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Structural Audit of Cancer Hospital Building Sawangi (Meghe), Wardha

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Abstract: *Now a Days we are designing RCC framed structure which is heart of building with consideration of factors and various and codes which is necessary and using different techniques to assess the old RCC framed Structure. In India, safety of old buildings is one of the major issues. As the strength of old hospital buildings get reduced in due course of time it creates structural defects such as unexpected over loading, material deterioration, physical damages or structural deficiency and if further utilization of such damaged structure is done, it may lead to serious damage of life and property. As Structural Audit of old building is mandatory as per municipal authorities and Government of Maharashtra has made "Structural Audit" of all old building compulsory As Prevention is better than cure, In this present dissertation we adopted Structural Auditing of Cancer hospital building which is situated at sawangi (meghe),Wardha (Maharashtra) is constructed in the year span of 1990-1992 So at the present scenario this building is 32 year Old and required to be checked in all aspect to Assure its safety. with Rebound Hammer Test, Ultrasonic Pulse Velocity Test, Half-cell test, pH and carbonation test including Visual Inspection and assessing the stability and safety of the structure to withstand for its remaining life by diagnosis and root cause of the problems by recommending strengthening and then retesting after strengthening is done to check the required strength which is expected.*

Keywords: Structural Audit Non-Destructive Testing; Repair Concrete, Carbonation Test, Strengthening

I. Introduction

Structural Audit is an overall health and performance check-up of a building like a doctor examines a patient. Structural Audit is an important tool for knowing the real status of the old building. It ensures that the building and its premises are safe and have no risk. It analyses and suggests appropriate repairs and retrofitting measures required for the buildings to perform better in its service life. Structural audit is done by an experienced and licensed structural consultant. Concrete is widely used to construct buildings, structures or any other projects. However, over time, the structure starts to age and begins to show signs like cracking, splitting, delamination and steel corrosion etc. All this leads to a shortening of the life and durability of the structure. As everyone knows that this structure was built with a lifespan of more than 50 years, but in reality, this longevity is still elusive. Demolishing existing structures and retrofitting concrete structures is an essential part of financial success. It is also contrary to the concept of green building where we want to save energy for future generations.

Government of Maharashtra has made "Structural Audit" of all old building compulsory as per the amendment to MMC ACT 1888 incorporating a new section 353 B enforcing from 13/2/2009. As per by-laws of Co-operative Housing society and clause no 77. Structural Audit is mandatory for all housing society buildings as per corporation directive and as follows:

Age of the Building	Structural Audit (Compulsory)
15 to 30 years	Once in 5 years
Above 30 years	Once in 3 years

All concrete structures are subject to chemical and physical changes. Durable concrete is concrete with a low failure rate. Concrete alone is durable but for structural application, reinforced concrete, composite materials are used. Reinforced concrete structure is not durable because it is not large. for reasons such as variation in production, load conditions in life and subsequent onslaught of environmental factors.

II. Review of Literature

[1] A.B.Mahadik and M. H. Jaiswal (2014) (Structural Audit of Buildings)

This paper deals to create alertness throughout the civil engineers, occupants and building owners regarding the actual health check of existing reinforced concrete structure known as the end result inspection. structure. If the service life of a concrete structure has exceeded 30 years or more, it needs to be structurally inspected to avoid deformation and save lives. Concrete is widely used because of its inexpensive raw materials, ease of construction, ease of construction, and high strength-to-cost ratio. The construction industry is interested in improving the social, economic and environmental parameters of sustainability. Since 1980, India's infrastructure industry has increased public investment and growth in the infrastructure industry, leading to the construction of new multi-storey concrete apartments that are now more than thirty years old. Many structures were built during this period, and expected weathering has reduced its durability over time due to structural flaws, material degradation, and physical damage. In this article, we understand how to improve the life of a building by recommending preventive and remedial measures such as repair and renovation.

[2] Saiesh L. Naik BasavrajSaunshi (2021) (Structural Audit of Rcc Building)

In present study author covers the structural audit of the old RCC-building by carrying out site inspection and performing Non-destructive test on the structure and then this structure is modeled and analyzed using ETABS and Demand to capacity ratio is determined. Suitable recommendations are given after checking strength and stability of the structural members in order to retrofit damaged structural member. Finally structural audit report is prepared for the structure. From visual observation the author of paper concluded that even though heavy reinforcement is provided for the structural component and demand to capacity ratio is less than one for all structural members. The condition of reinforcement provided is very bad and lost its Strength due to corrosion. The structure is unsafe to carry any further load as due to corrosion there is reduction in the cross 11 section of the reinforcement resulting on deflection under their own weight. It is observed that main reason of damage of the structural component is due to corrosion and ageing. Corrosion in structural element is observed due to dampness and leakage from the slabs, cracks in walls etc.

[3] Shirish Lal (2021) (Structural Health Assessment of a RCC Building)

This review paper covers the study of Structural Health Assessment of RCC Buildings. Structural health assessment is the structural audit/ technical survey of the building in order to check its strength, stability and life of the structure. Structural audit is the preliminary step in restoration and maintenance of the building. Structures can be any kind it can be Historical, Heritage Structure, Residential building, Commercial building or an Industrial building. Every structure has its own serviceability period, and within this period it should stand sturdily on its position. A collapsed mechanism has increased and today's structures are getting collapsed before there service period is completed. Hence, it is suggested to monitor it periodically by taking a structural expert opinion

[4] B. H Chafekar, O.S Kadam K.B Kale, S.R Mohite, P.A Shinde, V.P Koyle 2013-2014 (Structural audit)

In present study author covers the structural audit is necessary to know about the structure. A structure is a system of inter connected elements to carry loads safely to underground earth. The health examination of concrete building called as structural audit. The author shows different methods in paper: E.g., Visual inspection, non-destructive test

Present study about structural audit is done on the basis of visual inspection method. This is the initial step to carry out the structural audit. By visual inspection only visual damages or defects in components of building should be observed. For detection of technical damage or defect for a particular component of building at particular place non-destructive tests are necessary. By this test results and comparing with standard results, get the condition of structural components. It is very useful to decide repair and maintaince method.

[5] K.R. Sonawane, Dr. A.W. Dhawale. (2017) (Structural Audit: A Case Study of Nasik Residential Building, Maharashtra, India)

This review paper covers the study of the life cycle of building can be broadly divided into four phases i.e., architectural planning, structural design, and construction maintenance. In most of building at most care is taken in first three cases but maintenance is forgotten. Ignorance to maintenance causes severe structural distress in building over period of time. Regarding the structural health of building and repair required can be carried out. Such an investigation can be carried out using the following methods: a) Visual examination b) Non-Destructive Testing c) Partial Destructive Testing.

