04/06/2025

STRUCTURAL INTEGRITY & ASSESSMENT AUDIT REPORT

KUNJ VIHAR CGHS LTD.

PLOT NO 19, SECTOR 12, DWARKA, NEW DELHI - 110078.

REPORT SUBMITTED BY-

UNIQUE DESIGNERS & ENGINEERS PVT. LTD.

Satya the Hive, 6th Floor, Unit No-637, 638, 639 Sec-102, Near Shyam baba Chowk, Vill :- Dhankot Gurgaon-123505 Haryana

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1.Introduction

1.1 Background

This structural audit report covers the assessment of **Kunj Vihar CGHS Ltd**., located at **Plot No. 19, Sector 12, Dwarka, New Delhi-110078**, conducted by **Unique Designers & Engineers Pvt. Ltd**. on **04/06/2025.** The residential complex, comprising three **G+10 RCC blocks (A, B, and C)** and around **20 years old**, shows signs of deterioration such as cracks in columns, beams, staircases, exposed and corroded rebars, and plaster cracking. Reveals concrete spalling and reinforcement corrosion. This audit aims to evaluate the structural condition, identify causes of distress, and recommend effective repair and protection measures to ensure the buildings' long-term safety and durability

1.2 Scope of Work

- ***Visual Inspection***

 – Identification of cracks, corrosion, spalling, seepage, and visible structural deficiencies.

- ***Non-Destructive Testing (NDT)***

 – Rebound Hammer and UPV tests to assess concrete strength and internal integrity.

- ***Structural Deficiencies Assessment***

 – Evaluation of member performance, construction defects, and deterioration due to age or environment.

- ***Documentation***

 – Photo evidence and zone-wise mapping of observed defects.

- ***Analysis & Reporting***

 – Interpretation of findings with recommendations for repair, strengthening, and preventive measures

1.3 Methodology

1. *Visual Inspection:* Documented cracks in structural elements, reinforcement corrosion, water seepage, minor concrete spalling, plaster cracks and plumbing defects.
2. *NDT Tests:*
   - Rebound Hammer (IS 13311 Part 2): Surface hardness and estimated compressive strength.
   - Ultrasonic Pulse Velocity (IS 13311 Part 1): Homogeneity, voids, and internal cracks.

N D T

BUILDING DETAILS

- **Structure Type:** RCC Framed Structure
- **Building Usage**: Residential
- **Number of Floors**: Ground + 10 Upper Floor (G+10)
- **Approximate Age of Building:** 20 years
- **Structure Type:** RCC-framed residential complex

TESTS CONDUCTED

Rebound Hammer Test (RHT)

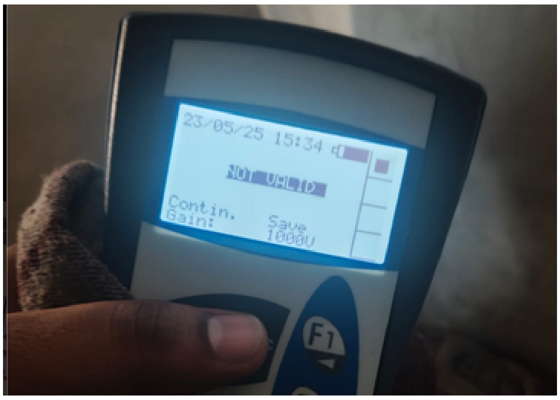
Objective: To evaluate the surface hardness and indirectly assess the compressive strength of concrete.
Method: IS 13311 (Part 2) guidelines were followed.
Interpretation: The RH values were found to be within acceptable limits, suggesting that the surface hardness and compressive strength of concrete are generally adequate across tested areas.

Ultrasonic Pulse Velocity Test (UPVT)

Objective: To determine the quality and uniformity of concrete.

Method: IS 13311 (Part 1) was used for reference.

Interpretation: UPVT results indicated doubtful quality in some upper slab,and beam locations, pointing to non-uniformity in concrete—likely due to aging effects or inconsistencies in original workmanship.



NDT Procedure for Quality Analysis of Concrete

1. Ultrasonic Pulse Velocity

Purpose

Although there is no fundamental relationship between pulse velocity and strength, an estimation of strength can be obtained by correlation. The method has perhaps a greater potential for comparing known sound concrete with affected concrete.

Ultrasonic pulse velocity is a means of assessing variations in the apparent strength of concrete.

The quality gradation of concrete can be appraised at best qualitatively as 'excellent', 'good', 'medium' or 'doubtful'. The meanings of the term 'excellent', 'good', 'medium' and 'doubtful' are based on ultra sonic pulse velocity measured at site and are as per the nomenclature of IS 516(Part5):2018. To strike balance between the reliability, speed and damage to structure, core tests have to be used to establish a correlation between rebound number index and the estimated in-situ strength with the USPV test results in the investigation.

Objective of testing:-

Ultrasonic pulse velocity test is used to establish the following:

- Homogeneity of concrete
- Presence of cracks voids, honeycombing and other imperfections
- Changes in the structure of concrete which may occur with time.
  Quality of one element of concrete in relation to another i.e. comparative quality analysis and gradation of concrete.
- The values of dynamic elastic modulus of the concrete.

References:-

- BS 6089:1981 and BS 1881:Part203
- IS 516(Part5):2018
- ASTM: C597-83.

Influencing factors:-

The velocity of a pulse of ultrasonic energy in concrete is influenced by the stiffness and mechanical strength of the concrete

- Moisture content: The moisture content of the concrete have a small effect in the velocity and can increase the pulse velocity by 2%.
- Surface condition: The testing surface should be smooth any roughness cannot provide reliable readings because of gap between transducers and testing surface.
- Temperature: Ideal Temperature is between 50C and 300C; Temperature between 300C to 600C can reduce the pulse velocity up to 5%; below freezing temperature results in an increase the pulse velocity up to 7.5%.
- Stress: When concrete is subjected to a stress which is abnormally high for a quality of concrete,the pulse velocity may be reduced due to development of micro-cracks.
- Reinforcing bars: The velocity measured in reinforced concrete in the vicinity of reinforcing bars is usually higher than in plain concrete because pulse velocity in steel is 1.2-1.9 times the velocity in plain concrete. Wherever possible, measurements should be made in such a way that steel does not lie in the path of the pulse.

Testing method:-

According to IS 516(Part5):2018 clause 5.2 transducers with a frequency of 50 to 60 kHz are useful for most all round applications, and as per IS 516(Part5):2018 clause 6.2 the path length should be long enough not to be significantly influenced by the heterogeneous nature of concrete. This test requires a flat surface generally only appropriate for unspalled surfaces.

In view of inherent variability in the test results, sufficient number of readings should be taken by dividing the entire structure in suitable grid of markings 30x30 cm or even smaller. Each junction point of the grid becomes a point of observation.

There are three possible methods of testing according to the type of surface:

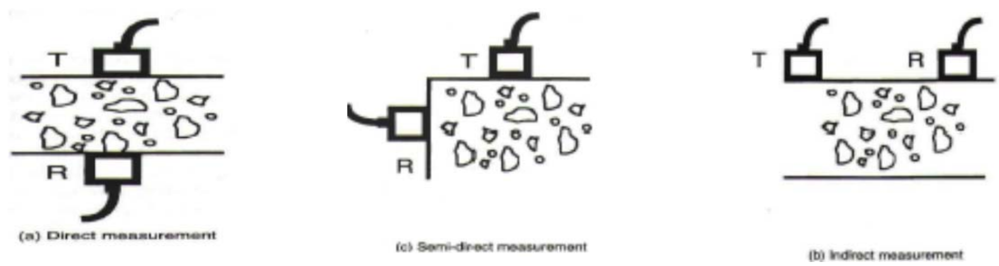


Table 1: Velocity Criterion for Concrete Quality Grading
[Ref: IS:516 PART 5 SEC1)]

Sr. No.	USPV by Cross Probing (km/sec)	Concrete Quality Grading.
1	ABOVE 4.4	EXCELLENT
2	3.75 - 4.4	GOOD
3	3.0 - 3.75	DOUBTFIL
4	BVELOW 3.0	POOR

2. Rebound Hammer Test:-

Purpose:-

This test gives a measure of the surface hardness of the concrete surface. Although there is no direct relationship between this measurement of surface hardness and strength, an

Rebound hammer is the best known methods of comparing the concrete in different parts of a structure and indirectly assessing concrete strength. The rebound hammer should be considered as a means of assessing variations of strength within a structure rather than an accurate means of assessing the strength.

Objective of testing:-

Rebound hammer test is performed to determine the following:

- Surface hardness
- Uniformity of concrete over the structure
- Grade of concrete
- Estimated strength which is derived from establishing a relationship between in-situ core strength and rebound number.

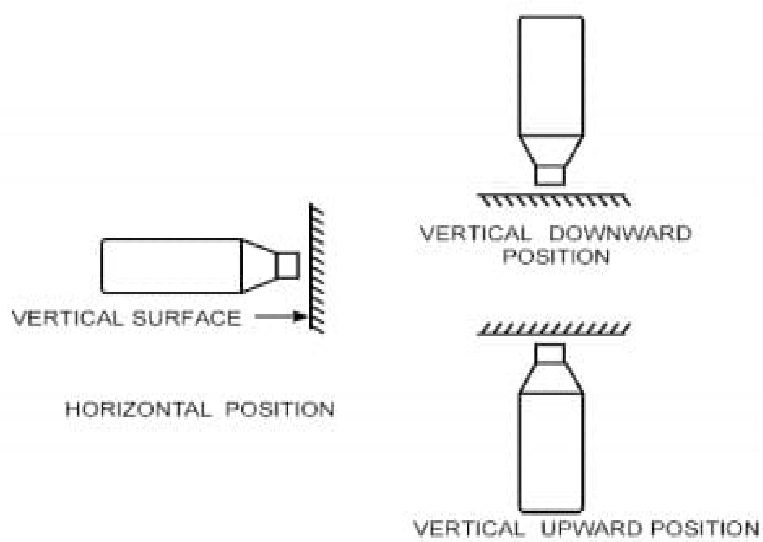
References:-

- BS 6089:1981 and BS 1881:Part 202,
- IS13311(Part2):1992
- ASTM C 805-02

Influencing factors:-

Rebound hammer test results are considerably influenced by these factors:

- Size, shape and rigidity of the specimen
- Age of test specimen
- Smoothness of surface and internal moisture condition of the concrete
- Carbonation of concrete surface



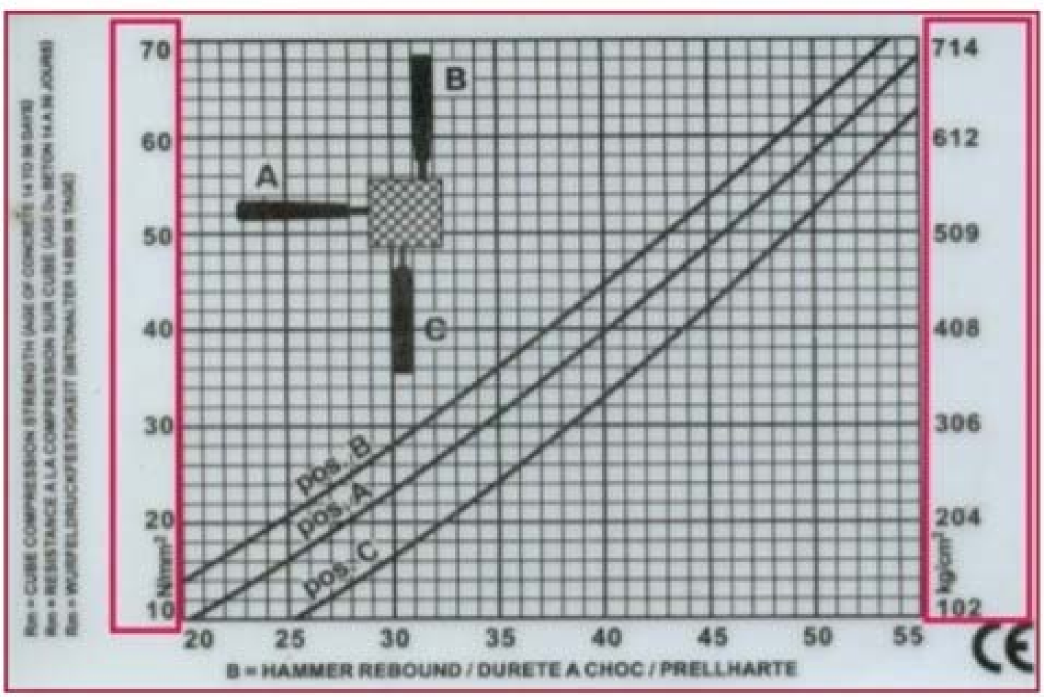
Testing Method:-

According to ASTM C 805-02 clause 7.1 the concrete members to be tested shall be at least 100mm thick and fixed within a structure. Towelled surfaces generally exhibit high rebound numbers than screed or formed finishes. Do not compare the test results if the form material against which the concrete is placed is not similar.

