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REHABILITATION OF RCC ELEVATED STORAGE RESERVOIR-A CASE STUDY

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Abstract

Many of the existing reinforced concrete structures throughout the world are in urgent need of strengthening, repair or reconstruction because of damages of structural members due to various reasons. Direct observation of these damaged structures has shown that damage occurs usually to beams, columns and the failure is mainly due to increase in stress levels of the members. [1]

The Rehabilitation of the existing damaged Elevated storage reservoir with pile foundation of capacity 68m^3 is used in this work to evaluate the effectiveness of retrofitting techniques, called Concrete Jacketing. One of the column support settles down by 130mm out four columns .The analysis of the structure are carried out and the root cause of the settlement of the support are investigated. The RC braces and columns are strengthened by reducing the stress using 1.25 factor. It is seen that the strengthened member exhibit significant reduction in the stresses. It appears that the proposed Retrofitting technique will have a significant impact in Engineering practice in the near future.

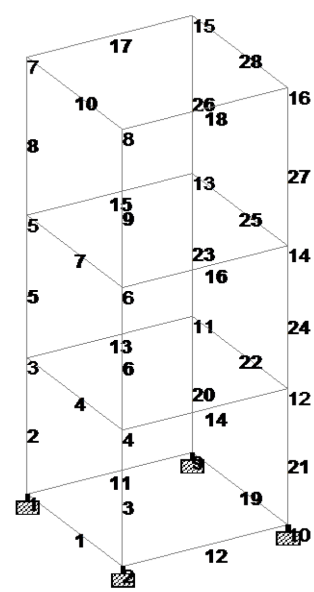
Keywords –analysis, roots cause, retrofitting, support displacement, concrete jacketing

1. Introduction

The Main object of this project is to Rehabilitate the existing damaged Elevated Storage Reservoir situated at village Funde,Tal.-Uran, Dist.- Raigad,Maharashtra state.The ESR is under the authority of Maharashtra Jeevan Pradhikaran,New Panvel,Mumbai.The storage capacity of the reservoir is 68 m3 . it is used for the supply of water to the funde village.The construction work of ESR with pile foundation is completed and also hydraulically tested in February 2007. The water supply through this reservoir is made to village regularly since May 2007.The container is circular in shape with slab at top and bottom. The height of staging is 12m. The columns are of four numbers with 400mm diameter. One number of brace beam at ground level and 2numbers of brace beam at above ground level are provided.Pile foundation consist of two numbers of piles of 400mm diameter with pile cap under each column.On 3rd March 2009, it is noticed by the authority that, out four numbers of columns one column seems to be settled down by 130mm and tilted. The visible cracks are also seen to Ground level brace.To assess the stability of structure for further use, it is proposed to analyze the structure for the existing condition. After investigation of root cause of Failure of structure, the strengthening of structure by concrete jacketing is carried out.

2. CASES CONSIDERED FOR ANALYSIS OF STRUCTURE

The structure is analyze with the help of Staad Pro. The analyze is done for two different cases that is CASE I When the structure is in stable condition or without the effect of support displacement and CASE II When one of the column of the structure settles down(sinking of support) by 130mm



MODEL VIEW

2.1CASE I: Analysis of structure without Support Displacement

The structure is analyze for the stable condition, the values of the Beam combined axial and bending stresses are given in the table No1,For load combination Deal load + Water load + Seismic load

2.2 CASE II: Analysis of structure with Support Displacement of 130mm.

The structure is analyze for the settlement of one of the column out four by 130mm , the values of the Beam combined axial and bending stresses are given in the table No.1,For load combination Deal load + Water load + Seismic load + Support Displacement by 130mm

3. ROOT CAUSES OF THE FAILURE OF STRUCTURE

3.1NEGATIVE SKIN FRICTION

The negative skin friction may be the one of the most important reason for the failure of structure.

It may be possible the soil layer surrounding a portion of the pile shaft settles more than the pile a downward drag occurs on the pile. This drag is known as negative skin friction Negative skin friction may develop when a soft or loose soil surrounding the pile settles after the pile has installed.

The negative skin friction may occurs when the soil moves downward relative to the pile. It imposes extra downward load on pile.

3.2USE OF UNDER REAMED PILE FOUNDATION

The use of construction of straight piles in existing pile foundation may be one of the reasons that can possible.

Black cotton soil contains fine clay particles. This property induces a great affinity to water of such type of soil. Alternate swelling and shrinkage in extensive limit during wet and dry process respectively results cracks in soil without any warning. On this soil may suffer severe damage with the change of atmospheric conditions.

Under reamed piles are the most safe and economical foundation in Black cotton soil. Under reamed piles are bored cast in situ concrete piles having bulb shaped enlargement near base

3.3SETTLEMENT OF SOIL

The pile foundation consists not of a single pile, but of a group of pile, which act in the double role of reinforcing of soil and also of carrying the applied load down to deeper, stronger soil strata. Failure of the group may occur either by failure of the individual piles or as failure of the overall block of soil.