[6] Shah I. H. (2008) (Structural audit of RCC Building)

Has stated structural audit is an important tool for knowing the real status of the old buildings. The audit should highlight and investigate all the risk areas, critical areas and whether the building needs immediate attention. If the bldg. has changed the user, from residential to commercial or industrial, this should bring out the impact of such a change. This Publication gives step by step guidelines for carrying out structural audit of old buildings

[7] B.H Chafekar, O.S Kadam K.B Kale, S.R Mohite, P.A Shinde, V.P Koyle 2013-2014 (Structural audit)

studied that before going in detail about the structural audit is necessary to know about the structure. A structure is a system of inter connected elements to carry loads safely to underground earth. The health examination of concrete building called as structural audit. The author shows different methods in paper: E.g., Visual inspection, non-destructive test. Present study about structural audit is done on the basis of visual inspection method. This is the initial step to carry out the structural audit. By visual inspection only visual damages or defects in components of building should be observed. For detection of technical damage or defect for a particular component of building at particular place non-destructive tests are necessary. By this test results and comparing with standard results, get the condition of structural components. It is very useful to decide repair and maintaince method.

[8] M. M. Sonawane, D. H. Markad, V.G. Maindad, M. B. Patil, K. D. Manwar, P. D. Mote

Concluded that appropriate actions should then be implemented to improve the performance of structures and restore the desired function of structures. Thus, it is almost important to perform structural audit of existing buildings and to implement maintenance/ repair work timely which will lead to prolonged life of the building and safety of the occupant.

III. Objective

1. Identifying the various Non-Destructive Testing carried out on structure/building
2. To assess the condition of building.
3. Highlight the critical areas that need to be attended with immediate effect.
4. To comply with Municipal or any statutory requirements.
5. To identify any signs of material deterioration and critical areas to repair immediately
6. To enhance life cycle of building by suggesting preventive and corrective measure like repairs.
7. To check the staad-pro model after strengthening.

3.1 Purposes

1. To study the types of structural defects.
2. To understand the condition of building
3. To save human life and buildings
4. Identifying the various Non-Destructive testing carried out on building.
5. To comply with Municipal or any Statutory requirements.

IV. Methodology

1. Study of Architectural and Structural Drawings.
2. Visual Inspection
3. Non-Destructive Testing
    1. Ultrasonic-Pulse Velocity Test
    2. Rebound Hammer Test
    3. Half Cell Potential Meter Test

4. Ph Value
5. Cover Meter

4. Calculations, written and Preparation Structural Audit Report.
5. Beam Strengthening
6. After Strengthening Analysis of structure by using staad-pro software.

4.1 Study of Architectural and Structural Drawings

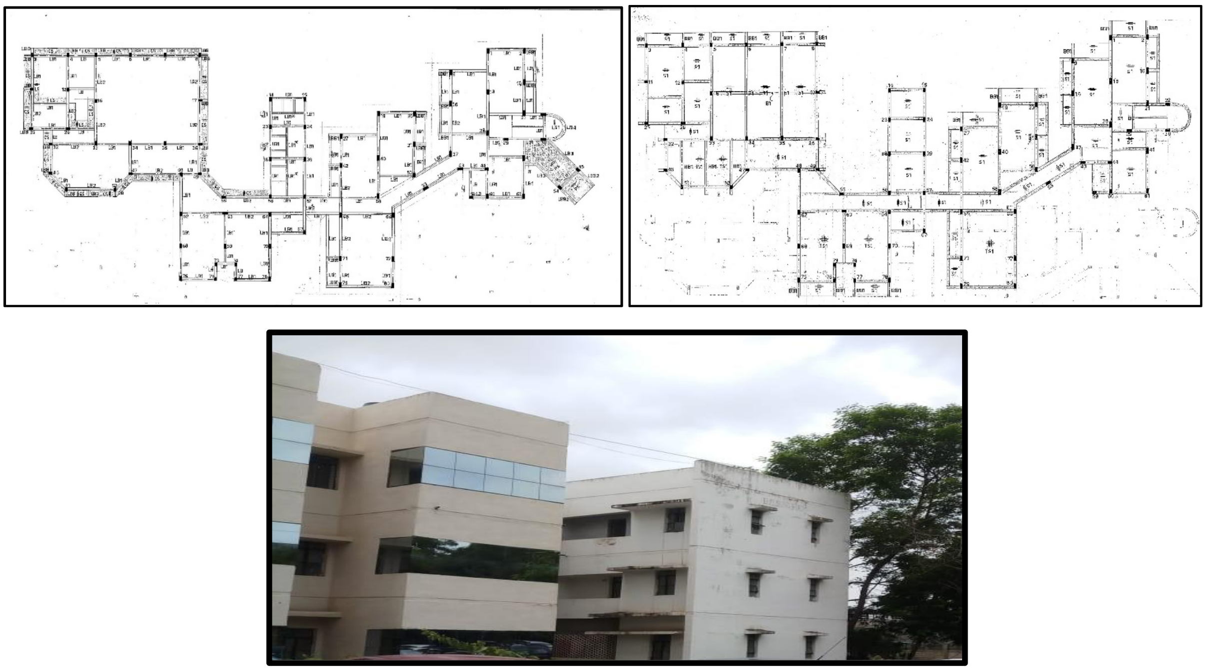


Figure 1: Ground, First & Second Floor Structural Plan

4.2 Visual Inspection

One of the most critical steps in non-destructive testing is visual inspection. Cracks, pop-outs, colour change, spalling, voids, honeycombing, disintegration, surface defects, weathering, staining, and loss of consistency are all examples of visual inspection. Visual inspection allows an engineer to obtain information that is useful in determining the health of a structure and allowing the creation of a subsequent testing program. And also used magnifying glass, light tamping hammer, measuring steel tape, bar detector, level gauge, digital camera and recording sheet.

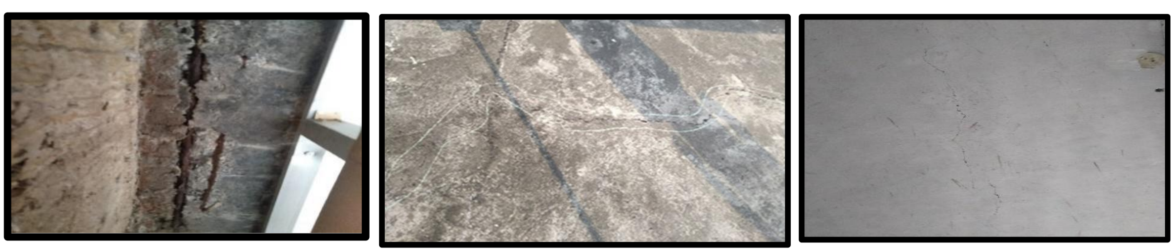


Figure 2: Crack Observed

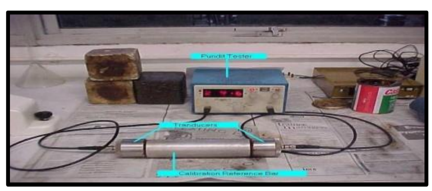
Figure 3: Crack and seepage observed.

