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Structural Design and Rehabilitation of Reinforced Concrete Structure

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ABSTRACT: Effective rehabilitation scheme for failed structure demands methodical analysis of various causes of failure and intended service loads and other functional details, The actual study under deliberation is the best example of rehabilitation Structural element – Basement RCC raft, failed to sustain uplift due to ground water table. This paper dealt with the rehabilitation of basement RCC raft foundation considering various design aspects like uplift due to ground water table, sub-soil properties and restriction on depth of raft to suffice available headroom for intended use.

Keywords: Rehabilitation, Piled Raft, Design, Anchor Pile, Flat Slab, Methodology

I. INTRODUCTION

Concrete structure is generally expected to give trouble free service though out its intended service life. However, these expectations are not achieved due to structural deficiency, faulty constructions methodology, poor quality control &construction specifications, material deterioration, harsher services environment than those expected during planning & design stages - change in intended use or change in live load, unanticipated over loading or unforeseen activities like fire, earthquake, explosion etc. Such structures require failure analysis & restoration to meet its function requirements by adopting appropriate repair and rehabilitation techniques. [(1)]

Piled Raft Foundation:-

Concept of pile raft foundation as per the graphical representation. [(2)]

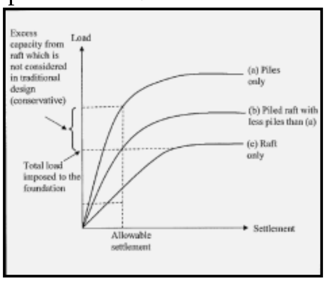

Fig 1 Concept of Pile Raft

Major underground water leakage though raft foundation at basement of Beach Resorts Goa compelled structural rehabilitation of the basement foundation. The structure was completed in year 2001. The structure was designed with RCC raft to cater uplift due to underground water and individual columns and footings to support the building.

II. LITRETURE REVIEW

Piled raft foundation is a piled foundation that implements the piles as elements used for enhancing the behaviour of the raft to satisfy the design requirements, and they are not considered as carriers for the total structural load. The design requirements may be related to the settlement control or increasing the ultimate bearing capacity of the foundation. Since the main purpose of the piles in the majority of piled foundations is to limit settlement, then the piles in the piled raft will serve mainly as settlement reducers. The concept of settlement reducing piles firstly proposed by Burland et al. leads to the use of limited number of piles beneath the raft to reduce settlement (total and/or differential) with a low cost compared to traditional pile foundation. Randolph has discussed the importance of focusing upon settlement issues rather than capacity in the design of piled foundations. Also Randolph has reviewed some analytical approaches for estimating the stiffness of pile foundations systems. The piled raft foundation has a complex behaviour involving different interactions between its various components. Therefore, a proper analytical model is needed to evaluate these interactions. Numerical methods, which are approximate, have been developed widely in the last two decades because numerical methods are less costly and may be used to consider many kinds of different soil and foundation geometries compared to field and model tests. According to Poulo, there are three broad classes of numerical analysis methods:

(1) simplified calculation methods
(2) Approximate computer-based methods and
(3) More rigorous computer-based methods.

Poulo also noted that the most feasible method of analysis is the 3Dlinear/nonlinear finite element or finite difference methods. Recently nonlinear 3D finite element and finite difference analyses have been conducted. However, modelling problems related to the soil–structure interface still remain in the 3D finite element and finite difference analysis. The great challenge in the numerical methods is the choice of proper input parameters to give reasonable output results. The procedure of choosing right values for the input parameters can be adjusted by making back analysis for well documented case histories.