Group action of piled foundation could results in failure or excessive settlement even though loading tests made on a single pile have indicated satisfactory capacity.

The elastic and consolidation settlements of the group are greater than those of single pile carrying the same working load as that on each pile within the group. This is because the Zone of soil which is stressed by the entire group extends to a much greater width and depth than the zone beneath the single pile.[8]

The settlement of a pile foundation may be due to elastic shortening of piles and due to the settlement of soil supporting the piles.

4. RESULT ANALYSIS

The result analysis after strengthening the structure with concrete jacketing. The stresses are reduced by considering a factor of 1.25 as shown the table No.1

5. RETROFITTING OF STRUCTURE CONCRETE JACKETING

This type of jacket uses a thick layer of reinforced concrete around the column and beam. The RC jacket increases flexural strength, shear strength, Axial strength and ductility of column. The longitudinal reinforcement should be dowelled with adequate anchorage in the footing to develop flexural strength.

The flexural strength of column is increased but it should be accompanied by foundation retrofit so as to ensure that plastic hinge forms in column and not in foundation.The confinement of circular columns can be achieved by using closely spaced hoops or spiral reinforcement. In the case of rectangular column, circular or elliptic jackets are more effective than rectangular jackets. In the later form of jacket longitudinal bars are susceptible to buckling in the middle region with the type of reinforcing .The concrete jacketing has an advantage of cost for construction. [8]

1. For beam nos.1,4,7,10,11,12,19,22,25,

The size is increased to 350 x 450mm instead of 250 x 350 mm as shown in Fig.no.1

2. For beam nos.13, 14, 15,16.

The size is increased to 320 x 420mm instead of 250 x 350 mm Fig.no.2

3. For beam nos.10,17,18,28

The size is increased to 500 x 700 mm instead of 400 x 600mm Fig.no.3

4. For columns nos.2,3,5,6,8,9,20,21,23,24,26,27

The size of the columns are increased to 450mm instead of 400mm. Fig.no.4

6. Conclusion

The retrofitted and the rehabilitated Elevated storage reservoir exhibited more strength than before. The Analysis of the structure confirmed that the strengthening the structure from externally wrapping concrete jacketing shows more strength and stability. The technique is a promising and a viable solution towards enhancing the stress, strength and stiffness characteristics of RC beams and RC columns.

If three sets of pile instead of two are provided in the design of the existing pile foundation than there will be less probability of sinking of support.

If the design of Ground level Braces and Column are design for the higher consideration then it would resist the stresses.

It may be necessary to provide another set of eight piles with beams at top and supporting the existing pile foundation. This will relieve the existing piles.

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Table No.1 Beam Combined Axial and Bending Stresses