Figure 4: Reinforcement Exposed and Concrete Damage

4.3 Non-Destructive Testing

A. Ultrasonic-Pulse Velocity Test

The ultrasonic pulse rate test consists of measuring the travel time of 50-55 Hz ultrasonic pulses generated by an acoustic transducer, which is kept in contact with the surface of the concrete element and received by another transducer is in contact with the surface of the concrete element on the other side.

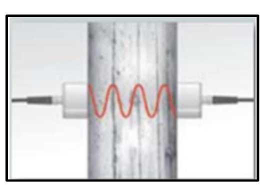


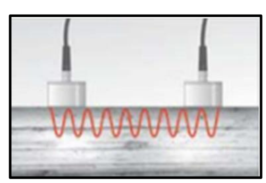
The methods of measurements of ultrasonic pulse velocity through concrete are

1. Direct Transmission (Cross Probing).
2. Semi-Direct Transmission
3. Indirect Transmission (Surface Probing)

Pulse velocity calculated by,

Pulse velocity = (Path length / Travel time)





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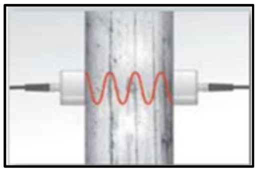
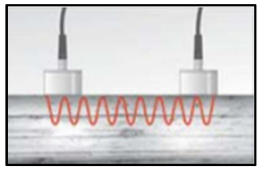
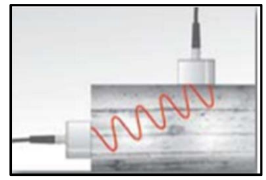


Directtransmission



Indirecttransmission

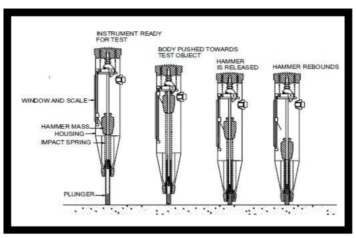


Semi-directtransmission

Sr. No.	Pulse Velocity by Cross Probing (Km/sec)	Concrete Quality Grading
1	Above4.5	Excellent
2	3.5 to 4.5	Good
3	3 to 3.5	Medium
4	Below3	Doubtful

B. Rebound Hammer Test

The rebound hammer test method is based on the idea that the elastic mass's rebound is determined by the hardness of the concrete surface it strikes. The spring-controlled mass in the rebound hammer rebounds when the plunger is pressed against the concrete surface. The quantity of mass rebound is determined by the hardness of the concrete surface. As a result, concrete hardness and rebound hammer readings can be linked to concrete compressive strength. On a graded scale, the rebound value is calculated. The compressive strength is determined using the graph that comes with the Rebound hammer. The rebound hammer test is carried out in accordance with IS 13311. (Part-2). It is used to determine the concrete's strength qualities.



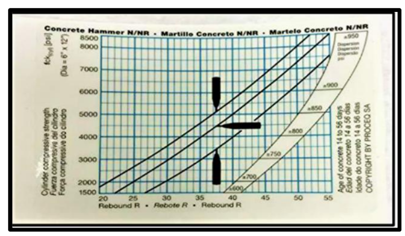


Figure 5: Rebound Hammer Testing

C. Half Cell Potential Meter Test

Half-cell potential measurements are typically performed by comparing the potential of an embedded reinforcing bar to a reference half-cell put on the concrete surface. A copper/copper sulphate or silver/silver chloride half-cell is commonly utilized, but other combinations are sometimes used. Concrete acts as an electrolyte, and the risk of reinforcement corrosion in the immediate vicinity of the test location can be empirically linked to the detected potential difference. Between two half-cells on the concrete surface, relevant measurements can be acquired in some conditions. A Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete is defined by ASTM C876 - 91.

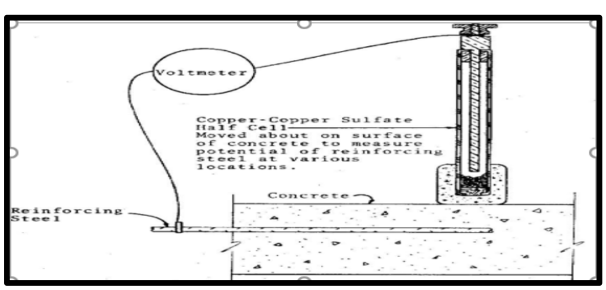


Figure 6: Half Cell Potential Meter Test

Probability of corrosion being Active	Half Cell Potentiometer	
Greater than 95	Cu-CuSO4Electrode Morenegativethan-350mV	Silver-Silverchloride Electrode Morenegativetha-700mV
50Percent	-200to -350mV	-500to-700mV
Less than 5 percent	More positive than -200mV	More positive than -500mV

D. pH Test

When the carbon dioxide in atmosphere in the presence of moisture reacts with hydrated cement, carbonation of concrete occurs. Carbonation process is also called as depassivation. Carbonation of concrete is associated with the corrosion of steel reinforcement and with shrinkage. The method to establish the extent of carbonation in concrete by applying a solution of 15mg Phenolphthalein & 10ml Ethanol diluted in 50ml of distilled water to a fresh fracture surface of concrete. The change of pink color of concrete indicates carbonation free concrete while the uncolored indicated carbonation. The pH of concrete lowers when the carbon dioxide in the air comes in contact with concrete, the process is called carbonation. A standard pH meter is used to measure the pH of concrete.

Indication	PH	Remark
Pink	Greater Than 9	Non-Carbonated Concrete
Colourless	Less Than 9	Carbonated Concrete

Table 3.5: Interpretation of pH Test Result

Figure 7: pH and Carbonation Test.

E. Cover Meter

To prevent corrosion, a sufficient cover thickness is required. A cover thickness survey is helpful in determining current cover thickness in a specific region where damage has been found, as well as elsewhere on the same structure, for comparison. The cover meter is a type of non-destructive test that's also commonly referred to as Cover Meters. The cover Meter is used to locate and measure bar diameters.

