F.E.M ANALYSIS OF ANNULAR MAT FOUNDATION WITH & WITHOUT ANNULAR BEAM

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Abstract - *Application of annular raft foundation in various modern structures: Circular tower-shaped structures, like TV towers, microwave towers, chimneys, cooling towers, overhead water tanks, etc For this purpose, three raft cases are considered, which are mentioned below.*
(1) Annular raft with a ring beam. (AM+RB)
(2) Annular raft without ring beam (AM+ERB)
(3) Circular Solid raft.
This study aims to evaluate these foundation systems' structural behavior and performance under various loading conditions. For the analysis, the overhead tank (O.H.T.) foundation is considered, of different capacities of the tank like 415000 liters, , Safe bearing capacity is regarded as 25 tons for all the above cases. STADD models have been created for design work. Considering the SBC mentioned above, the Allowable settlement considered is 50mm; six no's of the models need to be modeled for comparison, shown in tabulated form.
A comparative analysis is done to examine the effect of geometrical characteristics of annular rafts, considering different ratios of inner radius to outer radius chosen. The ratio of the ring beam's radius to the raft's outer radius is also taken as a variable for obtaining different results in our thesis work. An F.E.M.-based analysis is done to determine critical moments and deflections in both annular and circular rafts. Comparison of this base pressure critical moments, shear force, bending stress, and deflections are made based on the above-mentioned case, including the cost comparison foundation. The concrete grade is M-30, and HYSD FE 500 steel reinforcement is used in design calculation. The load combination is followed as IS 1893-2016 and IS 456-2000—seismic zone 3. The software package staad pro v8i and connect edition is used. To provide relevant calculations, Microsoft Excel is used.

Key Words: Annular raft, ring beam, Stability, STAAD Pro, IS 456:2000, AM+RB,AM+ERB,CSR

1. INTRODUCTION

The foundation is a mediator to effectively transfer the load from the superstructure to the soil, without any failure for both the structure and the soil. Annular Mat foundation is one of the effective types of shallow foundations, which carries the load to the soil without any differential settlement in the soil. Annular foundation may be used where the base soil has a low bearing capacity and/or the column loads are so large that more than 50 percent of the area is covered by conventional spread footings.

In the present era, factors like rapid urbanization and massive developments taking place at one place or the other have also given rise to instances of failure of the structures, which in turn, sometimes lead to colossal destruction and loss of lives. For this reason, the study of the bearing capacity of soil has attained paramount significance. On one hand, overestimation of the bearing capacity results in structures potentially prone to disastrous collapse, while its underestimation can make the foundation uneconomic.

There are various theories for the design of the Annular foundation. Those vary from conventional manual calculation methods to most modern computer-based methods. The finite element method is one of the effective and economical numerical methods for analyzing these foundations. For the Annular Mat foundation, advanced numerical modeling techniques are utilized by dividing the MAT into grid elements and predicting the behavior of the structure under loading for critical elements projects.

1.1. TYPES OF FOUNDATIONS

• Shallow Foundation

- A shallow foundation is a type of foundation that transfers building loads to the earth very near the surface, rather than to deeper soil or rock layers. Shallow foundations are typically used for small, simple structures such as houses, garages, and sheds. They are also used for some larger structures, such as bridges and towers. The soil below shallow foundations is usually not excavated or reinforced in any way.

• Deep Foundation.

- Deep foundation means pile foundation, its recommended where the soil bearing capacity very less like inorganic clay soil and black cotton soil.
- When soil SPT (N) is less than 15 for zone-3 and less than 10 SPT(N) for Zone -2 then deep foundation is recommended as per IS code 1893-2016

• **Annular or Raft Foundation**.

- The raft foundation is generally recommended in underground structure, or when the footing area exceeds 50% of the building than raft foundation is provided.
- The Annular or raft foundation also supports the control the differential settlement.
- Annular raft foundation in various modern structures: Circular tower-shaped structures, like TV towers, microwave towers, chimneys, cooling towers, overhead water tanks, etc.