Therefore, the overall objective of this study focuses on investigating the behaviour of the piled raft foundation system in clay by changing of some parameters as: - Piles' number, length and configuration (distribution of piles over the raft). The change in the piles, number, length and configuration in addition to the change in subsoil properties produces a wide variety of cases to be studied. From this variety we may see the effect of changing each variable separately in a condition that may be close to a real one. From the parametric study aims at helping the engineers in taking a logical path in an iterative design process for a piled raft foundation. [3]

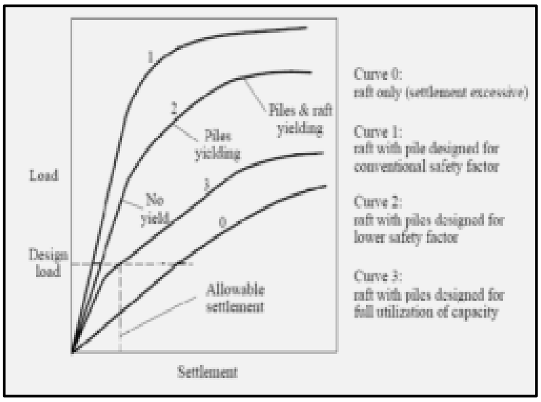

Fig 2 Load settlement curves for piled rafts according to various design philosophy [4]

III. STRUCTURAL DESIGN

It is common in foundation design to consider first the use of a shallow foundation system, such as a raft, to support a structure and then if it is not adequate, to design a fully piled foundation in which the entire design loads are resisted by the piles. Despite such design assumptions, it is common for a raft to be the part of the foundation system (e.g. because of the need to provide a basement below the structure). In the past few years, there has been an increasing recognition that the use of piles to reduce raft settlements and differential settlements can lead to considerable economy without compromising the safety and performance of the foundation. Such a foundation makes use of both the raft and the piles, and is referred to here as a pile enhanced raft or a piled raft.

Design Of Piled Raft Foundation:-

Functional requirements and Available Design parameters

Parameters of Existing RCC Raft:

a) Grade of Concrete existing RCC raft : M 20 (As per available drawing)
b) Thickness of existing RCC raft : 150 mm (± 25 mm) thick (As per site condition which is less than as required by drawing)
c) Reinforcement in existing RCC raft: 8 mm Ø @ 250 – 300 mm spacing in both directions. (As per site condition which is more than as required by drawing)

Function Requirements of Beach resort: The affected portion of the basement is being used as conference hall of the resort which has restricted headroom of 3.0 m. Resort intend to continue it as Conference hall without any reduction in headroom on rehabilitation of it RCC raft.Available Design Parameters: Existing Structural framework of the building:The building load is transferred to their individual footing underneath the basement floor. RCC raft at basement level forms a structural member to sustain uplift of underground water of head 2m.It is concluded that the existing RCC raft has been failed to sustain uplift due its structural inadequacy. Therefore, rehabilitation shall be confined to RCC raft of basement. In rehabilitation scheme of RCC raft, existing raft has been discarded as a part of structural members and it is decided to design new RCC raft of restricted depth 150 mm thick with anchor micro piles across the raft at required spacing.

Parameter of Sub-Soil Data and Ground Water Table:

a) C : 0 (Sandy Soil)
b) Ø: 37 deg
c) Ground Water Table: Maximum level above the basement raft: 2.0 mt

1. Design of Anchor Pile [(A) (B)]:-

Piles in Granular Soils: -

The ultimate load capacity (Qu) of piles, in kN, in granular soils is given by the following formula from **IS 2911:1:4:2010** or **IRC 78:2000**:-

$$Qu = Ap \times (1/2 \times D \times \gamma \times N\gamma + P_D \times Nq) + \sum_{i=1}^{n} K \times Pdi \times \tan\delta \times Asi$$

Part I Calculation. (End bearing resistance)

Ap x (1/2 x D x γ x Nγ + PD x Nq) --------------- (1)