Heavily textured, soft or surfaces with loose mortar shall be ground flat with abrasive stone. Smooth formed or towelled surfaces do not have to be ground prior to testing.

Also this test is not conducted directly over the reinforcing bars having cover less than 20mm. The surface under test should be clean and smooth because rough surfaces cannot be tested as they do not give reliable results. Dirt or other loose material on the surface can be removed using a grinding stone prior to test.

Average Rebound Number	Quality of Concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
< 20	Poor concrete
0	Delaminated



Test Results & Analysis

Rebound Hammer Test For (Block A)

COLUMNS

	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
GROUND FLOOR	C1	HORIZONTAL	35	25	32	31	31	31	31	24.8
	C2	HORIZONTAL	34	31	34	26	34	28	31	24.8
	C3	HORIZONTAL	29	26	34	25	25	31	28	20.2
	C4	HORIZONTAL	25	30	34	27	26	34	29	21.6
	C5	HORIZONTAL	27	29	34	29	30	33	30	23.0
	C6	HORIZONTAL	30	27	28	32	34	30	30	23.0
	C7	HORIZONTAL	27	33	25	27	31	27	28	20.2
	C8	HORIZONTAL	25	31	30	30	31	34	30	23.0
	C9	HORIZONTAL	28	26	29	33	33	35	31	24.8
	C10	HORIZONTAL	29	27	32	33	28	27	29	21.6
	C11	HORIZONTAL	32	31	33	31	30	26	31	24.8
	C12	HORIZONTAL	35	29	26	33	32	35	32	26.6
	C13	HORIZONTAL	34	26	28	25	27	32	29	21.6
	C14	HORIZONTAL	33	29	33	31	34	32	32	26.6
	C15	HORIZONTAL	33	31	29	34	30	26	31	24.8
	C16	HORIZONTAL	26	32	33	27	30	25	29	21.6
	C17	HORIZONTAL	31	33	29	29	29	25	29	21.6
	C18	HORIZONTAL	29	30	26	33	28	34	30	23.0
	C19	HORIZONTAL	29	34	33	26	30	27	30	23.0
	C20	HORIZONTAL	28	35	31	32	27	30	31	24.8
	C21	HORIZONTAL	28	34	30	35	33	28	31	24.8
	C22	HORIZONTAL	26	35	34	33	32	31	32	26.6
	C23	HORIZONTAL	34	34	33	35	25	35	33	28.4
	C24	HORIZONTAL	25	26	28	32	25	32	28	20.2
	C25	HORIZONTAL	29	30	27	25	26	27	27	18.8
	C26	HORIZONTAL	31	25	25	33	25	26	28	20.2
	C27	HORIZONTAL	26	28	35	32	32	35	31	24.8
	C28	HORIZONTAL	34	31	26	34	34	26	31	24.8
	C29	HORIZONTAL	31	28	31	25	25	29	28	20.2
	C30	HORIZONTAL	33	28	34	33	28	28	31	24.8
	C31	HORIZONTAL	35	35	26	29	26	32	31	24.8
	C32	HORIZONTAL	34	32	28	35	30	33	32	26.6
	C33	HORIZONTAL	30	29	26	29	31	34	30	23.0
	C34	HORIZONTAL	25	34	27	29	25	32	29	21.6
	C35	HORIZONTAL	32	32	28	34	28	26	30	23.0
	C36	HORIZONTAL	33	34	35	27	29	33	32	26.6
	C37	HORIZONTAL	29	32	30	25	29	26	29	21.6
	C38	HORIZONTAL	28	29	25	27	30	30	28	20.2
	C39	HORIZONTAL	33	28	30	34	26	33	31	24.8
	C40	HORIZONTAL	33	27	26	33	30	25	29	21.6

COLUMNS										
FIFTH FLOOR	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
	C1	HORIZONTAL	26	33	27	32	29	34	30	23.0
	C2	HORIZONTAL	30	31	32	35	28	33	32	26.6
	C3	HORIZONTAL	32	34	30	30	29	29	31	24.8
	C4	HORIZONTAL	33	28	26	27	27	33	29	21.6
	C5	HORIZONTAL	28	31	30	32	34	33	31	24.8
	C6	HORIZONTAL	30	29	25	33	31	31	30	23.0
	C7	HORIZONTAL	35	35	26	31	35	26	31	24.8
	C8	HORIZONTAL	29	26	33	29	30	30	30	23.0
	C9	HORIZONTAL	32	29	30	32	33	31	31	24.8
	C10	HORIZONTAL	25	32	35	26	26	34	30	23.0
	C11	HORIZONTAL	35	31	34	28	29	27	31	24.8
	C12	HORIZONTAL	29	26	29	29	28	34	29	21.6
	C13	HORIZONTAL	34	28	27	35	27	34	31	24.8
	C14	HORIZONTAL	31	33	28	29	29	31	30	23.0
	C15	HORIZONTAL	31	33	26	27	35	32	31	24.8
	C16	HORIZONTAL	33	30	35	30	35	29	32	26.6
	C17	HORIZONTAL	34	33	35	29	25	25	30	23.0
	C18	HORIZONTAL	31	31	31	29	34	35	32	26.6
	C19	HORIZONTAL	26	28	33	32	27	35	30	23.0
	C20	HORIZONTAL	26	30	33	27	30	30	29	21.6
	C21	HORIZONTAL	32	31	29	32	26	32	30	23.0
	C22	HORIZONTAL	32	30	33	33	26	27	30	23.0
	C23	HORIZONTAL	29	31	27	27	31	35	30	23.0
	C24	HORIZONTAL	29	32	26	33	33	33	31	24.8
	C25	HORIZONTAL	26	32	27	31	28	28	29	21.6
	C26	HORIZONTAL	33	28	33	32	33	32	32	26.6
	C27	HORIZONTAL	25	30	31	32	31	33	30	23.0
	C28	HORIZONTAL	28	26	29	35	28	27	29	21.6
	C29	HORIZONTAL	35	35	27	28	25	33	31	24.8
	C30	HORIZONTAL	34	32	34	26	27	35	31	24.8
	C31	HORIZONTAL	31	25	28	34	27	28	29	21.6
	C32	HORIZONTAL	31	33	31	35	32	30	32	26.6
	C33	HORIZONTAL	35	35	31	29	32	27	32	26.6
	C34	HORIZONTAL	35	35	31	32	27	35	33	28.4
	C35	HORIZONTAL	29	27	32	35	32	32	31	24.8
	C36	HORIZONTAL	31	32	32	27	35	29	31	24.8
	C37	HORIZONTAL	34	30	32	25	32	32	31	24.8
	C38	HORIZONTAL	27	28	32	34	32	25	30	23.0
	C39	HORIZONTAL	32	34	27	35	34	25	31	24.8
	C40	HORIZONTAL	27	31	29	29	33	25	29	21.6

COLUMNS										
	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
SEVENTH FLOOR	C1	HORIZONTAL	28	35	29	29	31	31	31	24.8
	C2	HORIZONTAL	32	33	33	28	28	28	30	23.0
	C3	HORIZONTAL	28	29	26	31	30	25	28	20.2
	C4	HORIZONTAL	25	29	30	35	28	34	30	23.0
	C5	HORIZONTAL	25	33	26	27	25	35	29	21.6
	C6	HORIZONTAL	27	27	25	27	35	29	28	20.2
	C7	HORIZONTAL	32	33	34	27	26	30	30	23.0
	C8	HORIZONTAL	26	27	27	28	32	34	29	21.6
	C9	HORIZONTAL	26	28	29	29	34	35	30	23.0
	C10	HORIZONTAL	27	35	33	34	34	25	31	24.8
	C11	HORIZONTAL	35	33	25	32	34	35	32	26.6
	C12	HORIZONTAL	29	26	25	25	33	29	28	20.2
	C13	HORIZONTAL	30	35	25	30	32	27	30	23.0
	C14	HORIZONTAL	30	34	30	34	34	33	33	28.4
	C15	HORIZONTAL	29	31	26	26	31	32	29	21.6
	C16	HORIZONTAL	28	26	26	31	26	25	27	18.8
	C17	HORIZONTAL	28	31	25	35	30	25	29	21.6
	C18	HORIZONTAL	35	26	27	30	32	32	30	23.0
	C19	HORIZONTAL	35	30	34	28	27	35	32	26.6
	C20	HORIZONTAL	34	27	33	33	33	32	32	26.6
	C21	HORIZONTAL	32	28	35	31	30	34	32	26.6
	C22	HORIZONTAL	30	35	27	32	29	30	31	24.8
	C23	HORIZONTAL	31	30	35	31	33	26	31	24.8
	C24	HORIZONTAL	27	33	34	33	34	31	32	26.6
	C25	HORIZONTAL	25	31	31	30	35	29	30	23.0
	C26	HORIZONTAL	27	35	27	33	33	26	30	23.0
	C27	HORIZONTAL	29	26	35	30	35	28	31	24.8
	C28	HORIZONTAL	30	26	27	25	31	35	29	21.6
	C29	HORIZONTAL	29	30	30	29	25	26	28	20.2
	C30	HORIZONTAL	25	33	29	30	35	25	30	23.0
	C31	HORIZONTAL	29	32	26	34	32	26	30	23.0
	C32	HORIZONTAL	27	25	28	29	27	34	28	20.2
	C33	HORIZONTAL	30	28	27	31	28	32	29	21.6
	C34	HORIZONTAL	26	28	34	34	32	32	31	24.8
	C35	HORIZONTAL	25	35	30	34	32	33	32	26.6
	C36	HORIZONTAL	29	29	26	25	27	29	28	20.2
	C37	HORIZONTAL	34	32	25	30	34	31	31	24.8
	C38	HORIZONTAL	26	28	27	27	28	35	29	21.6
	C39	HORIZONTAL	25	33	26	27	33	29	29	21.6
	C40	HORIZONTAL	33	31	25	35	27	26	30	23.0

AVERAGE STRENGTH OF COLUMNS				
COLUMN NO.	GROUND FLOOR	FIFTH FLOOR	SEVENTH FLOOR	AVERAGE STRENGTH (MPA)
C1	25	23	25	24
C2	25	27	23	25
C3	20	25	20	22
C4	22	22	23	22
C5	23	25	22	23
C6	23	23	20	22
C7	20	25	23	23
C8	23	23	22	23
C9	25	25	23	24
C10	22	23	25	23
C11	25	25	27	25
C12	27	22	20	23
C13	22	25	23	23
C14	27	23	28	26
C15	25	25	22	24
C16	22	27	19	22
C17	22	23	22	22
C18	23	27	23	24
C19	23	23	27	24
C20	25	22	27	24
C21	25	23	27	25
C22	27	23	25	25
C23	28	23	25	25
C24	20	25	27	24
C25	19	22	23	21
C26	20	27	23	23
C27	25	23	25	24
C28	25	22	22	23
C29	20	25	20	22
C30	25	25	23	24
C31	25	22	23	23
C32	27	27	20	24
C33	23	27	22	24
C34	22	28	25	25
C35	23	25	27	25
C36	27	25	20	24
C37	22	25	25	24
C38	20	23	22	22
C39	25	25	22	24
C40	22	22	23	22