Sr. No.	**Test result**	**Interpretations**
1.	Required Cover Thickness and Good Quality Concrete.	Relatively low corrosion prone
2.	Required Cover Thickness and Bad Quality of Concrete Cover.	corrosion prone
3.	Less cover thickness and bad quality of concrete cover.	corrosion prone

Table 3.3: Interpreting Cover thickness result

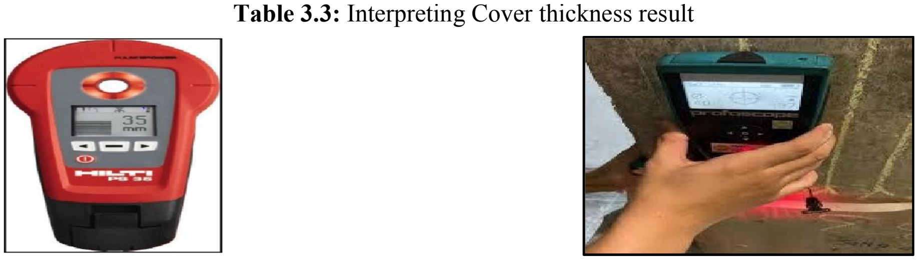
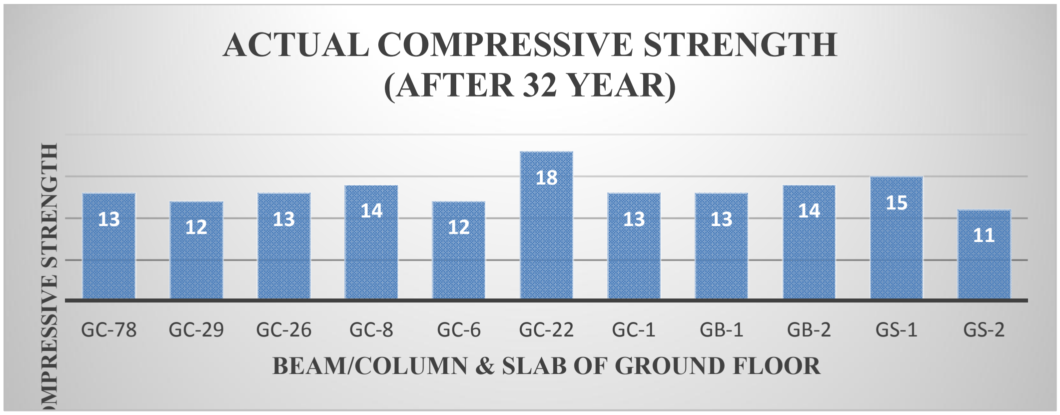


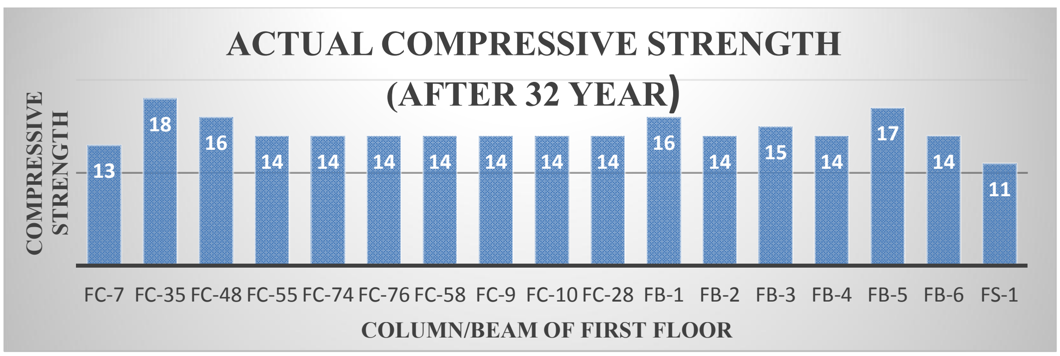
Figure 8: Cover Meter Equipment

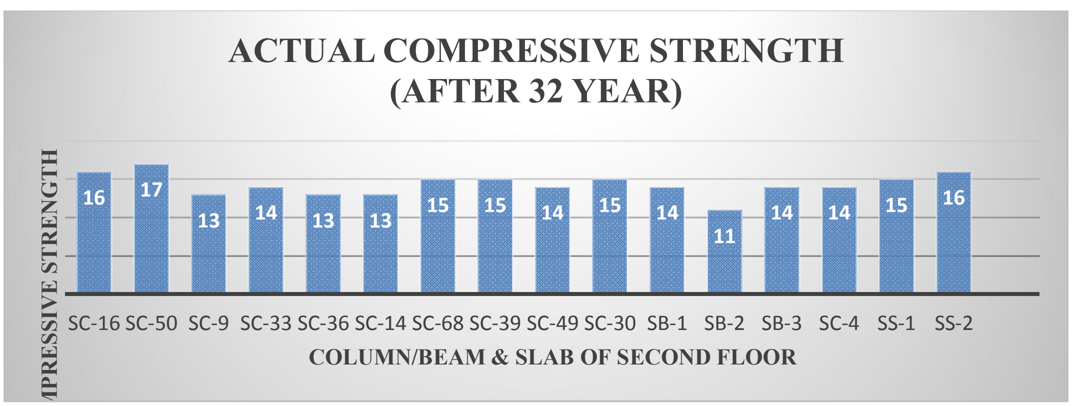
V. Results of Tests and Calculations

5.1 Rebound Hammer Test Results

Rebound hammer test indicate that the compressive strength at maximum location ranges from 11 to 18 N/mm2 (Refer to IS 13311(Part II):1992). The average compressive strength is 15 N/ mm^2. Table 5.4. gives the results interpreted after carrying out rebound hammer test. After 30 years reduce 50 % reading as per IS 13311(Part II):1992.