Where,

Ap = C/s area of pile toe in cm2

= $\pi/4 \times 10^2$

= 78.53 cm2

D = Stem diameter in cm

= 10 cm

γ = Effective unit weight of soil at toe Kg/cm^3

= 0.001 Kg/cm^3

Nγ = Bearing capacity factor as per IS: 6403 – 1981 Page no. 08

= 22.40

PD = Effective overburden pressure at pile toe Kg/cm^2

= 0.001 x (8.5) x 100

= 0.85 Kg/cm^2

Nq = Bearing capacity factor as per IS: 6403-1981

= 18.40

Now Putting the values in the equation (1) we get:-

= 78.53 (½ x 10 x 0.001 x 22.40 + 0.85 x 18.40)

= 78.53 (0.112 + 15.64)

= 78.53 (15.752)

= 1237.00 Kg

= 1.237 T

Part II calculation (Skin friction resistance)

K x Pdi x tanδ x Asi---------------------- (2)

Where,

K = Co efficient of earth pressure = 1

Pdi = Effective overburden pressure in Kg/cm^2 for ith layer

= 0.001 x 8.5 x 100

= 0.85 Kg/cm^2

δ = Angle of wall friction between piles and soil

= 37

Asi = Surface area of pile in cm2 in ith layer

= Perimeter x Height

= π x 10 x 850

= 26703.53 cm^2

Now Putting the values in the equation (2) we get:-

= 1 x 0.85 x tan 37 x 26703.53

= 17104.17 Kg

= 17.104 T

Therefore Ultimate bearing capacity:-

Qu = 1.237 + 17.104

= 18.341 T

Safe bearing capacity:-

Taking factor of safety as 1.5:-

Q safe = 18.341/1.5

= 12.22 T

Taking factor of safety as 2.5:-

Q safe = 18.341/2.5

= 7.33 T

Calculation of number of piles required:-

For FS = 1.5

= Total load/Q safe

= 474.59/12.22

= 39 no's

For FS = 2.5

= Total load/Q safe

= 474.59/7.33

= 65 no's

Load on each pile:-

For FS = 1.5

= 474.59/39

= 12.16 T

For FS = 2.5

= 474.59/65

= 7.30 T

But for actual number of piles as per the site condition is 95 no's therefore,

= 474.59/95

= 4.99

= 5.0 T

Therefore the load on each pile is 5.0 T.

2. Design of Flat Slab for the new raft slab for basement [(5) (C)]:-

Flat slabs system of construction is one in which the beams used in the conventional methods of constructions are done away with. The slab directly rests on the column and load from the slab is directly transferred to the columns and then to the foundation. To support heavy loads the thickness of slab near the support with the column is increased and these are called drops, or columns are generally provided with enlarged heads called column heads or capitals.

Absence of beam gives a plain ceiling, thus giving better architectural appearance and also less vulnerability in case of fire than in usual cases where beams are used. Plain ceiling diffuses light better, easier to construct and requires cheaper form work. As per local conditions and availability of materials different countries have adopted different methods for design of flat slabs and given their guidelines in their respective codes.

The aim of this project is to try and illustrate the methods used for flat slab design using **IS: 456-2000** design codes. For carrying out this project an interior panel of a flat slab with dimensions 1.0 x 1.0 m and was designed using the codes given above.

Available data:-

1) Size of slab = 150 mm
2) Without drop and column head
3) Size of the column (anchor pile) = 100 mm Dia.
4) Grade of steel = Fe 415
5) Grade of concrete = M 25

1) Thickness:-

Since drop is not provided and HYSD bars are used span to thickness ratioshall not be exceed

= Span/0.9 x 26
= 1000/28.8
= 34.72 mm

As per the IS 456-2000 the minimum thickness shall be 125 mm, so we provided 150mm.

2) Load Calculation:-

Net upward pressure = 43.35 KN/m2
Therefore Factored load = 1.5 x 43.35
= 65.025 KN/m^2

3) Total design load in a panel:-

W = 65.025 x L_2 x Ln
Where,
L_2 = Length of span transverse to L_1
Ln = Clear span extending from face to face of column, capitals, brackets or walls but not less than 0.65 L_1.