BEAMS

	BEAM NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
GROUND FLOOR	B1	HORIZONTAL	26	33	25	30	35	30	30	23.0
	B2	HORIZONTAL	31	32	29	31	31	27	30	23.0
	B3	HORIZONTAL	33	33	34	32	31	25	31	24.8
	B4	HORIZONTAL	25	26	25	29	24	32	27	18.8
	B5	HORIZONTAL	29	35	31	29	29	33	31	24.8
	B6	HORIZONTAL	30	28	34	35	30	26	31	24.8
	B7	HORIZONTAL	31	29	35	28	29	34	31	24.8
	B8	HORIZONTAL	28	27	26	35	29	27	29	21.6
	B9	HORIZONTAL	33	30	32	31	26	34	31	24.8
	B10	HORIZONTAL	25	26	25	26	28	28	26	17.4
	B11	HORIZONTAL	26	35	26	32	25	35	30	23.0
	B12	HORIZONTAL	29	25	31	29	28	30	29	21.6
	B13	HORIZONTAL	27	34	32	26	25	33	30	23.0
	B14	HORIZONTAL	25	30	34	31	26	29	29	21.6
	B15	HORIZONTAL	33	35	29	35	28	33	32	26.6
	B16	HORIZONTAL	30	26	35	30	25	34	30	23.0
	B17	HORIZONTAL	31	34	35	34	33	28	33	28.4
	B18	HORIZONTAL	30	35	25	35	34	29	31	24.8
	B19	HORIZONTAL	30	25	28	31	31	34	30	23.0
	B20	HORIZONTAL	27	34	31	32	26	33	31	24.8

Ultrasonic Pulse Velocity BLOCK (A)

COLUMNS

	COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
GROUND FLOOR	C1	DIRECT	230	58	4.0	GOOD
	C2	DIRECT	230	59	3.9	GOOD
	C3	DIRECT	230	76	3.0	DOUBTFUL
	C4	DIRECT	230	52	4.4	GOOD
	C5	DIRECT	230	55	4.2	GOOD
	C6	DIRECT	230	58	4.0	GOOD
	C7	SEMIDIRECT	190	56	3.4	DOUBTFUL
	C8	INDIRECT	230	45	5.6	EXCELLENT
	C9	DIRECT	230	58	4.0	GOOD
	C10	INDIRECT	300	63	5.3	EXCELLENT
	C11	INDIRECT	300	62	5.3	EXCELLENT
	C12	INDIRECT	300	58	5.7	EXCELLENT
	C13	INDIRECT	300	63	5.3	EXCELLENT
	C14	INDIRECT	300	69	4.8	EXCELLENT
	C15	INDIRECT	300	71	4.7	EXCELLENT
	C16	INDIRECT	300	68	4.9	EXCELLENT
	C17	INDIRECT	300	73	4.6	EXCELLENT
	C18	INDIRECT	300	55	6.0	EXCELLENT
	C19	SEMIDIRECT	212	56	3.8	GOOD
	C20	INDIRECT	300	68	4.9	EXCELLENT
	C21	SEMIDIRECT	212	56	3.8	GOOD
	C22	DIRECT	230	60	3.8	GOOD
	C23	INDIRECT	300	70	4.8	EXCELLENT
	C24	SEMIDIRECT	190	51	3.7	DOUBTFUL
	C25	INDIRECT	300	105	3.4	DOUBTFUL
	C26	INDIRECT	300	81	4.2	GOOD
	C27	INDIRECT	300	70	4.8	EXCELLENT
	C28	SEMIDIRECT	190	49	3.9	GOOD
	C29	INDIRECT	300	84	4.1	GOOD
	C30	INDIRECT	300	50	6.5	EXCELLENT
	C31	INDIRECT	300	51	6.4	EXCELLENT
	C32	SEMIDIRECT	190	48	4.0	GOOD
	C33	INDIRECT	300	61	5.4	EXCELLENT
	C34	SEMIDIRECT	212	49	4.3	GOOD
	C35	INDIRECT	300	64	5.2	EXCELLENT
	C36	SEMIDIRECT	190	47	4.0	GOOD
	C37	INDIRECT	300	75	4.5	EXCELLENT
	C38	SEMIDIRECT	212	63	3.4	DOUBTFUL
	C39	INDIRECT	300	52	6.3	EXCELLENT
	C40	INDIRECT	300	66	5.0	EXCELLENT

COLUMNS						
	COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
FIFTH FLOOR	C1	INDIRECT	300	50	6.5	EXCELLENT
	C2	INDIRECT	300	46	7.0	EXCELLENT
	C3	SEMIDIRECT	190	47	4.0	GOOD
	C4	SEMIDIRECT	190	59	3.2	DOUBTFUL
	C5	SEMIDIRECT	190	48	4.0	GOOD
	C6	SEMIDIRECT	212	52	4.1	GOOD
	C7	SEMIDIRECT	212	53	4.0	GOOD
	C8	DIRECT	300	51	5.9	EXCELLENT
	C9	INDIRECT	300	62	5.3	EXCELLENT
	C10	DIRECT	230	45	5.1	EXCELLENT
	C11	DIRECT	230	56	4.1	GOOD
	C12	INDIRECT	300	89	3.9	GOOD
	C13	DIRECT	230	58	4.0	GOOD
	C14	INDIRECT	300	52	6.3	EXCELLENT
	C15	INDIRECT	300	45	7.2	EXCELLENT
	C16	INDIRECT	300	58	5.7	EXCELLENT
	C17	DIRECT	230	54	4.3	GOOD
	C18	INDIRECT	300	56	5.9	EXCELLENT
	C19	SEMIDIRECT	190	45	4.2	GOOD
	C20	INDIRECT	300	95	3.7	DOUBTFUL
	C21	INDIRECT	300	50	6.5	EXCELLENT
	C22	SEMIDIRECT	212	48	4.4	GOOD
	C23	INDIRECT	300	61	5.4	EXCELLENT
	C24	INDIRECT	300	59	5.6	EXCELLENT
	C25	SEMIDIRECT	212	55	3.9	GOOD
	C26	INDIRECT	300	75	4.5	EXCELLENT
	C27	DIRECT	230	45	5.1	EXCELLENT
	C28	INDIRECT	300	85	4.0	GOOD
	C29	INDIRECT	300	71	4.7	EXCELLENT
	C30	SEMIDIRECT	190	50	3.8	GOOD
	C31	INDIRECT	300	50	6.5	EXCELLENT
	C32	DIRECT	230	60	3.8	GOOD
	C33	INDIRECT	300	57	5.8	EXCELLENT
	C34	INDIRECT	300	79	4.3	GOOD
	C35	INDIRECT	300	59	5.6	EXCELLENT
	C36	DIRECT	230	60	3.8	GOOD
	C37	INDIRECT	300	56	5.9	EXCELLENT
	C38	SEMIDIRECT	212	49	4.3	GOOD
	C39	INDIRECT	300	49	6.6	EXCELLENT
	C40	INDIRECT	300	47	6.9	EXCELLENT

SEVENTH FLOOR — COLUMNS					
COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
C1	INDIRECT	300	68	4.9	EXCELLENT
C2	INDIRECT	300	45	7.2	EXCELLENT
C3	INDIRECT	300	95	3.7	DOUBTFUL
C4	INDIRECT	300	69	4.8	EXCELLENT
C5	DIRECT	230	53	4.3	GOOD
C6	INDIRECT	300	81	4.2	GOOD
C7	SEMI DIRECT	190	49	3.9	GOOD
C8	INDIRECT	300	68	4.9	EXCELLENT
C9	INDIRECT	300	52	6.3	EXCELLENT
C10	DIRECT	230	50	4.6	EXCELLENT
C11	INDIRECT	300	53	6.2	EXCELLENT
C12	SEMI DIRECT	212	57	3.7	DOUBTFUL
C13	INDIRECT	300	64	5.2	EXCELLENT
C14	INDIRECT	300	49	6.6	EXCELLENT
C15	INDIRECT	300	69	4.8	EXCELLENT
C16	INDIRECT	300	129	2.8	POOR
C17	INDIRECT	300	69	4.8	EXCELLENT
C18	DIRECT	230	61	3.8	GOOD
C19	INDIRECT	300	51	6.4	EXCELLENT
C20	INDIRECT	300	54	6.1	EXCELLENT
C21	INDIRECT	300	50	6.5	EXCELLENT
C22	SEMIDIRECT	212	48	4.4	GOOD
C23	DIRECT	230	54	4.3	GOOD
C24	DIRECT	230	53	4.3	GOOD
C25	INDIRECT	300	63	5.3	EXCELLENT
C26	INDIRECT	300	70	4.8	EXCELLENT
C27	DIRECT	230	59	3.9	GOOD
C28	SEMIDIRECT	212	46	4.6	EXCELLENT
C29	INDIRECT	300	85	4.0	GOOD
C30	DIRECT	230	61	3.8	GOOD
C31	DIRECT	230	59	3.9	GOOD
C32	SEMIDIRECT	190	47	4.0	GOOD
C33	INDIRECT	300	81	4.2	GOOD
C34	DIRECT	230	56	4.1	GOOD
C35	DIRECT	230	55	4.2	GOOD
C36	SEMIDIRECT	212	67	3.2	DOUBTFUL
C37	DIRECT	230	53	4.3	GOOD
C38	INDIRECT	300	71	4.7	EXCELLENT
C39	INDIRECT	300	55	6.0	EXCELLENT
C40	DIRECT	230	58	4.0	GOOD

AVERAGE QUALITY OF COLUMNS					
COLUMN NO.	GROUND FLOOR	FIFTH FLOOR	SEVENTH FLOOR	AVERAGE READING	QUALITY
C1	6.5	6.5	4.9	6.0	EXCELLENT
C2	7.0	7.0	7.2	7.1	EXCELLENT
C3	4.0	4.0	3.7	3.9	GOOD
C4	3.2	3.2	4.8	3.8	GOOD
C5	4.0	4.0	4.3	4.1	GOOD
C6	4.1	4.1	4.2	4.1	GOOD
C7	4.0	4.0	3.9	4.0	GOOD
C8	5.9	5.9	4.9	5.6	EXCELLENT
C9	5.3	5.3	6.3	5.6	EXCELLENT
C10	5.1	5.1	4.6	4.9	EXCELLENT
C11	4.1	4.1	6.2	4.8	EXCELLENT
C12	3.9	3.9	3.7	3.8	GOOD
C13	4.0	4.0	5.2	4.4	GOOD
C14	6.3	6.3	6.6	6.4	EXCELLENT
C15	7.2	7.2	4.8	6.4	EXCELLENT
C16	5.7	5.7	2.8	4.7	EXCELLENT
C17	4.3	4.3	4.8	4.5	GOOD
C18	5.9	5.9	3.8	5.2	EXCELLENT
C19	4.2	4.2	6.4	4.9	EXCELLENT
C20	3.7	3.7	6.1	4.5	GOOD
C21	6.5	6.5	6.5	6.5	EXCELLENT
C22	4.4	4.4	4.4	4.4	GOOD
C23	5.4	5.4	4.3	5.0	EXCELLENT
C24	5.6	5.6	4.3	5.2	EXCELLENT
C25	3.9	3.9	5.3	4.3	GOOD
C26	4.5	4.5	4.8	4.6	EXCELLENT
C27	5.1	5.1	3.9	4.7	EXCELLENT
C28	4.0	4.0	4.6	4.2	GOOD
C29	4.7	4.7	4.0	4.5	GOOD
C30	3.8	3.8	3.8	3.8	GOOD
C31	6.5	6.5	3.9	5.6	EXCELLENT
C32	3.8	3.8	4.0	3.9	GOOD
C33	5.8	5.8	4.2	5.2	EXCELLENT
C34	4.3	4.3	4.1	4.2	GOOD
C35	5.6	5.6	4.2	5.1	EXCELLENT
C36	3.8	3.8	3.2	3.6	DOUBTFUL
C37	5.9	5.9	4.3	5.4	EXCELLENT
C38	4.3	4.3	4.7	4.5	GOOD
C39	6.6	6.6	6.0	6.4	EXCELLENT
C40	6.9	6.9	4.0	5.9	EXCELLENT