Bacing/ Column No.	Bacing/ Column	Size of Section		Increased Size of Section		d	Stress without support displacement		Stress with support displacement		Increase in Stress		Stress Requirement with 1.25 Factor of Safety		Actual Stresses in Modified Structure	
		Width/ Dia(mm)	Depth (mm)	Width/ Dia(mm)	Depth (mm)		Max Tens	Max Comp	Max Tens	Max Comp	Max Tens	Max Comp	Max Tens	Max Comp	Max Tens	Max Comp
							MPA	MPA	MPA	MPA	MPA	MPA	MPA	MPA	MPA	MPA
1	Bracing	250	350	350	450	0	-0.53	0.53	-0.53	0.53	0.00	0.00	-0.42	0.42	-0.41	0.41
1	Bracing	250	350	350	450	3.97	-0.53	0.53	-0.53	0.53	0.00	0.00	-0.42	0.42	-0.41	0.41
2	Column	400		450		0	-11.30	15.87	-50.35	38.72	345.54	144.06	-9.04	12.69	-6.87	10.90
2	Column	400		450		3.74	-3.02	7.41	-20.12	8.31	565.62	12.15	-2.42	5.93	-2.32	6.17
3	Column	400		450		0	-11.30	15.87	-19.87	42.20	75.80	165.99	-9.04	12.69	-6.87	10.90
3	Column	400		450		3.74	-3.02	7.41	-24.03	46.18	695.00	523.27	-2.42	5.93	-2.32	6.17
4	Bracing	250	350	350	450	0	-0.46	0.46	-56.47	56.47	12097.41	12202.61	-0.37	0.37	-0.33	0.32
4	Bracing	250	350	350	450	3.97	-0.46	0.46	-55.55	55.55	11898.27	12001.74	-0.37	0.37	-0.33	0.32
5	Column	400		450		0	-7.70	12.75	-41.55	34.42	439.68	169.91	-6.16	10.20	-4.88	9.22
5	Column	400		450		3.92	-6.91	11.79	-35.13	27.82	408.10	136.05	-5.53	9.43	-4.48	8.64
6	Column	400		450		0	-7.70	12.75	-19.22	36.72	149.63	187.90	-6.16	10.20	-4.88	9.22
6	Column	400		450		3.92	-6.91	11.79	-13.65	30.96	97.38	162.73	-5.53	9.43	-4.48	8.64
7	Bracing	250	350	350	450	0	-0.49	0.48	-66.70	66.70	13595.48	13679.96	-0.39	0.39	-0.35	0.35
7	Bracing	250	350	350	450	3.97	-0.49	0.48	-65.73	65.72	13396.10	13479.13	-0.39	0.39	-0.35	0.35
8	Column	400		450		0	-4.80	10.42	-32.25	30.61	571.50	193.85	-3.84	8.33	-3.41	8.11
8	Column	400		450		4.34	-11.28	16.69	-53.98	52.14	378.55	212.37	-9.02	13.35	-7.01	11.51
9	Column	400		450		0	-4.80	10.42	-17.58	30.49	265.98	192.73	-3.84	8.33	-3.41	8.11
9	Column	400		450		4.34	-11.28	16.69	-33.01	45.72	192.65	173.95	-9.02	13.35	-7.01	11.51
10	Bracing	300	600	500	700	0	-0.10	0.11	-45.32	45.33	45676.77	42261.68	-0.08	0.09	-0.06	0.07
10	Bracing	300	600	500	700	3.97	-0.10	0.11	-45.11	45.12	45468.69	42069.16	-0.08	0.09	-0.06	0.07
11	Bracing	250	350	350	450	0	-0.53	0.53	-0.53	0.53	0.00	0.00	-0.42	0.42	-0.41	0.41
11	Bracing	250	350	350	450	3.97	-0.53	0.53	-0.53	0.53	0.00	0.00	-0.42	0.42	-0.41	0.41
12	Bracing	250	350	350	450	0	-0.53	0.53	-183.63	183.6	34481.1	34481.17	-0.42	0.42	-0.41	0.41

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12	Bracing	250	350	350	450	3.97	-0.53	0.53	-184.69	184.69	34680.98	34680.98	-0.42	0.42	-0.41	0.41
13	Bracing	250	350	320	420	0	-19.01	19.01	-75.02	75.02	294.61	294.67	-15.21	15.21	-10.74	10.74
13	Bracing	250	350	320	420	3.97	-19.94	19.93	-75.95	75.94	280.96	281.03	-15.95	15.94	-11.47	11.47
14	Bracing	250	350	320	420	0	-19.94	19.93	-68.17	68.17	241.97	242.03	-15.95	15.94	-11.47	11.47
14	Bracing	250	350	320	420	3.97	-19.01	19.01	-69.09	69.09	263.42	263.47	-15.21	15.21	-10.74	10.74
15	Bracing	250	350	320	420	0	-20.88	20.88	-87.09	87.09	317.13	317.18	-16.70	16.70	-11.72	11.72
15	Bracing	250	350	320	420	3.97	-21.85	21.85	-88.06	88.06	303.02	303.06	-17.48	17.48	-12.50	12.49
16	Bracing	250	350	320	420	0	-21.85	21.85	-49.71	49.71	127.50	127.52	-17.48	17.48	-12.50	12.49
16	Bracing	250	350	320	420	3.97	-20.88	20.88	-50.68	50.68	142.74	142.76	-16.70	16.70	-11.72	11.72
17	Bracing	300	600	500	700	0	-4.88	4.89	-50.10	50.11	927.00	925.50	-3.90	3.91	-2.03	2.03
17	Bracing	300	600	500	700	3.97	-5.08	5.09	-50.30	50.31	889.63	888.23	-4.07	4.07	-2.15	2.16
18	Bracing	300	600	500	700	0	-5.08	5.09	-40.45	40.46	695.75	694.66	-4.07	4.07	-2.15	2.16
18	Bracing	300	600	500	700	3.97	-4.88	4.89	-40.65	40.66	733.39	732.21	-3.90	3.91	-2.03	2.03
19	Bracing	250	350	350	450	0	-0.53	0.53	-184.69	184.69	34680.9	34680.98	-0.42	0.42	-0.41	0.41
19	Bracing	250	350	350	450	3.97	-0.53	0.53	-183.63	183.63	34481.1	34481.17	-0.42	0.42	-0.41	0.41
20	Column	400		450		0	-9.07	18.42	-31.14	58.26	243.20	216.28	-7.26	14.74	-5.11	12.99
20	Column	400		450		3.74	-0.96	10.13	-27.02	53.96	2702.59	432.49	-0.77	8.11	-0.73	8.43
21	Column	400		450		0	-9.07	18.42	-19.12	9.12	110.72	-50.50	-7.26	14.74	-5.11	12.99
21	Column	400		450		3.74	-0.96	10.13	-45.25	35.07	4593.46	246.05	-0.77	8.11	-0.73	8.43
22	Bracing	250	350	350	450	0	-0.46	0.46	-88.56	88.56	19028.2	19193.90	-0.37	0.37	-0.33	0.32
22	Bracing	250	350	350	450	3.97	-0.46	0.46	-87.64	87.64	18829.1	18993.03	-0.37	0.37	-0.33	0.32
23	Column	400		450		0	-6.52	14.77	-28.06	48.75	330.17	230.16	-5.22	11.81	-4.05	10.92
23	Column	400		450		3.92	-5.68	13.74	-21.58	42.09	279.98	206.35	-4.54	10.99	-3.60	10.29
24	Column	400		450		0	-6.52	14.77	-24.53	20.06	276.05	35.88	-5.22	11.81	-4.05	10.92
24	Column	400		450		3.92	-5.68	13.74	-29.53	24.88	419.86	81.07	-4.54	10.99	-3.60	10.29
25	Bracing	250	350	350	450	0	-0.49	0.48	-72.04	72.04	14693.0	14784.30	-0.39	0.39	-0.35	0.35
25	Bracing	250	350	350	450	3.97	-0.49	0.48	-71.07	71.07	14493.6	14583.47	-0.39	0.39	-0.35	0.35
26	Column	400		450		0	-4.51	11.57	-24.68	39.04	446.93	237.52	-3.61	9.25	-3.30	9.09
26	Column	400		450		4.34	-11.15	18.00	-46.57	60.72	317.71	237.40	-8.92	14.40	-7.04	12.62
27	Column	400		450		0	-4.51	11.57	-22.84	22.55	406.09	94.92	-3.61	9.25	-3.30	9.09
27	Column	400		450		4.34	-11.15	18.00	-39.94	39.44	258.27	119.16	-8.92	14.40	-7.04	12.62
28	Bracing	300	600	500	700	0	-0.10	0.11	-45.64	45.65	45998.9	42559.81	-0.08	0.09	-0.06	0.07
28	Bracing	300	600	500	700	3.97	-0.10	0.11	-45.43	45.44	45790.9	42368.22	-0.08	0.09	-0.06	0.07