W = 65.025 x 1 x 0.824
W = 53.58 KN/m^2

4) Moment:-

Panel moment (For interior panel)
M0 = WLn/8
= (53.58 x 0.824)/8
=5.51KN-m

Panel –ve moment (For interior panel)
= 0.65 x M0
= 0.65 x 5.51
= 3.58 KN-m

Panel +ve Moment (For interior panel)
= 0.35 x M0
= 0.35 x 5.51
= 1.93 KN-m

Distribution of moment into column strip and middle strip:-

	Column strip in KN-m	Middle strip in KN-m
-ve moment	Mnc = 5.38	Mnm = 1.78
+ve moment	Mpc = 2.32	Mpm = 1.55

5) Checking for the thickness selected:-

Since Fe 415 steel is used
Mulim = 0.138 fck bd^2
Width of column strip = 0.50 x 1000
= 500 mm
Mu lim = 0.138 x 25 x 500 x 1502
= 38.81 x 10^6 N-mm
= 38.81 KN-m

Thickness provided is OK.

6) Check for shear:-

Shear to be resisted by critical section
V = 53.58 x 1 x 1 – 53.58 x 0.212 x 0.212
V = 53.58 – 2.408
V = 51.172 KN

ζv = (V x 1000)/4 x 212 x 124
= (51.172 x 1000)/ 4 x 212 x 124
= 0.48 N/mm^2

Ks = 0.5 + βc
Where,
βc = 1
But Ks value should not be greater than 1
Therefore Ks = 1

And,

ζc = 0.25 √ fck
= 0.25 √ 25
= 1.25 N/mm2

Therefore ζv <ζc ------------------------------Safe
Shear reinforcement not required.

7) Reinforcement:-

a) For –ve moment in the column strip.

Mnc= 5.38 KN-m

Mnc= 0.87 x fy x Ast x d (1 – (Ast/bd) x (fy/fck))
5.38 x 10^6 = 0.87 x 415 x Ast x 124 (1 – (Ast/500 x 124) x (415/25))
5.38 x 10^6 = 44.77 x 10^3Ast (1 – 1.33 x 10^{-4})
5.38 x 10^6 = 44.77 x 10^3Ast – 5.95Ast^2
5.95 Ast^2 – 44.77 x 10^3 Ast + 5.38 x 10^6 = 0
Therefore,
Ast = 122.15 mm^2

This is to be provided in a column strip of width 1000 mm. Hence using 12 mm bars spacing required is given by,

S = ((π/4 x 122)/122.15) x 1000
S = 925 mm

b) For +ve moment in the column strip.

Mpc= 2.32 KN-m

Mpc= 0.87 x fy x Ast x d (1 – (Ast/bd) x (fy/fck))
$2.32 \times 10^6 = 0.87 \times 415 \times Ast \times 124\ (1 – (Ast/500 \times 124) \times (415/25))$
$2.32 \times 10^6 = 44.77 \times 10^3 Ast\ (1 – 1.33 \times 10^{-4})$
$2.32 \times 10^6 = 44.77 \times 10^3 Ast – 5.95 Ast^2$
$5.95\ Ast^2 – 44.77 \times 10^3\ Ast + 2.32 \times 10^6 = 0$
Therefore,
$Ast = 52.182\ mm^2$

This is to be provided in a column strip of width 1000 mm. Hence using 12 mm bars spacing required is given by,

S = ((π/4 x 122)/52.182) x 1000
S = 2167 mm

c) For –ve moment in the middle strip.

Mnm= 1.78KN-m

Mnm= 0.87 x fy x Ast x d (1 – (Ast/bd) x (fy/fck))
$1.78 \times 10^6 = 0.87 \times 415 \times Ast \times 124\ (1 – (Ast/500 \times 124) \times (415/25))$
$1.78 \times 10^6 = 44.77 \times 10^3 Ast\ (1 – 1.33 \times 10^{-4})$
$1.78 \times 10^6 = 44.77 \times 10^3 Ast – 5.95 Ast^2$
$5.95\ Ast^2 – 44.77 \times 10^3\ Ast + 1.78 \times 10^6 = 0$
Therefore,
$Ast = 39.97\ mm^2$

This is to be provided in a middle strip of width 1000 mm. Hence using 12 mm bars spacing required is given by,

S = ((π/4 x 122)/39.97) x 1000
S = 2829 mm

d) For +ve moment in the middle strip.