BEAMS						
	BEAM NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	ESTIMATED STRENGTH (MPA)
GROUND FLOOR	B1	INDIRECT	300	49	6.6	EXCELLENT
	B2	DIRECT	230	58	4.0	GOOD
	B3	DIRECT	230	56	4.1	GOOD
	B4	INDIRECT	300	87	3.9	GOOD
	B5	INDIRECT	300	62	5.3	EXCELLENT
	B6	INDIRECT	300	68	4.9	EXCELLENT
	B7	SEMI DIRECT	210	55	3.8	GOOD
	B8	SEMI DIRECT	210	54	3.9	GOOD
	B9	DIRECT	230	51	4.5	EXCELLENT
	B10	DIRECT	230	85	2.7	POOR
	B11	INDIRECT	300	58	5.7	EXCELLENT
	B12	DIRECT	230	59	3.9	GOOD
	B13	DIRECT	230	59	3.9	GOOD
	B14	DIRECT	230	60	3.8	GOOD
	B15	DIRECT	230	60	3.8	GOOD
	B16	DIRECT	230	56	4.1	GOOD
	B17	DIRECT	230	49	4.7	EXCELLENT
	B18	DIRECT	230	58	4.0	GOOD
	B19	DIRECT	230	47	4.9	EXCELLENT
	B20	DIRECT	230	59	3.9	GOOD

Rebound Hammer Test For (Block B)

COLUMNS

FLOOR	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
GROUND FLOOR	C1	HORIZONTAL	28	34	34	26	27	28	30	23.0
	C2	HORIZONTAL	26	26	28	33	34	32	30	23.0
	C3	HORIZONTAL	29	29	25	30	33	25	29	21.6
	C4	HORIZONTAL	31	27	35	28	27	27	29	21.6
	C5	HORIZONTAL	29	31	26	34	28	25	29	21.6
	C6	HORIZONTAL	32	25	31	33	34	28	31	24.8
	C7	HORIZONTAL	31	25	31	26	33	28	29	21.6
	C8	HORIZONTAL	29	35	28	28	29	27	29	21.6
	C9	HORIZONTAL	32	25	27	33	35	33	31	24.8
	C10	HORIZONTAL	28	28	35	33	29	30	31	24.8
	C11	HORIZONTAL	31	30	33	34	29	27	31	24.8
	C12	HORIZONTAL	35	32	34	27	25	35	31	24.8
	C13	HORIZONTAL	28	29	31	32	34	33	31	24.8
	C14	HORIZONTAL	35	25	34	25	28	26	29	21.6
	C15	HORIZONTAL	35	32	30	27	34	33	32	26.6
	C16	HORIZONTAL	34	29	31	29	31	27	30	23.0
	C17	HORIZONTAL	28	28	34	35	31	31	31	24.8
	C18	HORIZONTAL	26	35	31	35	28	27	30	23.0
	C19	HORIZONTAL	28	29	28	25	25	35	28	20.2
	C20	HORIZONTAL	26	32	34	33	34	31	32	26.6
	C21	HORIZONTAL	32	28	25	33	31	30	30	23.0
	C22	HORIZONTAL	33	26	31	28	33	25	29	21.6
	C23	HORIZONTAL	34	34	28	34	25	27	30	23.0
	C24	HORIZONTAL	26	26	34	34	30	28	30	23.0
	C25	HORIZONTAL	33	26	31	30	35	32	31	24.8
	C26	HORIZONTAL	35	32	29	26	31	27	30	23.0
	C27	HORIZONTAL	33	25	30	35	35	31	32	26.6
	C28	HORIZONTAL	25	29	29	29	35	34	30	23.0
	C29	HORIZONTAL	27	30	35	35	30	31	31	24.8
	C30	HORIZONTAL	35	26	32	29	25	25	29	21.6
	C31	HORIZONTAL	25	25	28	35	35	32	30	23.0
	C32	HORIZONTAL	31	29	32	30	26	29	30	23.0
	C33	HORIZONTAL	26	28	33	32	33	25	30	23.0
	C34	HORIZONTAL	25	30	31	35	27	32	30	23.0
	C35	HORIZONTAL	26	29	34	26	35	30	30	23.0
	C36	HORIZONTAL	28	33	27	28	27	33	29	21.6
	C37	HORIZONTAL	25	26	29	35	26	26	28	20.2
	C38	HORIZONTAL	33	28	28	25	29	32	29	21.6
	C39	HORIZONTAL	35	32	30	28	25	27	30	23.0
	C40	HORIZONTAL	29	31	25	30	29	29	29	21.6

COLUMNS

	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
FIFTH FLOOR	C1	HORIZONTAL	30	27	32	31	29	28	30	23.0
	C2	HORIZONTAL	30	28	27	34	29	32	30	23.0
	C3	HORIZONTAL	34	27	26	34	30	33	31	24.8
	C4	HORIZONTAL	34	28	30	28	25	31	29	21.6
	C5	HORIZONTAL	31	34	31	33	30	32	32	26.6
	C6	HORIZONTAL	32	31	35	32	26	33	32	26.6
	C7	HORIZONTAL	29	31	27	25	35	33	30	23.0
	C8	HORIZONTAL	35	32	30	34	30	34	33	28.4
	C9	HORIZONTAL	28	33	25	32	34	27	30	23.0
	C10	HORIZONTAL	25	28	31	29	35	27	29	21.6
	C11	HORIZONTAL	31	34	32	32	27	30	31	24.8
	C12	HORIZONTAL	25	28	30	32	31	29	29	21.6
	C13	HORIZONTAL	26	31	33	32	25	29	29	21.6
	C14	HORIZONTAL	26	34	30	30	25	35	30	23.0
	C15	HORIZONTAL	35	28	35	28	26	32	31	24.8
	C16	HORIZONTAL	35	30	30	29	25	27	29	21.6
	C17	HORIZONTAL	25	30	28	30	30	32	29	21.6
	C18	HORIZONTAL	27	26	33	32	25	33	29	21.6
	C19	HORIZONTAL	35	26	32	32	32	32	32	26.6
	C20	HORIZONTAL	30	35	26	29	26	30	29	21.6
	C21	HORIZONTAL	30	31	31	34	35	29	32	26.6
	C22	HORIZONTAL	26	34	31	35	32	35	32	26.6
	C23	HORIZONTAL	35	33	31	28	33	27	31	24.8
	C24	HORIZONTAL	34	29	33	25	25	30	29	21.6
	C25	HORIZONTAL	29	29	34	30	25	35	30	23.0
	C26	HORIZONTAL	34	32	31	26	29	33	31	24.8
	C27	HORIZONTAL	30	29	25	32	34	30	30	23.0
	C28	HORIZONTAL	31	33	25	31	33	25	30	23.0
	C29	HORIZONTAL	31	31	31	33	33	28	31	24.8
	C30	HORIZONTAL	25	29	26	29	35	32	29	21.6
	C31	HORIZONTAL	25	25	30	33	25	27	28	20.2
	C32	HORIZONTAL	33	32	35	34	25	33	32	26.6
	C33	HORIZONTAL	29	29	25	27	33	25	28	20.2
	C34	HORIZONTAL	28	26	29	28	29	35	29	21.6
	C35	HORIZONTAL	30	28	27	35	25	31	29	21.6
	C36	HORIZONTAL	34	32	35	34	31	32	33	28.4
	C37	HORIZONTAL	33	31	29	25	31	29	30	23.0
	C38	HORIZONTAL	26	35	26	31	28	34	30	23.0
	C39	HORIZONTAL	29	34	28	30	33	34	31	24.8
	C40	HORIZONTAL	28	26	32	29	32	29	29	21.6

COLUMNS										
	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
SEVENTH FLOOR	C1	HORIZONTAL	28	35	27	32	27	31	30	23.0
	C2	HORIZONTAL	28	26	35	35	32	31	31	24.8
	C3	HORIZONTAL	35	28	25	31	29	34	30	23.0
	C4	HORIZONTAL	30	33	28	35	32	35	32	26.6
	C5	HORIZONTAL	33	28	34	34	32	29	32	26.6
	C6	HORIZONTAL	35	25	34	35	34	34	33	28.4
	C7	HORIZONTAL	27	34	31	33	25	28	30	23.0
	C8	HORIZONTAL	34	27	32	27	28	28	29	21.6
	C9	HORIZONTAL	28	34	29	35	33	30	32	26.6
	C10	HORIZONTAL	25	28	27	28	32	31	29	21.6
	C11	HORIZONTAL	32	34	28	34	33	32	32	26.6
	C12	HORIZONTAL	33	32	34	33	32	32	33	28.4
	C13	HORIZONTAL	27	35	31	25	28	33	30	23.0
	C14	HORIZONTAL	28	25	28	28	30	29	28	20.2
	C15	HORIZONTAL	28	32	25	29	27	28	28	20.2
	C16	HORIZONTAL	30	26	29	29	30	30	29	21.6
	C17	HORIZONTAL	28	32	32	27	26	28	29	21.6
	C18	HORIZONTAL	32	25	35	28	32	29	30	23.0
	C19	HORIZONTAL	34	34	35	32	27	32	32	26.6
	C20	HORIZONTAL	25	28	27	29	31	28	28	20.2
	C21	HORIZONTAL	35	26	35	34	34	33	33	28.4
	C22	HORIZONTAL	28	25	25	26	35	32	29	21.6
	C23	HORIZONTAL	34	30	32	34	35	29	32	26.6
	C24	HORIZONTAL	31	28	29	32	34	31	31	24.8
	C25	HORIZONTAL	26	33	32	26	25	26	28	20.2
	C26	HORIZONTAL	27	28	26	29	27	25	27	18.8
	C27	HORIZONTAL	30	29	30	26	32	29	29	21.6
	C28	HORIZONTAL	29	30	34	34	27	29	31	24.8
	C29	HORIZONTAL	32	35	33	31	30	31	32	26.6
	C30	HORIZONTAL	30	31	32	26	33	31	31	24.8
	C31	HORIZONTAL	34	27	33	33	25	35	31	24.8
	C32	HORIZONTAL	27	34	33	25	25	26	28	20.2
	C33	HORIZONTAL	27	30	26	25	34	33	29	21.6
	C34	HORIZONTAL	28	35	27	34	34	29	31	24.8
	C35	HORIZONTAL	28	26	32	28	35	28	30	23.0
	C36	HORIZONTAL	32	31	33	32	30	28	31	24.8
	C37	HORIZONTAL	32	33	31	27	27	34	31	24.8
	C38	HORIZONTAL	26	33	34	25	33	33	31	24.8
	C39	HORIZONTAL	33	28	33	35	31	26	31	24.8
	C40	HORIZONTAL	27	33	29	31	30	31	30	23.0

AVERAGE STRENGTH OF COLUMNS				
COLUMN NO.	GROUND FLOOR	FIFTH FLOOR	SEVENTH FLOOR	AVERAGE STRENGTH (MPA)
C1	23	23	23	23
C2	23	23	25	24
C3	22	25	23	23
C4	22	22	27	23
C5	22	27	27	25
C6	25	27	28	27
C7	22	23	23	23
C8	22	28	22	24
C9	25	23	27	25
C10	25	22	22	23
C11	25	25	27	25
C12	25	22	28	25
C13	25	22	23	23
C14	22	23	20	22
C15	27	25	20	24
C16	23	22	22	22
C17	25	22	22	23
C18	23	22	23	23
C19	20	27	27	24
C20	27	22	20	23
C21	23	27	28	26
C22	22	27	22	23
C23	23	25	27	25
C24	23	22	25	23
C25	25	23	20	23
C26	23	25	19	22
C27	27	23	22	24
C28	23	23	25	24
C29	25	25	27	25
C30	22	22	25	23
C31	23	20	25	23
C32	23	27	20	23
C33	23	20	22	22
C34	23	22	25	23
C35	23	22	23	23
C36	22	28	25	25
C37	20	23	25	23
C38	22	23	25	23
C39	23	25	25	24
C40	22	22	23	22