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Sr. No	Description	Rebound Number						Average	Compressive Strength
GROUND FLOOR									
1.	Column GC-78	28	32	32	34	28	36	32.29	13
2.	Column GC-29	38	28	32	30	30	34	32	12
3.	Column GC-26	36	36	32	28	36	32	33.33	13
4.	Column GC-8	38	30	38	36	36	30	34.66	14
5	Column GC-6	28	30	32	28	34	30	30.33	12
6	Column GC-22	38	42	40	36	38	42	39.33	18
7	Column GC-1	38	42	40	38	38	40	33	13
8	Beam GB-1	38	30	32	32	36	30	33	13
9	Beam GB-2	32	40	36	36	30	30	35	14
10	Slab GS-1	38	42	40	42	40	38	40	15
11	Slab GS-2	32	38	38	32	30	36	34.33	11
FIRST FLOOR									
1	Column FC-7	40	36	38	44	38	40	32	13
2	Column FC-35	40	36	38	36	44	38	38.66	18
3.	Column FC-48	38	36	38	36	38	32	36.33	16
4	Column FC-55	30	36	32	38	32	34	33.33	14
5	Column FC-74	30	32	32	38	30	34	33.66	14
6	Column FC-76	30	32	32	38	34	36	33.66	14
7	Column FC-58	32	36	40	36	30	30	34	14
8	Column FC-9	32	36	30	36	34	32	33.33	14
9	Column FC-10	34	36	30	34	32	28	32.33	14
10	Column FC-28	34	32	30	34	32	36	33	14
11	Beam FB-1	40	36	38	38	40	38	38.33	16
12	Beam FB-2	36	32	30	30	32	38	33	14

13	Beam FB-3	32	34	36	36	38	34	35	15
14	Beam FB-4	32	36	36	32	30	36	33.66	14
15	Beam FB-5	32	36	42	40	38	32	38.33	17
16	Beam FB-6	30	34	36	32	34	36	33.66	14
17	Slab FS-1	34	36	32	34	36	38	35	11
SECOND FLOOR									
1	Column SC-16	38	40	36	34	38	36	37	16
2	Column SC-50	36	38	40	36	40	36	37.66	17
3	Column SC-13	32	36	34	36	38	34	35	15
4	Column SC-9	30	32	34	32	30	34	32	13
5	Column SC-33	30	34	36	32	38	32	33.66	14
6	Column SC-36	32	30	28	36	32	30	31.33	13
7	Column SC-14	34	30	30	36	28	30	31.33	13
8	Column SC-68	38	34	36	34	36	38	36	15
9	Column SC-39	34	38	34	36	38	32	35.33	15
10	Column SC-49	34	34	38	32	30	32	33.33	14
11	Column SC-30	32	36	34	38	38	36	35.66	15
12	Beam SB-1	36	32	30	32	34	32	32.66	14
13	Beam SB-2	30	28	30	32	30	30	30	11
14	Beam SB-3	32	34	36	34	32	30	33	14
15	Beam SB-4	32	36	32	38	30	34	34.33	14
16	Slab SS-1	40	42	30	32	34	38	36	15
AVERAGE COMPRESSIVE STRENGTH									**15 N/mm^2**
MINIMUM COMPRESSIVE STRENGTH									**11 N/mm^2**

5.2 Ultrasonic Plus Velocity Test Result-

It was observed that the Ultrasonic Pulse velocity results with direct and indirect method indicate the maximum readings between 2.80 Km/Sec to 4.35 Km/Sec (IS 13311 Part I-1992) 2018 Hardened concrete - methods of test Part 5 Non - destructive testing of concrete section 1 Ultrasonic Pulse velocity testing (First Revision).

Sr. No.	Description	Type of method	No. of point	Ultrasonic pulse velocity test (km/sec)		
				Min.	Max.	Average
			GROUND FLOOR			
1	Column GC-78	Indirect	12	2.59	3.56	3.07
2	Column GC 29	Indirect	6	2.36	3.23	2.80
3	Column GC-26	Direct	6	2.05	3.58	2.80
4	Column GC-8	Indirect	6	2.98	3.41	3.19
5	Column GC-6	Indirect	6	2.85	3.04	3.00
6	Column GC-22	Indirect	6	2.91	5.26	4.09
7	Column GC-1	Indirect	6	2.70	3.78	3.24
8	Beam GB-1	Indirect	6	2.54	3.63	3.09
9	Beam GB-2	Indirect	12	2.74	4.08	3.41
10	Slab GS-1	Indirect	6	2.96	4.13	3.55
			FIRST FLOOR			
1	Column FC-7	Indirect	6	2.48	3.11	2.80
2	Column FC-7	Direct	6	2.71	3.01	2.86
3	Column FC-35	Indirect	6	2.71	3.74	3.23
4	Column FC-48	Semi-direct	6	2.86	5.65	4.25
5	Column FC-48	Direct	6	2.79	3.78	3.35
6	Column FC-55	Indirect	6	2.84	3.90	3.37
7	Column FC-74	Indirect	6	2.73	3.90	3.32
8	Column FC-76	Semi-direct	6	2.54	3.68	3.11
9	Column FC-76	Indirect	6	2.19	3.63	2.91
10	Column FC-58	Indirect	6	3.20	4.45	3.83

11	Column FC-9	Indirect	6	2.15	4.08	3.12
13	Column FC-10	Indirect	6	2.14	4.28	3.21
14	Column FC-28	Indirect	6	3.33	4.45	3.89
15	Beam FB-1	Indirect	6	3.63	4.92	4.28
16	Beam FB-2	Indirect	6	2.67	4.23	3.45
17	Beam FB-3	Indirect	6	3.27	4.23	3.75
18	Beam FB-4	Indirect	6	2.67	3.53	3.10
19	Beam FB-5	Indirect	6	2.23	4.08	3.16
SECOND FLOOR						
1	Column SC-16	Indirect	6	2.71	5.17	3.94
2	Column SC-50	Direct	6	2.55	3.73	3.14
3	Column SC-13	Indirect	6	2.17	3.50	2.83
4	Column SC-9	Indirect	6	2.87	3.63	3.25
5	Column SC-33	Indirect	6	2.72	4.51	3.62
6	Column SC-36	Indirect	6	2.83	4.13	3.48
7	Column SC-14	Indirect	6	3.17	4.29	3.73
8	Column SC-68	Indirect	6	3.13	3.67	3.40
9	Column SC-39	Indirect	6	3.04	3.94	3.49
10	Column SC-49	Indirect	6	2.96	3.99	3.48
11	Column SC-30	Indirect	6	2.72	3.17	3.00
12	Beam SB-1	Indirect	6	2.83	3.78	3.31
13	Beam SB-2	Indirect	6	2.37	3.38	3.00
14	Beam SB-3	Indirect	6	2.84	5.86	4.35
15	Slab SS-1	Indirect	6	2.96	3.30	3.13