Mpm = 1.55 KN-m

Mpm= 0.87 x fy x Ast x d (1 – (Ast/bd) x (fy/fck))
$1.55 \times 10^6 = 0.87 \times 415 \times Ast \times 124\ (1 – (Ast/500 \times 124) \times (415/25))$
$1.55 \times 10^6 = 44.77 \times 10^3 Ast\ (1 – 1.33 \times 10^{-4})$
$1.55 \times 10^6 = 44.77 \times 10^3 Ast – 5.95 Ast^2$
$5.95\ Ast^2 – 44.77 \times 10^3\ Ast + 1.55 \times 10^6 = 0$
Therefore,
$Ast = 34.782\ mm^2$

This is to be provided in a middle strip of width 1000 mm. Hence using 12 mm bars spacing required is given by,

S = ((π/4 x 122)/34.782) x 1000
= 3251 mm

From the design of new raft slab, for maximum moment, we have taken the steel as 12 @ 200 mm both ways as per the IS code specification and also the anchor resin has been provided so as to minimize the chances of failure of new raft slab, the minimum depth of 100 mm for anchor resin has to be provided for the interlocking between the new raft slab and the retaining wall.

Comment: From the design of Anchor pile and the raft slab, 20mm dia Steel should be used for the anchor pile and 12 @ 200mm steel should be used for the raft slab with the anchor resin.

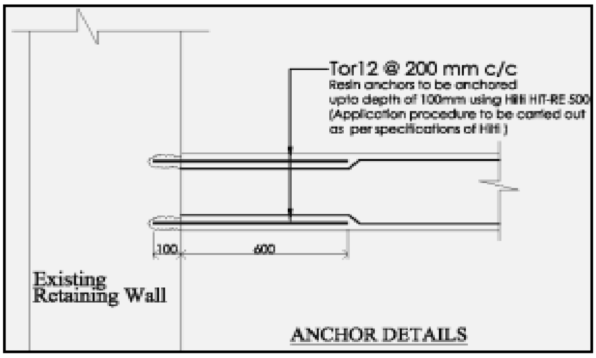

Fig.3 Detail of Resin anchor

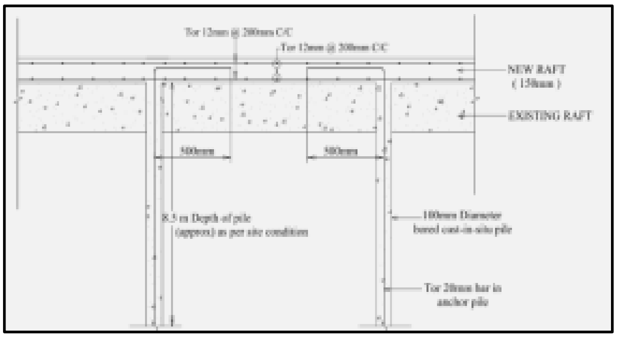

Fig.4 R/F Detail for new raft and Anchor pile

IV. WORK METHODOLOGY AND EXECUTION

1. Work Methodology for Piled Raft Foundation:-The execution of rehabilitation should be carried out according to the following steps. Special care should always be taken to ensure the high quality of work.

1.1 For Anchor Pile:-

1) Ground marking:-

As per the rehabilitation design issued by me, the contractor has carried out anchor pile marking on basement raft.