BEAMS											
GROUND FLOOR	BEAM NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
	B1	HORIZONTAL	35	27	35	34	25	30	31	24.8
	B2	HORIZONTAL	29	30	27	28	33	30	30	23.0
	B3	HORIZONTAL	35	27	33	34	25	31	31	24.8
	B4	HORIZONTAL	33	29	33	29	34	35	32	26.6
	B5	HORIZONTAL	25	30	34	30	25	26	28	20.2
	B6	HORIZONTAL	31	29	29	34	25	32	30	23.0
	B7	HORIZONTAL	27	34	31	27	27	26	29	21.6
	B8	HORIZONTAL	29	30	34	28	31	32	31	24.8
	B9	HORIZONTAL	31	34	32	34	31	34	33	28.4
	B10	HORIZONTAL	31	35	25	31	32	35	32	26.6
	B11	HORIZONTAL	31	25	31	31	34	25	30	23.0
	B12	HORIZONTAL	35	26	35	34	33	28	32	26.6
	B13	HORIZONTAL	30	30	28	34	31	25	30	23.0
	B14	HORIZONTAL	28	26	33	30	32	30	30	23.0
	B15	HORIZONTAL	35	32	35	33	31	29	33	28.4
	B16	HORIZONTAL	33	28	27	34	30	34	31	24.8
	B17	HORIZONTAL	27	35	29	25	25	25	28	20.2
	B18	HORIZONTAL	30	26	30	31	34	34	31	24.8
	B19	HORIZONTAL	35	26	28	33	30	31	31	24.8
	B20	HORIZONTAL	26	35	34	33	31	29	31	24.8

Ultrasonic Pulse Velocity BLOCK B

COLUMNS

GROUND FLOOR

COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
C1	DIRECT	230	56	4.1	GOOD
C2	DIRECT	230	61	3.8	GOOD
C3	DIRECT	230	55	4.2	GOOD
C4	DIRECT	230	56	4.1	GOOD
C5	DIRECT	230	57	4.0	GOOD
C6	DIRECT	230	50	4.6	EXCELLENT
C7	SEMIDIRECT	190	45	4.2	GOOD
C8	INDIRECT	230	45	5.6	EXCELLENT
C9	DIRECT	230	61	3.8	GOOD
C10	INDIRECT	300	55	6.0	EXCELLENT
C11	INDIRECT	300	60	5.5	EXCELLENT
C12	INDIRECT	300	79	4.3	GOOD
C13	INDIRECT	300	49	6.6	EXCELLENT
C14	INDIRECT	300	71	4.7	EXCELLENT
C15	INDIRECT	300	70	4.8	EXCELLENT
C16	INDIRECT	300	83	4.1	GOOD
C17	INDIRECT	300	52	6.3	EXCELLENT
C18	INDIRECT	300	55	6.0	EXCELLENT
C19	SEMIDIRECT	212	68	3.1	DOUBTFUL
C20	INDIRECT	300	72	4.7	EXCELLENT
C21	SEMIDIRECT	212	55	3.9	GOOD
C22	DIRECT	230	57	4.0	GOOD
C23	INDIRECT	300	71	4.7	EXCELLENT
C24	SEMIDIRECT	190	48	4.0	GOOD
C25	INDIRECT	300	48	6.8	EXCELLENT
C26	INDIRECT	300	67	5.0	EXCELLENT
C27	INDIRECT	300	68	4.9	EXCELLENT
C28	SEMIDIRECT	190	49	3.9	GOOD
C29	INDIRECT	300	63	5.3	EXCELLENT
C30	INDIRECT	300	67	5.0	EXCELLENT
C31	INDIRECT	300	61	5.4	EXCELLENT
C32	SEMIDIRECT	190	48	4.0	GOOD
C33	INDIRECT	300	54	6.1	EXCELLENT
C34	SEMIDIRECT	212	49	4.3	GOOD
C35	INDIRECT	300	52	6.3	EXCELLENT
C36	SEMIDIRECT	190	49	3.9	GOOD
C37	INDIRECT	300	89	3.9	GOOD
C38	SEMIDIRECT	212	53	4.0	GOOD
C39	INDIRECT	300	57	5.8	EXCELLENT
C40	INDIRECT	300	58	5.7	EXCELLENT

	COLUMNS					
	COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
FIFTH FLOOR	C1	INDIRECT	300	55	6.0	EXCELLENT
	C2	INDIRECT	300	52	6.3	EXCELLENT
	C3	SEMIDIRECT	190	49	3.9	GOOD
	C4	SEMIDIRECT	190	42	4.5	EXCELLENT
	C5	SEMIDIRECT	190	50	3.8	GOOD
	C6	SEMIDIRECT	212	52	4.1	GOOD
	C7	SEMIDIRECT	212	51	4.2	GOOD
	C8	DIRECT	300	65	4.6	EXCELLENT
	C9	INDIRECT	300	60	5.5	EXCELLENT
	C10	DIRECT	230	46	5.0	EXCELLENT
	C11	DIRECT	230	50	4.6	EXCELLENT
	C12	INDIRECT	300	69	4.8	EXCELLENT
	C13	DIRECT	230	53	4.3	GOOD
	C14	INDIRECT	300	45	7.2	EXCELLENT
	C15	INDIRECT	300	52	6.3	EXCELLENT
	C16	INDIRECT	300	72	4.7	EXCELLENT
	C17	DIRECT	230	48	4.8	EXCELLENT
	C18	INDIRECT	300	75	4.5	EXCELLENT
	C19	SEMIDIRECT	190	45	4.2	GOOD
	C20	INDIRECT	300	58	5.7	EXCELLENT
	C21	INDIRECT	300	63	5.3	EXCELLENT
	C22	SEMIDIRECT	212	48	4.4	GOOD
	C23	INDIRECT	300	64	5.2	EXCELLENT
	C24	INDIRECT	300	53	6.2	EXCELLENT
	C25	SEMIDIRECT	212	48	4.4	GOOD
	C26	INDIRECT	300	56	5.9	EXCELLENT
	C27	DIRECT	230	52	4.4	GOOD
	C28	INDIRECT	300	74	4.6	EXCELLENT
	C29	INDIRECT	300	55	6.0	EXCELLENT
	C30	SEMIDIRECT	190	49	3.9	GOOD
	C31	INDIRECT	300	88	3.9	GOOD
	C32	DIRECT	230	51	4.5	EXCELLENT
	C33	INDIRECT	300	89	3.9	GOOD
	C34	INDIRECT	300	73	4.6	EXCELLENT
	C35	INDIRECT	300	56	5.9	EXCELLENT
	C36	DIRECT	230	47	4.9	EXCELLENT
	C37	INDIRECT	300	59	5.6	EXCELLENT
	C38	SEMIDIRECT	212	55	3.9	GOOD
	C39	INDIRECT	300	48	6.8	EXCELLENT
	C40	INDIRECT	300	51	6.4	EXCELLENT

COLUMNS						
	COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
SEVENTH FLOOR	C1	INDIRECT	300	71	4.7	EXCELLENT
	C2	INDIRECT	300	67	5.0	EXCELLENT
	C3	INDIRECT	300	71	4.7	EXCELLENT
	C4	INDIRECT	300	80	4.3	GOOD
	C5	DIRECT	230	47	4.9	EXCELLENT
	C6	INDIRECT	300	56	5.9	EXCELLENT
	C7	SEMI DIRECT	190	45	4.2	GOOD
	C8	INDIRECT	300	69	4.8	EXCELLENT
	C9	INDIRECT	300	69	4.8	EXCELLENT
	C10	DIRECT	230	56	4.1	GOOD
	C11	INDIRECT	300	73	4.6	EXCELLENT
	C12	SEMI DIRECT	212	46	4.6	EXCELLENT
	C13	INDIRECT	300	64	5.2	EXCELLENT
	C14	INDIRECT	300	85	4.0	GOOD
	C15	INDIRECT	300	84	4.1	GOOD
	C16	INDIRECT	300	64	5.2	EXCELLENT
	C17	INDIRECT	300	61	5.4	EXCELLENT
	C18	DIRECT	230	73	3.2	DOUBTFUL
	C19	INDIRECT	300	48	6.8	EXCELLENT
	C20	INDIRECT	300	89	3.9	GOOD
	C21	INDIRECT	300	65	5.1	EXCELLENT
	C22	SEMIDIRECT	212	49	4.3	GOOD
	C23	DIRECT	230	48	4.8	EXCELLENT
	C24	DIRECT	230	58	4.0	GOOD
	C25	INDIRECT	300	87	3.9	GOOD
	C26	INDIRECT	300	52	6.3	EXCELLENT
	C27	DIRECT	230	58	4.0	GOOD
	C28	SEMIDIRECT	212	49	4.3	GOOD
	C29	INDIRECT	300	73	4.6	EXCELLENT
	C30	DIRECT	230	55	4.2	GOOD
	C31	DIRECT	230	60	3.8	GOOD
	C32	SEMIDIRECT	190	61	3.1	DOUBTFUL
	C33	INDIRECT	300	65	5.1	EXCELLENT
	C34	DIRECT	230	54	4.3	GOOD
	C35	DIRECT	230	61	3.8	GOOD
	C36	SEMIDIRECT	212	56	3.8	GOOD
	C37	DIRECT	230	59	3.9	GOOD
	C38	INDIRECT	300	51	6.4	EXCELLENT
	C39	INDIRECT	300	55	6.0	EXCELLENT
	C40	DIRECT	230	45	5.1	EXCELLENT

AVERAGE QUALITY OF COLUMNS					
COLUMN NO.	BASEMENT	GROUND FLOOR	FIRST FLOOR	AVERAGE READING	QUALITY
C1	6.0	6.0	4.7	5.5	EXCELLENT
C2	6.3	6.3	5.0	5.8	EXCELLENT
C3	3.9	3.9	4.7	4.2	GOOD
C4	4.5	4.5	4.3	4.4	GOOD
C5	3.8	3.8	4.9	4.2	GOOD
C6	4.1	4.1	5.9	4.7	EXCELLENT
C7	4.2	4.2	4.2	4.2	GOOD
C8	4.6	4.6	4.8	4.7	EXCELLENT
C9	5.5	5.5	4.8	5.3	EXCELLENT
C10	5.0	5.0	4.1	4.7	EXCELLENT
C11	4.6	4.6	4.6	4.6	EXCELLENT
C12	4.8	4.8	4.6	4.8	EXCELLENT
C13	4.3	4.3	5.2	4.6	EXCELLENT
C14	7.2	7.2	4.0	6.1	EXCELLENT
C15	6.3	6.3	4.1	5.5	EXCELLENT
C16	4.7	4.7	5.2	4.8	EXCELLENT
C17	4.8	4.8	5.4	5.0	EXCELLENT
C18	4.5	4.5	3.2	4.1	GOOD
C19	4.2	4.2	6.8	5.1	EXCELLENT
C20	5.7	5.7	3.9	5.1	EXCELLENT
C21	5.3	5.3	5.1	5.2	EXCELLENT
C22	4.4	4.4	4.3	4.4	GOOD
C23	5.2	5.2	4.8	5.1	EXCELLENT
C24	6.2	6.2	4.0	5.4	EXCELLENT
C25	4.4	4.4	3.9	4.3	GOOD
C26	5.9	5.9	6.3	6.0	EXCELLENT
C27	4.4	4.4	4.0	4.3	GOOD
C28	4.6	4.6	4.3	4.5	GOOD
C29	6.0	6.0	4.6	5.5	EXCELLENT
C30	3.9	3.9	4.2	4.0	GOOD
C31	3.9	3.9	3.8	3.9	GOOD
C32	4.5	4.5	3.1	4.0	GOOD
C33	3.9	3.9	5.1	4.3	GOOD
C34	4.6	4.6	4.3	4.5	GOOD
C35	5.9	5.9	3.8	5.2	EXCELLENT
C36	4.9	4.9	3.8	4.5	EXCELLENT
C37	5.6	5.6	3.9	5.0	EXCELLENT
C38	3.9	3.9	6.4	4.7	EXCELLENT
C39	6.8	6.8	6.0	6.5	EXCELLENT
C40	6.4	6.4	5.1	6.0	EXCELLENT