ANNULAR RAFT WITH BEAM AND WITHOUT BEAM

- In this case, a circular ring beam is incorporated in the foundation, Due to the incorporation of the beam, the bending moment and shear force sqx and sqy MY are directly carried by the beam, the annular raft inner projection and outer projection moment are reduced. The maximum negative bending moment Mx and My at the bottom of the raft and reinforcement provided accordingly. The positive bending moment Mx and My is very less at the top of the raft, so minimum reinforcement is provided.
- Ring beam design is carried out by considering maximum mz, manually, and staad.
- The punching check is carried out at a d/2 distance from the column face. One-way shear check is carried out at "d" distance where "d" is the effective depth foundation.

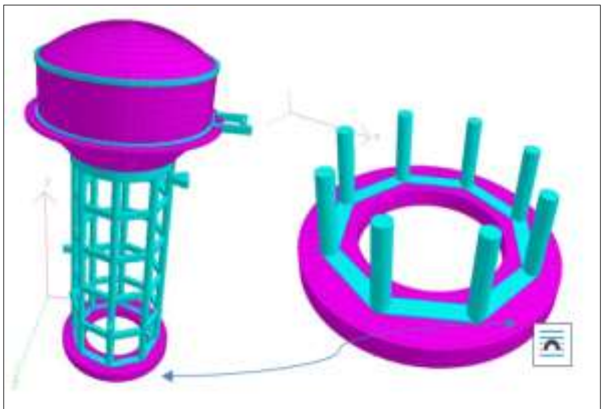

Fig -1: Elevated Storage Reservoir (AM+RB)

2. METHODOLOGY

Basic concept behind the use of a beam in the annular raft is economizing the section with respect to moments and shear force developed. In a normal raft the axial forces and lateral forces are directly carried by the raft due to this reinforcement and thickness provided accordingly, The finite element analysis carried out staad pro connect edition, The different case study is carried out,it is observed that when ring beam incorporated the forces are directly carried by ring beam. The raft inner /outer projection forces are reduced. Thus, the section can be economized.

To reach a certain conclusion, one of the variables should be taken as unknown, and the rest of the others should be made constant; therefore, in our research work, Dia of the raft and sbc variable. Other boundary conditions such as backfill soil characteristics, Grade of concrete and reinforcement, and designing methodology (Limit state method as per IS 456:2000) were kept constant during analysis and design work.

Analysis of the model: -

The following model is analyzed by the STAAD Pro software.

1. The annular mat foundation with annular beam (AM+RB) of the Elevated storage reservoir capacity of 415 kl and staging height provides 14 mtr.
2. The annular mat foundation with an annular beam (AM+ERB) of the Elevated storage reservoir capacity of 415 kl and staging height provides 14 mtr.

In AM+RB, beams are introduced in the annular raft. In AM+ERB is without a beam. Both types of foundations are analyzedwith the help of designed Excel spreadsheets and STAAD Prosoftware. The analysis results of the STAAD Pro software for all the heights were taken individually and compared with the analysis results of both types of retaining walls. The STAAD Pro output is then used in the Excel program to designit by the Limit state method. The quantities of Concrete and Steel were calculated with the help of a designed Excel sheet and compare the results.

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Table -1: Data Assumed for model analysis.

ANNULAR MAT FOUNDATION INCLUDING RING BEAM. (Am+Rb)	Thickness	500 MM
	Inner Dia	3300 MM
	Outer Dia	8700 MM
	concrete grade	M25
	steel grade	FE 500
	SBC	250KN/M2
ANNULAR MAT FOUNDATION WITHOUT BEAM.(Am+ERb)	Thickness	600 MM
	Inner Dia	3300 MM
	Outer Dia	8700 MM
	concrete grade	M25
	steel grade	FE 500
	SBC	250KN/M2
CIRCULAR SOLID RAFT	Thickness	600 MM
	Inner Dia	
	Outer dia	8700 MM
	concrete grade	M25
	steel grade	FE 500
	SBC	250KN/M2

Density of Water (γw) =	10	kN/m3
Elastic Modulus of Steel (Es) =	200000	N/mm2
For calculations related to Strength Calculations (IS:456)		
Per. Stress in Concrete due to Bending, (σcbc) =	10	N/mm2
Per. Stress in Steel due to Direct tension, (σst) =	130	N/mm2
Per. Stress in Concrete due to Direct tension (σcc) =	8	N/mm2
For calculations related to resistance to cracking (IS:3370)		
Per. Stress in Concrete due to Direct tension(σcbt) =	1.5	N/mm2
Per. Stress in Concrete due to Bending =	2	N/mm2
Elastic Modulus of Concrete, Tank (Ec) =	27386.1279	N/mm2
Elastic Modulus of Concrete, Staging (Ec) =	25000	N/mm2
Modular Ratio (m) =	9.33333333	
Earthquake Zone =	III	
Soil type =	Hard	Soil
Wind Speed =	50	m/sec