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5.3 Cover Meter Test

SR. NO	DESCRIPTION	COVER TO THE REINFORCEMENT IN (MM)
GROUND FLOOR		
1.	Column GC-78	54
2.	Column GC-29	52
3.	Column GC-26	44
4.	Column GC-8	50
5.	Column GC-6	57
6.	Column GC-22	50
7.	Column GC-1	62
8.	Beam GB-1	64
9.	Beam GB-2	59
10.	Slab GS-1	55
11.	Slab GS-2	56
FIRST FLOOR		
1	Column FC-7	50
2	Column FC-35	48
3	Column FC-48	78
4	Column FC-55	53
5	Column FC-74	62
6	Column FC-76	45
7	Column FC-58	56
8	Column FC-9	40
9	Column FC-10	44
10	Column FC-28	61
11	Beam FB1	58
12	Beam FB-2	50
13	Beam FB-3	62
14	Beam FB-4	48
15	Beam FB-5	58
16	Beam FB-6	60
17	Slab FS-1	54
SECOND FLOOR		
1	Column SC-16	59
2	Column SC-50	56
3	Column SC-13	64
4	Column SC-9	60
5	Column SC-33	60
6	Column SC-36	65
7	Column SC-14	58
8	Column SC-68	62
9	Column SC-39	64
10	Column SC-49	54
11	Column SC-30	72
12	Beam SB-1	70
13	Beam SB-2	55
14	Beam SB-3	63

15	Beam SB-4	58
16	Beam SB-5	64
17	Slab SS-1	55
MINIMUM COVER TO REINFORCEMENT		**44 mm**
AVERAGE COVER TO REINFORCEMENT		**78 mm**

5.4 Half Cell Potential Test

Sr No.	Description	Half Cell Potential
1	Beam No. GB-1	-409
2	Column No. GC-1	-377
3	Column No. GC-22	-417
4	Column No. FC-7	-370
5	Column No. FC-35	-366
6	Column No. FC-48	-375
7	Beam No. FB-1	-408
8	Beam No. FB-2	-423
9	Column No. SC-33	-382
10	Column No. SC-68	-321
11	Column No. SC-30	-297
12	Beam No. SB-1	-401
MINIMUM		**-297**
MAXIMUM		**-423**
AVERAGE		**-378**

5.5 PH and Carbonation Test Result

SR. NO.	PARTICULARS	pH	Depth of Carbonation (mm)
1	Column GC-3	8.26 to 9.62	Less than 15
2	Column GC-8	8.58 to 9.55	Less than 20
3	Column GC-6	8.20 to 9.19	Less than 25
4	Column GC-14	8.18 to 9.72	Less than 24
5	Column GC-10	8.41 to 9.89	Less than 22
6	Column GC-29	8.42 to 9.62	Less than 16
7	Column GC-22	8.53 to 9.62	Less than 18
8	Column GC-1	8.29 to 9.16	Less than 15
9	Beam GB-1	8.29 to 9.58	Less than 20
FIRST FLOOR			
1.	Column FC-48	8.50 to 9.30	Less than 25
2.	Column FC-8	8.28 to 9.55	Less than 24
3.	Column FC-58	8.27 to 9.19	Less than 20
4.	Column FC-7	8.13 to 9.53	Less than 15
5.	Beam FB-1	8.22 to 9.23	Less than 18
6.	Beam FB-2	8.24 to 9.48	Less than 15
SECOUND FLOOR			

1.	Column SC-33	8.62 to 9.50	Less than 25
2.	Column SC-16	8.28 to 9.78	Less than 20
3.	Column SC-36	8.51 to 9.45	Less than 15
4.	Column SC-13	8.28 to 9.28	Less than 20
5.	Column SC-39	8.11 to 9.21	Less than 15
6.	Beam SB-1	8.26 to 9.87	Less than 14
7.	Beam SB-2	8.62 to 9.82	Less than 18

5.6 Strengthening Scheme

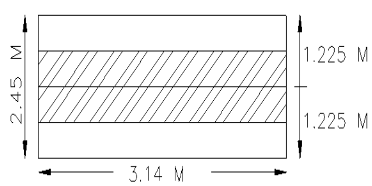
A. Steel Beam Strengthening

Beam can be strengthened by providing additional fixing steel beam girders at slab level. With the help of insert plat and anchor bolt is attached to column.

B. Procedure

1. As Per The Visual Inspection On Beam That Indicate Is Required To Strengthen The Beam
2. Remove Loose Cover From Column Surface
3. Clean The Surface With Wire Brush And Force Air.
4. Design Steel Beam And Anchor Bolt For The Maximum Loading
5. Drill The Holes For Fixing Shear Connector With HILTI HY200 Or HILTI Re500V3 Or Equivalent Chemical.
6. After Fixing Shear Connectors With The Help Of New Concrete (M25) (Micro Concrete + Aggregate).
7. New Concretes Must Be Cured For Minimum 10 Days.
8. Clean The Column Surface With Force Air. Place The Steel Beam As Per Drawing.

5.7 Design Steel Beam, Insert Plate and Anchor Bolt



considered one way slab for purpose of maximum loading.

Live load - 2 KN/M^2
Floor Finish – 1 KN/M^2
Self-Weight of Slab (0.120 X 25) – 3 KN/M^2

TOTAL =. 6 KN/M^2

Figure 9: Loading Area

SLAB LOAD = 3.140 X1.225 X 6 = 23.079 KN
WALL LOAD = 0.115 X3 X 3.14 X 20 = 21.66 KN
ASSUME SELF WEIGHT OF SECTION = 0.46 KN

TOTAL = 45.199

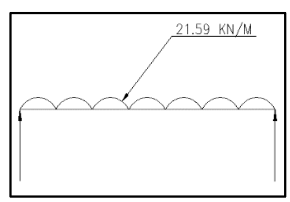


Figure10: Loading on beam

FACTORED LOAD = 1.5 X 45.199 = 67.798 KN

FACTORED LOAD / LENGTH 67.798 / 3.140
= 21.59 KN/M

1. **Calculate Bending Moment (Mu)**

$$Mu = \frac{W \times L^2}{8}$$

$$\frac{21.59 \times 3.14^2}{8}$$

Mu = 26.60 KN.M

2. **Calculate Share Force (Vu): -**

$$Vu = \frac{W \times L}{2}$$

$$\frac{21.59 \times 3.14}{2}$$

Vu = 33.89 KN

3. **Calculate Section Modulus:**

$$Zp = \frac{MU \times Y_{M0}}{FY}$$

$$Zp = \frac{26.60 \times 10^6 \times 1.1}{250}$$

$Zp = 117.04 \times 10^3\ MM^3$

$$Zp_{required} = \frac{ZP}{1.14}$$

$$\frac{117.04 \times 10^3}{1.14}$$

$= 102.66 \times 10^3\ MM^3$

PROVIDE ISMB -150 @ $ZP_Z = 110.48 \times 10^3\ MM^3$

ISMB -150 (AS PER USING IS 800:2007 CODE PAGE NO. 140)

h = 150 mm, Bf = 80 mm, Tf = 7.6 mm, tw = 4.8 mm, ry = 16.6 mm,
$Zez = 96.9 \times 10^3\ mm^3 Zpz = 110.45 \times 10^3\ mm^3$