BEAMS						
	BEAM NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	ESTIMATED STRENGTH (MPA)
GROUND FLOOR	B1	INDIRECT	300	55	6.0	EXCELLENT
	B2	DIRECT	230	58	4.0	GOOD
	B3	DIRECT	230	48	4.8	EXCELLENT
	B4	INDIRECT	300	70	4.8	EXCELLENT
	B5	INDIRECT	300	88	3.9	GOOD
	B6	INDIRECT	300	49	6.6	EXCELLENT
	B7	SEMI DIRECT	210	51	4.1	GOOD
	B8	SEMI DIRECT	210	50	4.2	GOOD
	B9	DIRECT	230	46	5.0	EXCELLENT
	B10	DIRECT	230	56	4.1	GOOD
	B11	INDIRECT	300	48	6.8	EXCELLENT
	B12	DIRECT	230	52	4.4	GOOD
	B13	DIRECT	230	53	4.3	GOOD
	B14	DIRECT	230	60	3.8	GOOD
	B15	DIRECT	230	48	4.8	EXCELLENT
	B16	DIRECT	230	52	4.4	GOOD
	B17	DIRECT	230	71	3.2	DOUBTFUL
	B18	DIRECT	230	59	3.9	GOOD
	B19	DIRECT	230	56	4.1	GOOD
	B20	DIRECT	230	51	4.5	EXCELLENT

Rebound Hammer Test For (Block C)

COLUMNS

GROUND FLOOR

COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
C1	HORIZONTAL	30	27	32	31	29	28	30	23.0
C2	HORIZONTAL	30	28	27	34	29	32	30	23.0
C3	HORIZONTAL	34	27	26	34	30	33	31	24.8
C4	HORIZONTAL	28	28	27	25	25	31	27	18.8
C5	HORIZONTAL	31	34	31	33	30	32	32	26.6
C6	HORIZONTAL	32	31	35	32	26	33	32	26.6
C7	HORIZONTAL	29	31	27	25	35	33	30	23.0
C8	HORIZONTAL	35	32	30	34	30	34	33	28.4
C9	HORIZONTAL	28	27	25	32	27	27	28	20.2
C10	HORIZONTAL	25	28	31	29	35	27	29	21.6
C11	HORIZONTAL	31	34	32	32	27	30	31	24.8
C12	HORIZONTAL	25	28	30	32	31	29	29	21.6
C13	HORIZONTAL	26	31	25	32	25	29	28	20.2
C14	HORIZONTAL	26	34	30	30	25	35	30	23.0
C15	HORIZONTAL	35	28	35	28	26	32	31	24.8
C16	HORIZONTAL	35	30	30	29	25	27	29	21.6
C17	HORIZONTAL	25	30	28	30	30	32	29	21.6
C18	HORIZONTAL	27	26	26	32	25	33	28	20.2
C19	HORIZONTAL	29	26	32	26	32	32	30	23.0
C20	HORIZONTAL	30	35	26	29	26	30	29	21.6
C21	HORIZONTAL	30	31	31	34	35	29	32	26.6
C22	HORIZONTAL	26	34	31	35	32	35	32	26.6
C23	HORIZONTAL	35	33	31	28	33	27	31	24.8
C24	HORIZONTAL	34	29	33	25	25	30	29	21.6
C25	HORIZONTAL	29	29	34	30	25	35	30	23.0
C26	HORIZONTAL	34	32	31	26	29	33	31	24.8
C27	HORIZONTAL	30	29	25	32	34	30	30	23.0
C28	HORIZONTAL	31	33	25	31	33	25	30	23.0
C29	HORIZONTAL	31	31	31	33	33	28	31	24.8
C30	HORIZONTAL	25	29	26	29	35	32	29	21.6
C31	HORIZONTAL	25	25	30	33	25	27	28	20.2
C32	HORIZONTAL	33	32	35	34	25	33	32	26.6
C33	HORIZONTAL	29	29	25	27	33	25	28	20.2
C34	HORIZONTAL	28	26	29	28	29	35	29	21.6
C35	HORIZONTAL	30	28	27	35	25	31	29	21.6
C36	HORIZONTAL	34	32	35	34	31	32	33	28.4
C37	HORIZONTAL	33	31	29	25	31	29	30	23.0
C38	HORIZONTAL	26	35	26	31	28	34	30	23.0
C39	HORIZONTAL	29	34	28	30	33	34	31	24.8
C40	HORIZONTAL	28	26	32	29	32	29	29	21.6

COLUMNS										
	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
FIFTH FLOOR	C1	HORIZONTAL	28	35	27	32	27	31	30	23.0
	C2	HORIZONTAL	28	26	35	35	32	31	31	24.8
	C3	HORIZONTAL	35	28	25	31	29	34	30	23.0
	C4	HORIZONTAL	30	33	28	35	32	35	32	26.6
	C5	HORIZONTAL	25	26	29	28	26	29	27	18.8
	C6	HORIZONTAL	35	25	34	35	34	34	33	28.4
	C7	HORIZONTAL	27	34	31	33	25	28	30	23.0
	C8	HORIZONTAL	34	27	32	27	28	28	29	21.6
	C9	HORIZONTAL	28	34	29	35	33	30	32	26.6
	C10	HORIZONTAL	25	28	27	28	32	31	29	21.6
	C11	HORIZONTAL	32	34	28	34	33	32	32	26.6
	C12	HORIZONTAL	33	32	34	33	32	32	33	28.4
	C13	HORIZONTAL	27	35	31	25	28	33	30	23.0
	C14	HORIZONTAL	28	33	28	28	35	25	30	23.0
	C15	HORIZONTAL	28	32	25	29	33	32	30	23.0
	C16	HORIZONTAL	30	26	29	29	30	30	29	21.6
	C17	HORIZONTAL	28	32	32	27	26	28	29	21.6
	C18	HORIZONTAL	32	25	35	28	32	29	30	23.0
	C19	HORIZONTAL	34	34	35	32	27	32	32	26.6
	C20	HORIZONTAL	25	28	27	29	31	28	28	20.2
	C21	HORIZONTAL	35	26	35	34	34	33	33	28.4
	C22	HORIZONTAL	28	25	25	26	35	32	29	21.6
	C23	HORIZONTAL	34	30	32	34	35	29	32	26.6
	C24	HORIZONTAL	31	28	29	32	34	31	31	24.8
	C25	HORIZONTAL	26	33	32	26	25	26	28	20.2
	C26	HORIZONTAL	27	28	26	29	27	25	27	18.8
	C27	HORIZONTAL	30	29	30	26	32	29	29	21.6
	C28	HORIZONTAL	29	30	34	34	27	29	31	24.8
	C29	HORIZONTAL	32	35	33	31	30	31	32	26.6
	C30	HORIZONTAL	30	31	32	26	33	31	31	24.8
	C31	HORIZONTAL	34	27	33	33	25	35	31	24.8
	C32	HORIZONTAL	27	34	33	25	25	26	28	20.2
	C33	HORIZONTAL	27	28	26	25	26	33	28	20.2
	C34	HORIZONTAL	28	35	27	34	34	29	31	24.8
	C35	HORIZONTAL	28	26	32	28	35	28	30	23.0
	C36	HORIZONTAL	32	31	33	32	30	28	31	24.8
	C37	HORIZONTAL	32	33	31	27	27	34	31	24.8
	C38	HORIZONTAL	26	33	34	25	33	33	31	24.8
	C39	HORIZONTAL	33	28	33	35	31	26	31	24.8
	C40	HORIZONTAL	27	33	29	31	30	31	30	23.0

COLUMNS

	COLUMN NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
SEVENTH FLOOR	C1	HORIZONTAL	28	30	32	26	33	28	30	23.0
	C2	HORIZONTAL	33	25	31	28	35	32	31	24.8
	C3	HORIZONTAL	25	25	30	35	32	33	30	23.0
	C4	HORIZONTAL	25	32	27	26	27	33	28	20.2
	C5	HORIZONTAL	28	27	29	30	35	27	29	21.6
	C6	HORIZONTAL	27	35	31	26	28	30	30	23.0
	C7	HORIZONTAL	28	26	31	31	28	25	28	20.2
	C8	HORIZONTAL	31	35	26	25	35	35	31	24.8
	C9	HORIZONTAL	30	25	35	26	33	30	30	23.0
	C10	HORIZONTAL	28	34	34	33	25	32	31	24.8
	C11	HORIZONTAL	35	29	25	31	28	32	30	23.0
	C12	HORIZONTAL	34	35	25	29	29	27	30	23.0
	C13	HORIZONTAL	32	27	26	31	35	34	31	24.8
	C14	HORIZONTAL	31	35	31	33	33	31	32	26.6
	C15	HORIZONTAL	25	29	34	25	32	29	29	21.6
	C16	HORIZONTAL	25	31	28	34	35	32	31	24.8
	C17	HORIZONTAL	30	26	35	33	27	32	31	24.8
	C18	HORIZONTAL	27	32	33	26	30	31	30	23.0
	C19	HORIZONTAL	27	30	33	31	34	30	31	24.8
	C20	HORIZONTAL	34	25	34	33	35	25	31	24.8
	C21	HORIZONTAL	25	25	31	35	26	27	28	20.2
	C22	HORIZONTAL	29	34	31	35	27	33	32	26.6
	C23	HORIZONTAL	29	32	27	29	35	28	30	23.0
	C24	HORIZONTAL	31	32	26	29	31	30	30	23.0
	C25	HORIZONTAL	30	30	33	32	31	30	31	24.8
	C26	HORIZONTAL	35	33	30	35	35	33	34	30.2
	C27	HORIZONTAL	31	32	31	33	33	26	31	24.8
	C28	HORIZONTAL	33	30	30	30	26	33	30	23.0
	C29	HORIZONTAL	26	27	31	27	30	29	28	20.2
	C30	HORIZONTAL	34	27	35	27	25	35	31	24.8
	C31	HORIZONTAL	31	29	34	30	35	25	31	24.8
	C32	HORIZONTAL	28	27	32	28	28	26	28	20.2
	C33	HORIZONTAL	30	33	25	33	31	33	31	24.8
	C34	HORIZONTAL	28	35	30	34	33	26	31	24.8
	C35	HORIZONTAL	35	31	25	28	28	33	30	23.0
	C36	HORIZONTAL	26	25	35	34	26	29	29	21.6
	C37	HORIZONTAL	25	35	33	30	30	33	31	24.8
	C38	HORIZONTAL	28	30	33	33	33	35	32	26.6
	C39	HORIZONTAL	30	34	25	25	25	29	28	20.2
	C40	HORIZONTAL	26	33	25	25	33	27	28	20.2

AVERAGE STRENGTH OF COLUMNS				
COLUMN NO.	GROUND FLOOR	FIFTH FLOOR	SEVENTH FLOOR	AVERAGE STRENGTH (MPA)
C1	23	23	23	23
C2	23	25	25	24
C3	25	23	23	24
C4	19	27	20	22
C5	27	19	22	22
C6	27	28	23	26
C7	23	23	20	22
C8	28	22	25	25
C9	20	27	23	23
C10	22	22	25	23
C11	25	27	23	25
C12	22	28	23	24
C13	20	23	25	23
C14	23	23	27	24
C15	25	23	22	23
C16	22	22	25	23
C17	22	22	25	23
C18	20	23	23	22
C19	23	27	25	25
C20	22	20	25	22
C21	27	28	20	25
C22	27	22	27	25
C23	25	27	23	25
C24	22	25	23	23
C25	23	20	25	23
C26	25	19	30	25
C27	23	22	25	23
C28	23	25	23	24
C29	25	27	20	24
C30	22	25	25	24
C31	20	25	25	23
C32	27	20	20	22
C33	20	20	25	22
C34	22	25	25	24
C35	22	23	23	23
C36	28	25	22	25
C37	23	25	25	24
C38	23	25	27	25
C39	25	25	20	23
C40	22	23	20	22

