONCLUSION

The present case study was focused on the design of hydraulic radial for a spillway. The computer aided design was carried out with the help of Microsoft excels software. From the present

case study following conclusions are: In the present study an economic and safer section was achieved by decreasing the Area in the section of elements of radial gate. It can be ascertained that the radial gate design can be optimized and one can get safer and economical design.

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