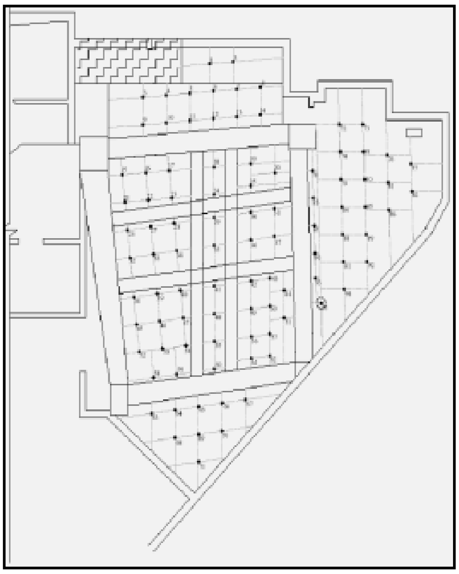

Fig.5 Marking of anchor pile on basement raft

2) Setting of Rig:-

The location of the anchor piles has been marked on the ground so after the completion of the marking the rig is set at the location and further the drilling process starts. Once the drilling is in process simultaneously the casings has to be installed so as to minimize the chances of collapse of the strata.

Fig.6 Setting of Rig at each location

3) Depth of the anchor piles:-

The depth of the anchor pile is set to 8.5 mts as per the design calculations, but at places if the hard stratum is found then it has to be stopped after some penetration into it.

Fig.8 Checking the Depth of Anchor pile

4) Insertion/Placing of bar into the bore hole:-

After the completion of the bore hole the bar of 3 meter length 3 pieces (Due to height restriction bar has to be cut into pieces) has to be welded by using proper chemical (Lokfix) and the connecting pipe, for better tensile loading on to the pile, The diameter of the bar used is 20mm.

Fig.9 Lokfix (Grout) used for the connecting the bars

Fig.10 Putting the Lokfix (Grout) in the connecting pipe to connect the bars

Fig.11 Insertion/placing of bar in the bore hole

5) Grouting the bore hole:-

After the bar is placed/inserted in the bore hole the cap is provided on top of the casing and under pressure the grouting is done. The grouting is done by using the proportion 1:6.

Fig.12 Preparing the proportion of 1:6 for grouting

Fig.13 Connecting the grouting pipe to the pump to create pressure

Fig.14 Plugging the anchor pile and starting the grouting process

Fig.15 During the pressurized grouting in progress

6) Concreting of the bore hole:-

After completion of the grouting the cap is removed and the concreting takes place, the proportion used for concreting is 1:1:2.

Fig.16 Preparing the material in proportion of 1:1:2 for concreting

Fig.17 Placing the funnel for pouring of concrete

Fig.18 Pouring the concrete in the bore hole

Fig.19 Concreting the bore hole

7) Removal of casing:-

The concreting is done in such a manner by calculating the volume of one batch of concrete and volume of one piece of casing so,

Volume of one batch of concrete $\geq$ Volume of one piece of casing.

By calculating the volume, casings are removed from the bore hole one after the other at each interval and the concreting of the bore hole (Anchor pile) takes place.

Fig.20 Removal of casing at each interval during the concerting work is in progress

8) Completion of Anchor Piles:-

The procedure is repeated for achievement of all the anchor piles, final view of the anchor piles.

Fig.21 Cleaning of basement and completion of all the anchor piles

Fig.22 Final view of completion of anchor piles

2 Raft Slab:-

1. Lokfix (New raft and Retaining wall):-

Before the Laying of steel the entire periphery need to be connected to the existing wall (Retaining Wall) by using Lokfix. The minimum insertion of bar into the retaining wall should be 100 mm.

Fig.23 Drilling and cleaning the hole

Fig.24 Fixing the bar in the drilled hole (Anchor Resin)

2. Laying of steel:-

As per the working drawing, the steel has to be laid on the existing raft slab with proper precision so as to minimize the chances of failure of the new raft slab.