BEAMS											
	BEAM NO.	HAMMER ALLIGNMENT	REBOUND READINGS						AVERAGE READING	ESTIMATED STRENGTH (MPA)
GROUND FLOOR	B1	HORIZONTAL	35	27	35	34	25	30	31	24.8
	B2	HORIZONTAL	29	30	27	28	33	30	30	23.0
	B3	HORIZONTAL	35	27	33	34	25	31	31	24.8
	B4	HORIZONTAL	26	25	26	29	27	28	27	18.8
	B5	HORIZONTAL	25	30	34	30	25	26	28	20.2
	B6	HORIZONTAL	31	29	29	34	25	32	30	23.0
	B7	HORIZONTAL	27	34	31	27	27	26	29	21.6
	B8	HORIZONTAL	29	30	34	28	31	32	31	24.8
	B9	HORIZONTAL	31	34	32	34	31	34	33	28.4
	B10	HORIZONTAL	31	35	25	31	32	35	32	26.6
	B11	HORIZONTAL	31	25	31	31	34	25	30	23.0
	B12	HORIZONTAL	35	26	35	34	33	28	32	26.6
	B13	HORIZONTAL	30	30	28	34	31	25	30	23.0
	B14	HORIZONTAL	28	26	33	30	32	30	30	23.0
	B15	HORIZONTAL	35	32	35	33	31	29	33	28.4
	B16	HORIZONTAL	33	28	27	34	30	34	31	24.8
	B17	HORIZONTAL	27	35	29	25	25	25	28	20.2
	B18	HORIZONTAL	30	26	30	31	34	34	31	24.8
	B19	HORIZONTAL	35	26	28	33	30	31	31	24.8
	B20	HORIZONTAL	26	35	34	33	31	29	31	24.8

Ultrasonic Pulse Velocity (BLOCK C)

COLUMNS

	COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
GROUND FLOOR	C1	DIRECT	230	60	3.8	GOOD
	C2	DIRECT	230	45	5.1	EXCELLENT
	C3	DIRECT	230	48	4.8	EXCELLENT
	C4	DIRECT	230	154	1.5	POOR
	C5	DIRECT	230	60	3.8	GOOD
	C6	DIRECT	230	48	4.8	EXCELLENT
	C7	SEMIDIRECT	190	50	3.8	GOOD
	C8	INDIRECT	230	56	4.6	EXCELLENT
	C9	DIRECT	230	71	3.2	DOUBTFUL
	C10	INDIRECT	300	49	6.6	EXCELLENT
	C11	INDIRECT	300	52	6.3	EXCELLENT
	C12	INDIRECT	300	52	6.3	EXCELLENT
	C13	INDIRECT	300	88	3.9	GOOD
	C14	INDIRECT	300	62	5.3	EXCELLENT
	C15	INDIRECT	300	50	6.5	EXCELLENT
	C16	INDIRECT	300	52	6.3	EXCELLENT
	C17	INDIRECT	300	63	5.3	EXCELLENT
	C18	INDIRECT	300	82	4.2	GOOD
	C19	SEMIDIRECT	212	49	4.3	GOOD
	C20	INDIRECT	300	46	7.0	EXCELLENT
	C21	SEMIDIRECT	212	55	3.9	GOOD
	C22	DIRECT	230	56	4.1	GOOD
	C23	INDIRECT	300	70	4.8	EXCELLENT
	C24	SEMIDIRECT	190	45	4.2	GOOD
	C25	INDIRECT	300	65	5.1	EXCELLENT
	C26	INDIRECT	300	55	6.0	EXCELLENT
	C27	INDIRECT	300	49	6.6	EXCELLENT
	C28	SEMIDIRECT	190	41	4.6	EXCELLENT
	C29	INDIRECT	300	61	5.4	EXCELLENT
	C30	INDIRECT	300	61	5.4	EXCELLENT
	C31	INDIRECT	300	92	3.8	GOOD
	C32	SEMIDIRECT	190	42	4.5	EXCELLENT
	C33	INDIRECT	300	63	5.3	EXCELLENT
	C34	SEMIDIRECT	212	50	4.2	GOOD
	C35	INDIRECT	300	46	7.0	EXCELLENT
	C36	SEMIDIRECT	190	50	3.8	GOOD
	C37	INDIRECT	300	63	5.3	EXCELLENT
	C38	SEMIDIRECT	212	49	4.3	GOOD
	C39	INDIRECT	300	68	4.9	EXCELLENT
	C40	INDIRECT	300	67	5.0	EXCELLENT

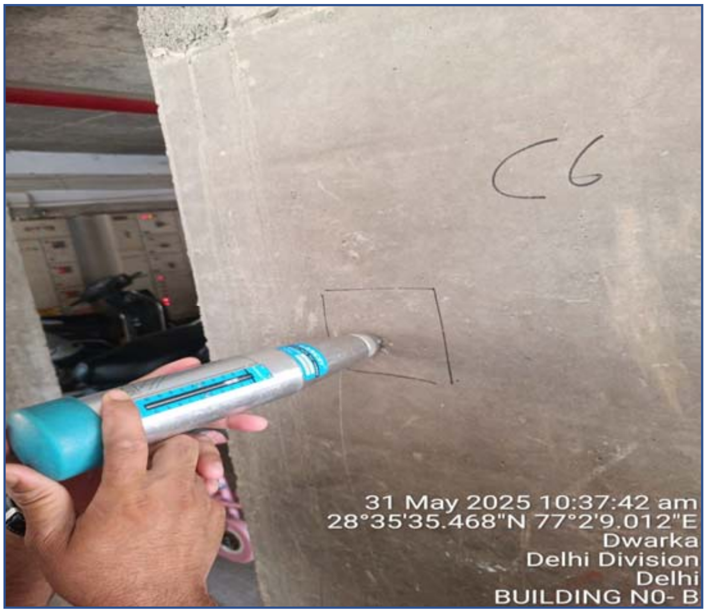
COLUMNS						
	COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
FIFTH FLOOR	C1	INDIRECT	300	51	6.4	EXCELLENT
	C2	INDIRECT	300	59	5.6	EXCELLENT
	C3	SEMIDIRECT	190	49	3.9	GOOD
	C4	SEMIDIRECT	190	48	4.0	GOOD
	C5	SEMIDIRECT	190	50	3.8	GOOD
	C6	SEMIDIRECT	212	55	3.9	GOOD
	C7	SEMIDIRECT	212	49	4.3	GOOD
	C8	DIRECT	300	74	4.1	GOOD
	C9	INDIRECT	300	65	5.1	EXCELLENT
	C10	DIRECT	230	56	4.1	GOOD
	C11	DIRECT	230	46	5.0	EXCELLENT
	C12	INDIRECT	300	52	6.3	EXCELLENT
	C13	DIRECT	230	48	4.8	EXCELLENT
	C14	INDIRECT	300	75	4.5	EXCELLENT
	C15	INDIRECT	300	71	4.7	EXCELLENT
	C16	INDIRECT	300	49	6.6	EXCELLENT
	C17	DIRECT	230	60	3.8	GOOD
	C18	INDIRECT	300	47	6.9	EXCELLENT
	C19	SEMIDIRECT	190	49	3.9	GOOD
	C20	INDIRECT	300	87	3.9	GOOD
	C21	INDIRECT	300	55	6.0	EXCELLENT
	C22	SEMIDIRECT	212	50	4.2	GOOD
	C23	INDIRECT	300	64	5.2	EXCELLENT
	C24	INDIRECT	300	45	7.2	EXCELLENT
	C25	SEMIDIRECT	212	68	3.1	DOUBTFUL
	C26	INDIRECT	300	66	5.0	EXCELLENT
	C27	DIRECT	230	51	4.5	EXCELLENT
	C28	INDIRECT	300	68	4.9	EXCELLENT
	C29	INDIRECT	300	49	6.6	EXCELLENT
	C30	SEMIDIRECT	190	49	3.9	GOOD
	C31	INDIRECT	300	55	6.0	EXCELLENT
	C32	DIRECT	230	67	3.4	DOUBTFUL
	C33	INDIRECT	300	85	4.0	GOOD
	C34	INDIRECT	300	56	5.9	EXCELLENT
	C35	INDIRECT	300	65	5.1	EXCELLENT
	C36	DIRECT	230	52	4.4	GOOD
	C37	INDIRECT	300	72	4.7	EXCELLENT
	C38	SEMIDIRECT	212	53	4.0	GOOD
	C39	INDIRECT	300	52	6.3	EXCELLENT
	C40	INDIRECT	300	49	6.6	EXCELLENT

COLUMNS						
	COLUMN NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	QUALITY
SEVENTH FLOOR	C1	INDIRECT	300	65	5.1	EXCELLENT
	C2	INDIRECT	300	80	4.3	GOOD
	C3	INDIRECT	300	52	6.3	EXCELLENT
	C4	INDIRECT	300	84	4.1	GOOD
	C5	DIRECT	230	48	4.8	EXCELLENT
	C6	INDIRECT	300	65	5.1	EXCELLENT
	C7	SEMI DIRECT	190	58	3.3	DOUBTFUL
	C8	INDIRECT	300	45	7.2	EXCELLENT
	C9	INDIRECT	300	74	4.6	EXCELLENT
	C10	DIRECT	230	58	4.0	GOOD
	C11	INDIRECT	300	56	5.9	EXCELLENT
	C12	SEMI DIRECT	212	56	3.8	GOOD
	C13	INDIRECT	300	60	5.5	EXCELLENT
	C14	INDIRECT	300	79	4.3	GOOD
	C15	INDIRECT	300	54	6.1	EXCELLENT
	C16	INDIRECT	300	66	5.0	EXCELLENT
	C17	INDIRECT	300	79	4.3	GOOD
	C18	DIRECT	230	49	4.7	EXCELLENT
	C19	INDIRECT	300	67	5.0	EXCELLENT
	C20	INDIRECT	300	69	4.8	EXCELLENT
	C21	INDIRECT	300	81	4.2	GOOD
	C22	SEMIDIRECT	212	53	4.0	GOOD
	C23	DIRECT	230	50	4.6	EXCELLENT
	C24	DIRECT	230	56	4.1	GOOD
	C25	INDIRECT	300	62	5.3	EXCELLENT
	C26	INDIRECT	300	56	5.9	EXCELLENT
	C27	DIRECT	230	52	4.4	GOOD
	C28	SEMIDIRECT	212	51	4.2	GOOD
	C29	INDIRECT	300	86	4.0	GOOD
	C30	DIRECT	230	45	5.1	EXCELLENT
	C31	DIRECT	230	56	4.1	GOOD
	C32	SEMIDIRECT	190	58	3.3	DOUBTFUL
	C33	INDIRECT	300	60	5.5	EXCELLENT
	C34	DIRECT	230	54	4.3	GOOD
	C35	DIRECT	230	64	3.6	DOUBTFUL
	C36	SEMIDIRECT	212	48	4.4	GOOD
	C37	DIRECT	230	51	4.5	EXCELLENT
	C38	INDIRECT	300	56	5.9	EXCELLENT
	C39	INDIRECT	300	87	3.9	GOOD
	C40	DIRECT	230	67	3.4	DOUBTFUL