BY USING STEEL TABLE

$R_1 = 9$ mm, $I_{XX} = 726.4 \times 10^6\ MM^4$
$I_Y = 52.6 \times 10^4\ MM^4$

5.8 Section Classification (page no 18 IS 800: 2007)

$$b = \frac{bf}{2} = \frac{80}{2} = 40 \text{ mm}$$

2 $d = h - 2(Tf + r_1) = 150 - 2(7.6+9) = 116.8$ mm

3. $$\frac{b}{tf} = \frac{40 \text{ mm}}{7.6 \text{ mm}} = 5.26 < 9.4\ \mathcal{E}$$

4. $$\frac{d}{tw} = \frac{116.8\text{mm}}{4.8 \text{ mm}} = 24.33 < 84\ \mathcal{E}$$

-Hence Is Satisfies the Condition of Plastic Section Bb=1

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Since

$\frac{d}{tw} = \frac{116.8 \text{ mm}}{4.8 \text{ mm}} = 24.33 < 84\,\varepsilon$

-Shear Buckling Check of Web Is Not Required

5.9 Checks for Design Shear (Vd)-

$Vd = \frac{AV \times FY}{\sqrt{3} \times Y_{m0}}$ $\quad Vd = \frac{(h \times tw) \times FY}{\sqrt{3} \times Y_{m0}}$

$\frac{(150 \times 4.8) \times 250}{\sqrt{3} \times 1.1}$ $\quad Vd = 94.47$ KN

Check For Shear

0.6 X Vd = 0.6 x 94.47 = 56.68

Vd> Vu 56.68 > 33.89

(Low shear)

5.10. Permissible Deflection (ẟ)

$\delta_{permissible}$= Le / 300 Le – effective length

3.140 300 = 10.46 mm

5.11 Check for Maximum Deflection ($\delta_{maximum}$)

$\delta_{maximum} = 5/384 \times w \times l^4 / EI$

$= 5/384 \times \frac{14.39 \times 2910^4}{(2 \times 10^5) \times (726.4 \times 10^4)}$

$\delta_{maximum}$= 9.24 mm

Hence Deflection Is Within Is Within Permissible Limit.

Hence safe ….

INSERT PLATE

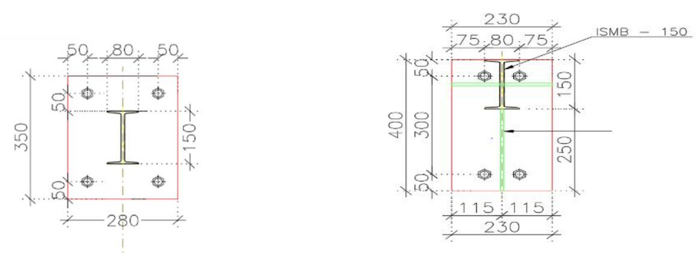

Figure 11: Insert Plate

Stress In Compression = $\frac{\text{Shear force}}{\text{Area of plate}} = \frac{33890}{92000}$ = 0.36 N/mm² > 4 N/mm²

M-15 grade of concrete Table no 25 As per IS456:2000

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ANCHOR BOLTS By Using Hilti Software. As per EN 1992-4 shown in fig.

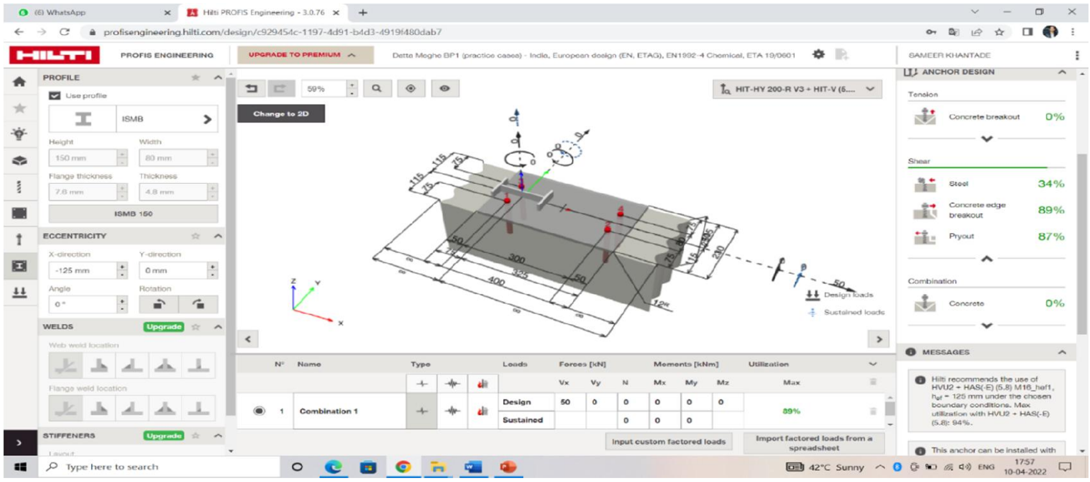

Figure 12: Anchor Bolts Report

Epoxy Grouting for Beam and Slab

This is the easiest and most common method of repairing a crack. It can be performed by relatively unskilled personnel and can be used to seal both fine pattern cracks and larger isolated cracks. Used to seal cracks against the ingress of moisture, chemicals and carbon dioxide. Two-component low-viscosity epoxy is a very low-viscosity epoxy grout material. Adhesive strength is high, tensile strength is high, viscosity is low, and curing is fast.

Water Proofing

This is the most effective and proven polymer impregnation solution. It is an alkaline material and goes well with concrete. In addition, the high bending strength and the excellent adhesiveness of the polymer enhance the high compressive strength of the cement matrix. During preparation, use crack filler to repair cracks and honeycomb surfaces. Cure according to standard, then remove all hardeners and sealers. Clean the surface and spray water for 24 hours to wet the surface. Before applying the polymer waterproof coating.