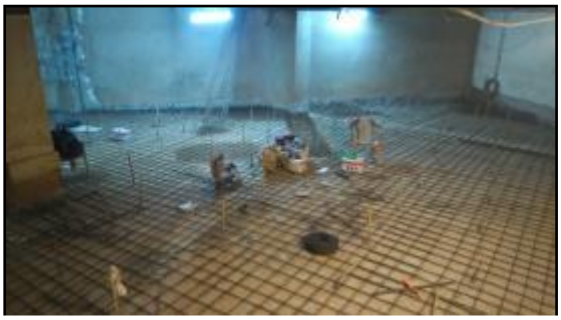

Fig.25 Laying of bottom steel

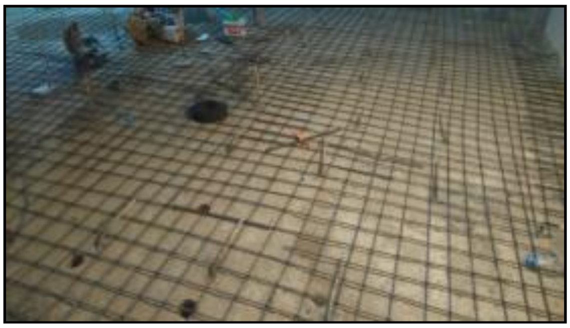

Fig.26 Bending the anchor pile steel in the new raft

Fig.27 Laying of top steel

Fig.28 Full completion of laying of top steel

3. Concreting of the raft:-

After completion of all the necessary requirements, the concreting has to take place with proper grade of concrete as specified. Also the proper bonding should be there with old and new raft slab so the application of FOSROC Nitobond to existing Raft slab.

Fig.29 Before the commencement of concreting application of NITOBOND to the existing raft slab

Fig.30 Concreting work in progress for new raft slab

Fig.31 Spreading of Armorcrete chemical on the existing raft slab

Fig.32 Final view after concreting of the new raft slab

V. QUALITY ASSURANCE & QUALITY CONTROL TESTING

For evaluation of the engineering properties different tests were conducted viz. Load tests on piles, Compression test as described below,

Load Tests on Pile:-

This test is required for one or more of the following purposes. This is done in case of important and/or major projects and number of tests may be one or more depending upon the number of piles required.

Note: - In case specific information about strata and past guiding experience is not available, there should be minimum of one test.

1) Determination of ultimate load capacities and allowable safe load by application of factor of safety.

2) To provide guidelines for setting up the limits of acceptance for routine tests.

3) To study the effect of piling on adjacent existing structures and takes decision for the suitability of type of piles to be used.

4) To get an idea of suitability of piling system, and To have a check on calculated load by dynamic or static approaches.

Note: - Piles used for initial testing are loaded to failure or at least twice the design load. Such piles are generally not used in the final construction.

Fig.33 Setting of frame for dial gauges for load tests on piles

Fig.34 Setup for load tests on piles

Fig.35 Documentation of dial gauge readings for load tests on piles

Fig.36 Discussion regarding the readings of load tests on piles with senior Engineer

As per design calculation safe bearing capacity of pile 7.33 T, But we loaded for ultimate bearing of 26416 kg on two piles therefore on one pile the maximum loading will be 13208 kg (i.e. 13.208 T), so we can assume that the pile is safe for uplift.[(6)]