3. ANALYSIS RESULT

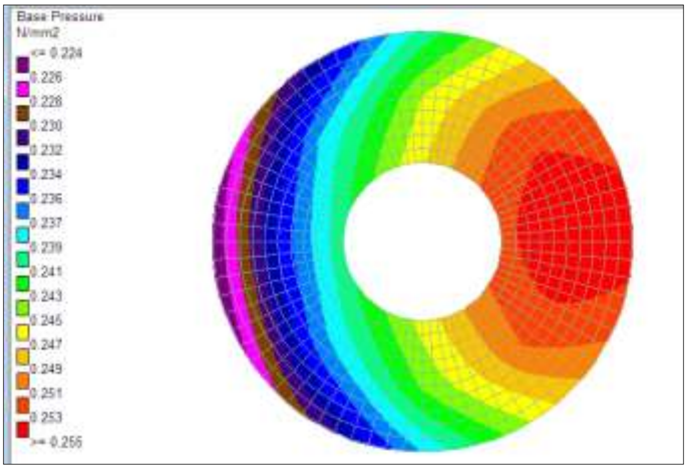

Fig -2: Base pressure AM+RB

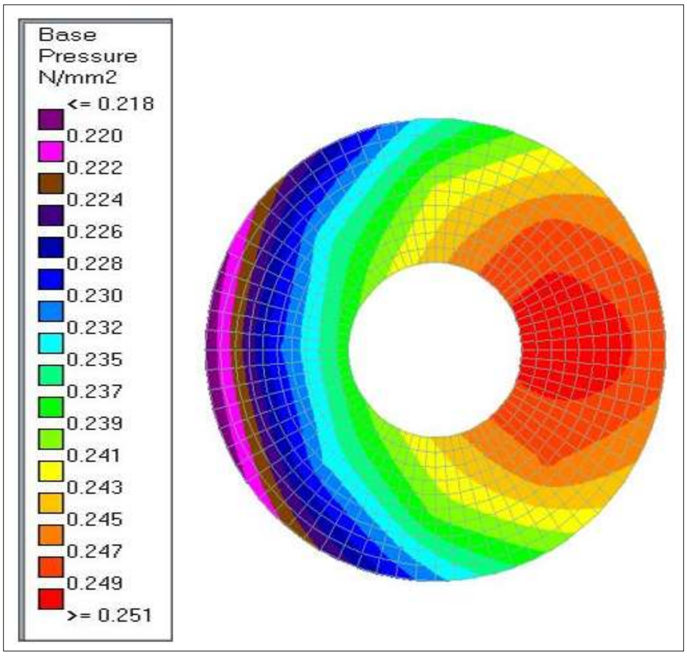

Fig -3: Base pressure AM+ERB

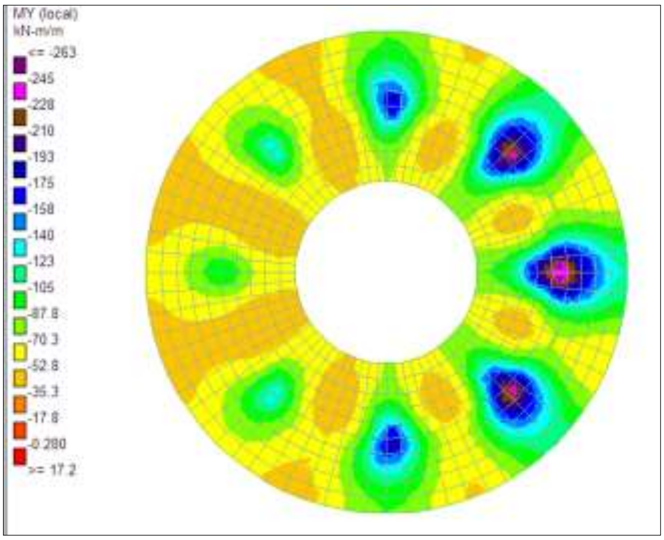

Fig -4: **Moment variation in AM+RB**

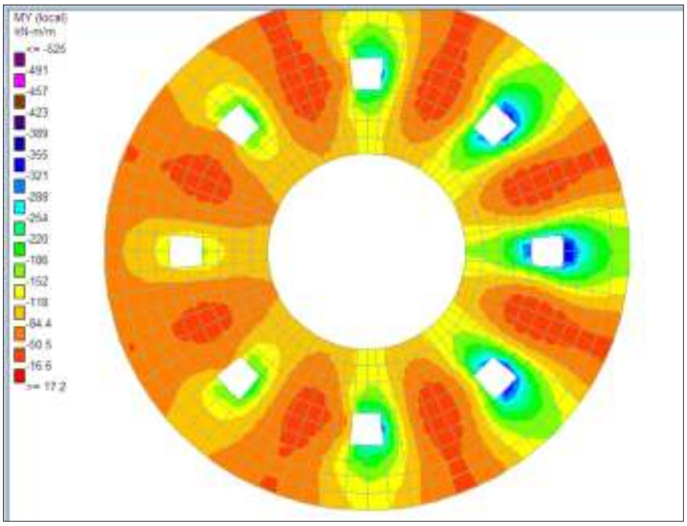

Fig -5: **Moment variation in AM+RB**

4. RESULTS AND COMPARISON

By analysis and design of an annular raft with STAAD Pro software, results were obtained for various conditions with or without a ring beam. Base pressure checking was done by modeling exact plates by applying spring modulus support reaction and properly replicating the loading conditions on the annular foundation.

In the first two cases, AM+RB fig 2 &4 and AM+ERB fig 3&5 the area of the raft and SBC is constant. In the third case area of the raft is increased due to a solid raft being provided. Further overturning moments and sliding moments were checked manually and designing was done using Excel sheets. Estimation of quantity was done there based on the poundage value of steel and concrete resulted from design parameters. Attempts are made while designing to provide steel diameters and spacing of bars which are easily approachable on-site during execution work.

ANALYSIS RESULT			
RAFT WITHOUT BEAM			
	BASE PRESSURE		
	GRAVITY =	252	kN/m2
	EQ/WL =	333	kN/m2
	M (+ve) =	67	KN.m
	M (-ve) =	336	KN.m
	Punching Shear =	0.86	N/mm2
	One Way Shear =	0.44	N/mm2
RAFT WITH BEAM`			
	BASE PRESSURE		