AFTER STRENGTHENING PLAN

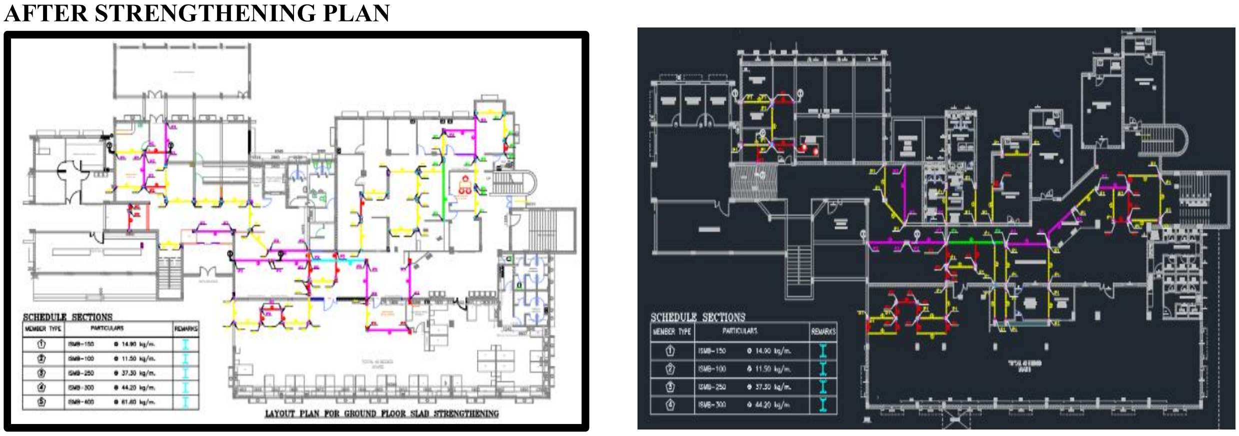

Figure 13: After Strengthening Ground &First Plan

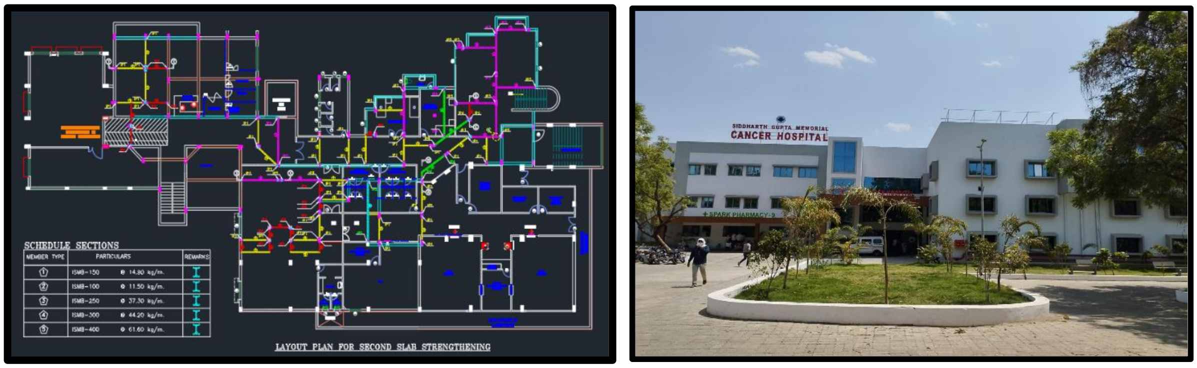

Figure 14: After Strengthening second & Elevation Plan

STAAD-PRO MODEL

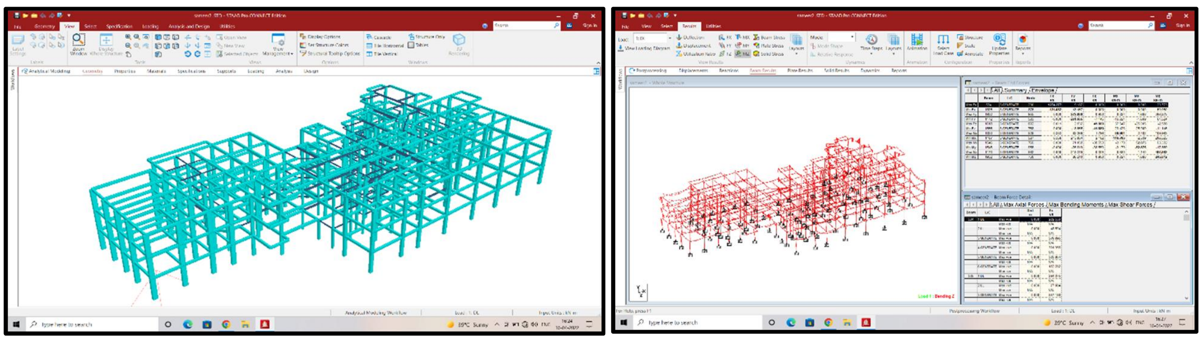

Figure 15: Staad-Pro Beam Results

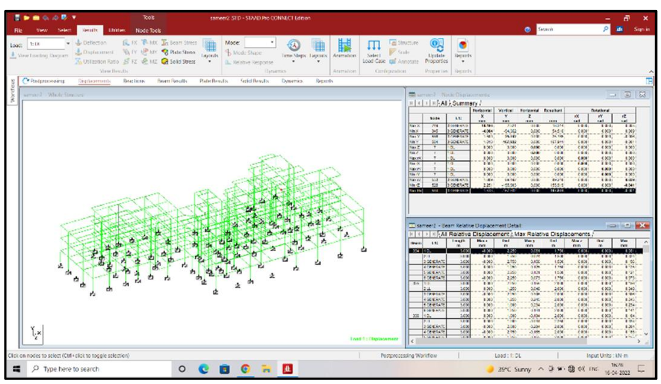

Figure 16: Staad-Pro Displacement Results

VI. Conclusion

Based on NDT results, Analysis and Design following conclusions are made:

The original grade of concrete was 15 N/mm^2. Due to carbonation effect and age of concrete strength is reduced. While conducting visual inspection on existing structure we found major cracks in columns, reinforcement exposed on various locations of columns, honeycombing and seepage, deterioration of concrete observed on maximum locations. They are repaired by using epoxy grouting and micro fine cement grouting with epoxy bonding agent, polymer repair and micro concrete.

As per Ultrasonic pulse velocity test result with direct, indirect and semi direct method indicates that maximum readings are between 2.80 to 4.09 km/sec (ref. to is 13311(part 1)1992) "non-destructive testing" of concrete method of testing, "ultrasonic pulse velocity" the quality of concrete is medium at maximum locations.

The original grade of concrete was 15 N/mm^2. As per the Rebound hammer test (refer IS 13311-part II 1992) Non-destructive testing of concrete method of test, the reading is confirming M11 to M18 grade of concrete.

Half-cell potentiometer test carried out to check the probable corrosion in reinforcement and sever corrosion observed at most of the locations of columns.

As per pH and carbonation test on concrete, it is observed that the pH of cover concrete is reduced and the passive layer over the reinforcement is intact and the carbonation depth has not crossed the reinforcement level at few locations.

Based on above all Non-Destructive test results it is observed that few locations linter beam at all floor are damaged and load carrying capacity is reduced. Hence, we had strengthened corresponding weak and damaged beam with Steel beam providing as per methodology and specifications given.

After repair and retrofitting of the structure such as all Non-Destructive test results and staad-pro analysis have been performed to check the results of the existing structure is safe for all loadings

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