Sr no.	Pressure Gauge Kg/cm2	Gauge pressure converted in terms of Kg	Time	Dial Gauge 1 mm	Dial Gauge 2 mm
1	12	1524	11.34	0	0
			11.39	0	0
			11.54	0	0
			12.09	0	0
2	24	3048	12.10	0	0
			12.15	0	0
			12.30	0	0
			12.45	0	0
3	36	4572	12.46	0	0
			12.51	0	0
			1.06	0	0
			1.21	0	0
4	48	6096	1.22	0	0
_	_	_	1.27	0	0
_	_	_	1.42	0	0
	_	_	1.57	0	0
5	72	9144	1.58	0	0
_	_	_	2.03	0	0
_	_	_	2.18	0	0
_	_	_	2.33	0	0
6	80	10160	2.34	0	0
_	_	_	2.39	0	0
_	_	_	2.54	0	0
_	_	_	3.09	0	0
7	100	12700	3.10	0	0
_	_	_	3.15	0	0
_	_	_	3.30	0	0
_	_	_	3.45	0	0
8	120	15240	11.52	0.29	0.45
_	_	_	11.57	0.29	0.45
_	_	_	12.12	0.30	0.45
_	_	_	12.27	0.30	0.45
9	140	17780	12.28	0.35	0.55
_	_	_	12.33	0.37	0.55
_	_	_	12.48	0.37	0.55
_	_	_	1.03	0.37	0.55
_	_	_	1.33	0.37	0.55
_	_	_	2.33	0.37	0.55
_	_	_	3.33	0.37	0.55
_	_	_	4.33	0.37	0.55
_	_	_	5.33	0.37	0.55
_	_	_	6.33	0.37	0.55
_	_	_	7.33	0.37	0.55
_	_	_	8.33	0.37	0.55
_	_	_	9.33	0.37	0.55
_	_	_	10.33	0.37	0.55
_	_	_	7.33	0.37	0.55
_	_	_	8.33	0.37	0.55
_	_	_	9.33	0.37	0.55
-	-	-	-	-	-
10	160	20320	10.23	0.48	0.66
_	_	_	10.28	0.48	0.66
_	_	_	10.43	0.48	0.66
_	_	_	10.58	0.48	0.66
_	_	_	_	_	_
11	180	22860	10.59	0.59	0.80
_	_	_	11.04	0.59	0.80
_	_	_	11.19	0.60	0.81
_	_	_	11.34	0.60	0.81
_	_	_	_	_	_
12	200	25400	11.35	0.82	0.96
_	_	_	11.40	0.83	0.99
_	_	_	11.55	0.85	1.01
_	_	_	12.25	0.85	1.01
_	_	_	12.40	0.85	1.01
_	_	_	1.10	0.85	1.01
_	_	_	1.40	0.85	1.01
_	_	_	_	_	_
13	208	26416	2.03	0.96	1.07
_	_	_	2.08	0.96	1.07
_	_	_	2.23	0.96	1.07
_	_	_	2.38	0.96	1.07

Table no.1 Report of load test on piles

Compression Test [(7) (D)]:-

A compression test is a method for determining the behaviour of materials under a compressive load. Compression tests are conducted by loading the test specimen between two plates and then applying a force to the specimen by moving the crossheads together. The compression test is used to determine elastic limit, proportionality limit, yield point, yield strength and compressive strength.

Sr no	Description	Size of the Cube mm	Load in kN	Strength in N/mm2
	7 DAYS			
1	Cube 1	150 x 150	650	28.88
2	Cube 2	150 x 150	700	31.11
3	Cube 3	150 x 150	750	33.33
	28 DAYS			
1	Cube 1	150 x 150	840	37.33
2	Cube 2	150 x 150	810	36.00
3	Cube 3	150 x 150	930	41.33

Table no.2 Compressive strength of concrete cubes

VI. CONCLUSION

1) Rehabilitation of basement RCC raft foundation is achieved by providing new RCC raft - flat slab with anchored micro piles 0f 100 mm diameter and depth up to 8 m, and with

injection grouting of sandy strata underlying the raft foundation.

2) Restriction on depth of the basement RCC raft was also taken into account and thereby no reduction in headroom for intended use, as available earlier
3) Methodical analysis of various causes of structural failure, effective and timely rehabilitation can restore the structure to intended use.

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CODES

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(B) **IRC 78:2000** - Standard Specifications and Code of Practices for Road Bridges.

(C) **IS 456: 2000** – Plain and Reinforced Concrete Code of Practice

(D) **IS 516:1959 –** Method of tests for strength of concrete