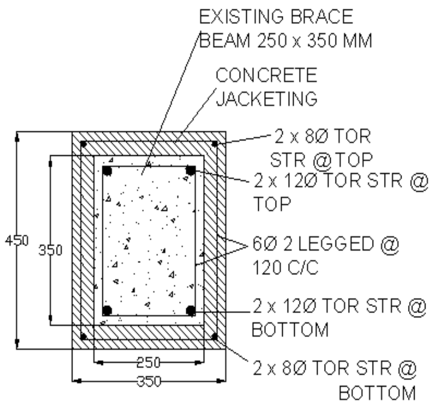
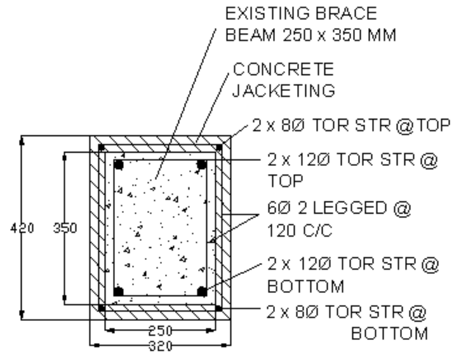


Fig.no.1



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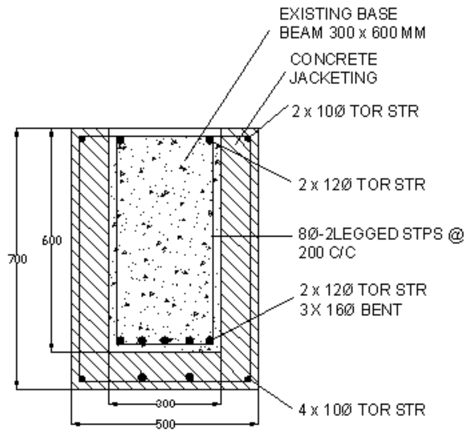

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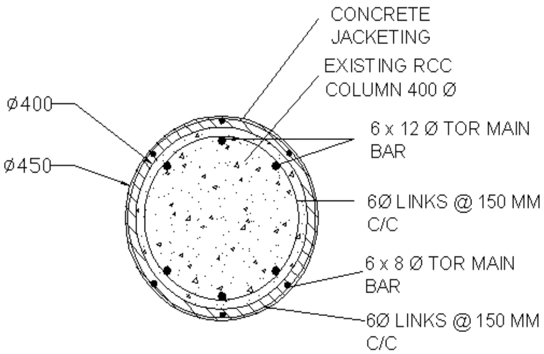

Fig.no.4