	GRAVITY =	254	kN/m2
	EQ/WL =	339	kN/m2
	M (+ve) =	51	KN.m
	M (-ve) =	221	KN.m
	Punching Shear =	0.68	N/mm2
	One Way Shear =	0.52	N/mm2

Table -4: Comparative Quantity

COMPARITIVE QUANTITY ANNULAR RAFT FOUNDATION				
DESCRIPTION		**CONCRETE QTY(M3)**	**BAR DETAIL**	**STEEL QTY(KG)**
ANNULAR MAT FOUNDATION INCLUDING RING BEAM.	Thickness	25	TOP #12@150MM C/C BOTH WAY BOTTOM #16@150 BOTH WAY	1850
	Inner Dia			
	Outer Dia			
	concrete grade			
	steel grade			
	SBC			
ANNULAR MAT FOUNDATION WITHOUT	Thickness	30	TOP #12@150MM C/C BOTH WAY BOTTOM #16@120C/C BOTHWAY	2110
	Inner Dia			
	Outer Dia			
	concrete grade			
	steel grade			
	SBC			

5. CONCLUSIONS

Based on the study carried out, the following conclusions are drawn:

1. The distribution of pressure below the foundation varies with the addition of a ring beam.
2. Maximum reduction in the negative moment along the MY and MX axis is about 30% by providing the ring beam.
3. No changes are observed overturning moment.
4. The steel is reduced by providing ring Beam system to the annular foundation.
5. During the analysis it has been observed that moments of the raft changes with respect to SBC.
6. The variation in ring beam size effect moment and shear force annular raft foundation.
7. It is also observed that the saving in cost of construction is 12% to 18% by the provision of Beam over the annular raft. There is about 10% saving in steel.

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