AVERAGE QUALITY OF COLUMNS					
COLUMN NO.	BASEMENT	GROUND FLOOR	FIRST FLOOR	AVERAGE READING	QUALITY
C1	6.4	6.4	5.1	6.0	EXCELLENT
C2	5.6	5.6	4.3	5.1	EXCELLENT
C3	3.9	3.9	6.3	4.7	EXCELLENT
C4	4.0	4.0	4.1	4.0	GOOD
C5	3.8	3.8	4.8	4.1	GOOD
C6	3.9	3.9	5.1	4.3	GOOD
C7	4.3	4.3	3.3	4.0	GOOD
C8	4.1	4.1	7.2	5.1	EXCELLENT
C9	5.1	5.1	4.6	4.9	EXCELLENT
C10	4.1	4.1	4.0	4.1	GOOD
C11	5.0	5.0	5.9	5.3	EXCELLENT
C12	6.3	6.3	3.8	5.4	EXCELLENT
C13	4.8	4.8	5.5	5.0	EXCELLENT
C14	4.5	4.5	4.3	4.4	GOOD
C15	4.7	4.7	6.1	5.2	EXCELLENT
C16	6.6	6.6	5.0	6.1	EXCELLENT
C17	3.8	3.8	4.3	4.0	GOOD
C18	6.9	6.9	4.7	6.2	EXCELLENT
C19	3.9	3.9	5.0	4.2	GOOD
C20	3.9	3.9	4.8	4.2	GOOD
C21	6.0	6.0	4.2	5.4	EXCELLENT
C22	4.2	4.2	4.0	4.2	GOOD
C23	5.2	5.2	4.6	5.0	EXCELLENT
C24	7.2	7.2	4.1	6.1	EXCELLENT
C25	3.1	3.1	5.3	3.9	GOOD
C26	5.0	5.0	5.9	5.3	EXCELLENT
C27	4.5	4.5	4.4	4.5	GOOD
C28	4.9	4.9	4.2	4.7	EXCELLENT
C29	6.6	6.6	4.0	5.7	EXCELLENT
C30	3.9	3.9	5.1	4.3	GOOD
C31	6.0	6.0	4.1	5.3	EXCELLENT
C32	3.4	3.4	3.3	3.4	DOUBTFUL
C33	4.0	4.0	5.5	4.5	EXCELLENT
C34	5.9	5.9	4.3	5.3	EXCELLENT
C35	5.1	5.1	3.6	4.6	EXCELLENT
C36	4.4	4.4	4.4	4.4	GOOD
C37	4.7	4.7	4.5	4.6	EXCELLENT
C38	4.0	4.0	5.9	4.6	EXCELLENT
C39	6.3	6.3	3.9	5.5	EXCELLENT
C40	6.6	6.6	3.4	5.6	EXCELLENT

BEAMS						
GROUND FLOOR	BEAM NO.	TESTING METHOD	DISTANCE (MM)	TRAVEL TIME (MICROSEC)	AVERAGE VELOCITY (KM/SEC)	ESTIMATED STRENGTH (MPA)
	B1	INDIRECT	300	57	5.8	EXCELLENT
	B2	DIRECT	230	61	3.8	GOOD
	B3	DIRECT	230	47	4.9	EXCELLENT
	B4	INDIRECT	300	75	4.5	EXCELLENT
	B5	INDIRECT	300	87	3.9	GOOD
	B6	INDIRECT	300	54	6.1	EXCELLENT
	B7	SEMI DIRECT	210	51	4.1	GOOD
	B8	SEMI DIRECT	210	50	4.2	GOOD
	B9	DIRECT	230	55	4.2	GOOD
	B10	DIRECT	230	51	4.5	EXCELLENT
	B11	INDIRECT	300	48	6.8	EXCELLENT
	B12	DIRECT	230	52	4.4	GOOD
	B13	DIRECT	230	45	5.1	EXCELLENT
	B14	DIRECT	230	58	4.0	GOOD
	B15	DIRECT	230	51	4.5	EXCELLENT
	B16	DIRECT	230	54	4.3	GOOD
	B17	DIRECT	230	73	3.2	DOUBTFUL
	B18	DIRECT	230	61	3.8	GOOD
	B19	DIRECT	230	55	4.2	GOOD
	B20	DIRECT	230	56	4.1	GOOD

SNAPS



COLUMN REBOUND

COLUMN REBOUND

COLUMN REBOUND

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COLUMN REBOUND

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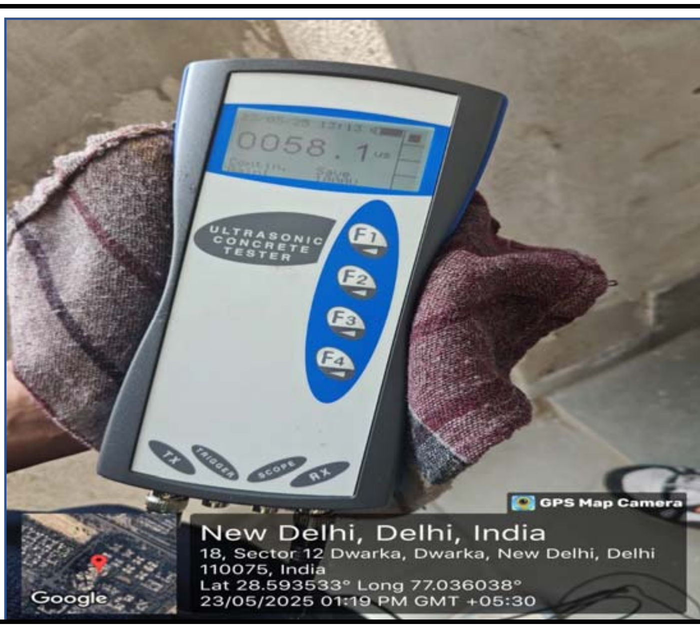
SLAB REBOUND	SLAB REBOUND

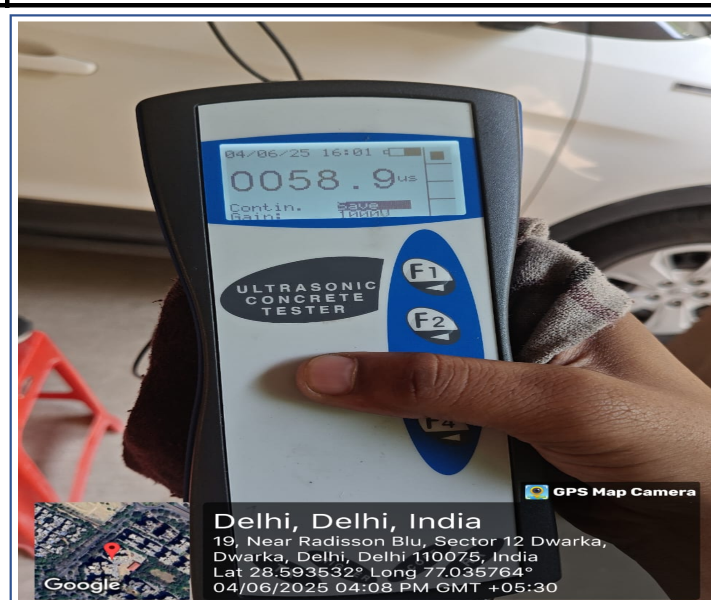
COLUMN UPVT	COLUMN UPVT



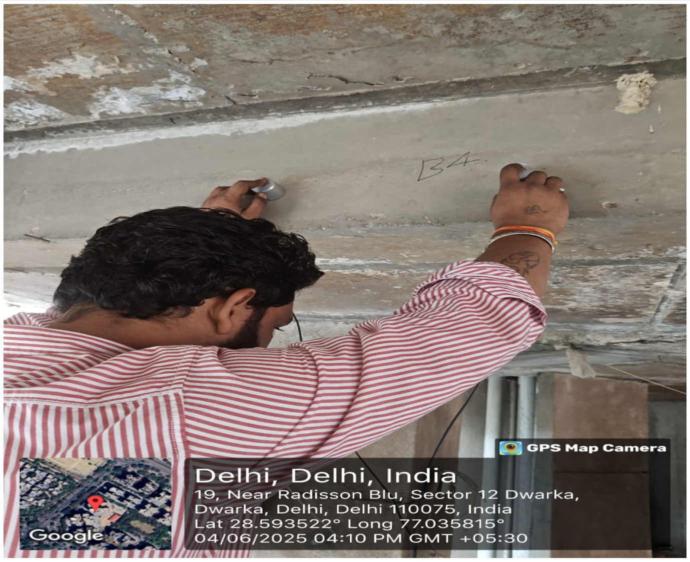
COLUMN UPVT	COLUMN UPVT

COLUMN UPVT	COLUMN UPVT

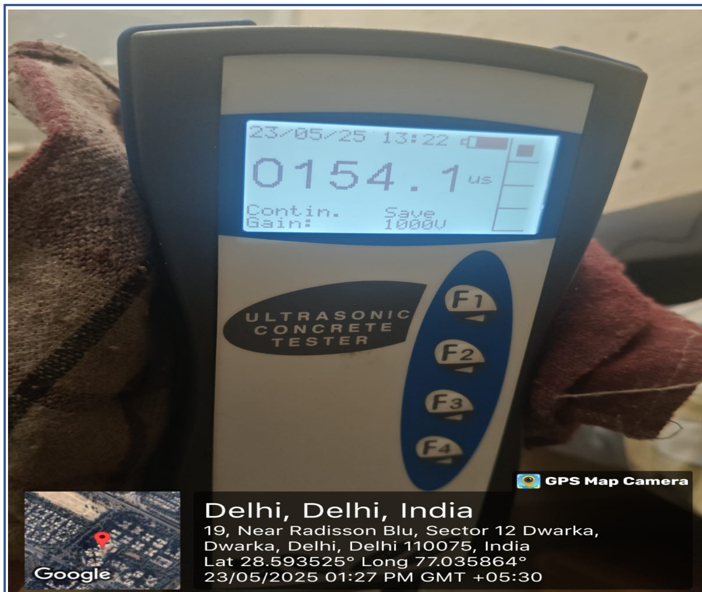
BEAM UPVT	BEAM UPVT



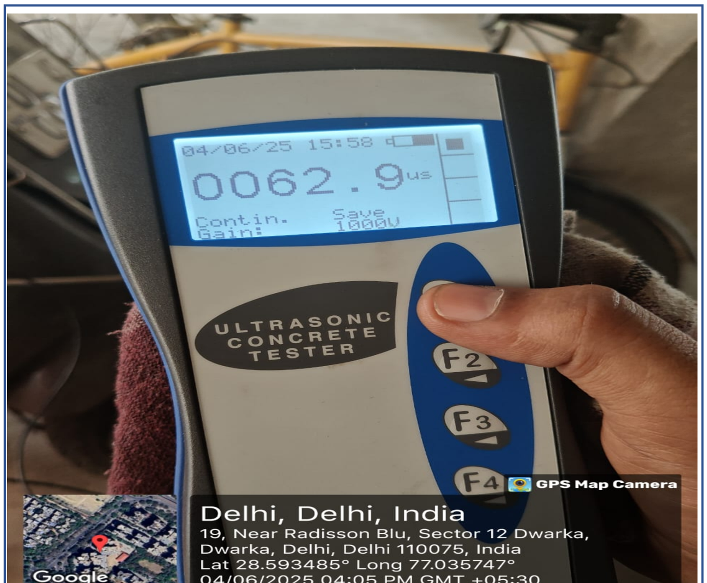
BEAM UPVT	BEAM UPVT

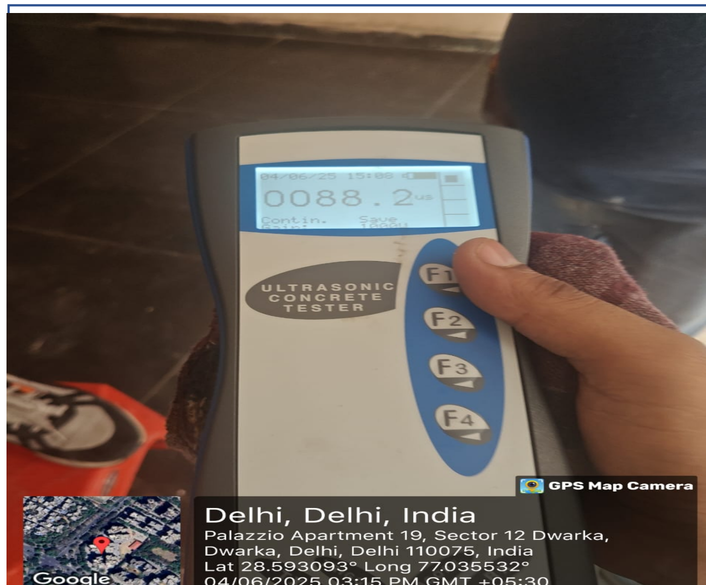


BEAM UPVT	BEAM UPVT



COLUMN UPVT	COLUMN UPVT





COLUMN UPVT	COLUMN UPVT

VISUAL INSPECTION FINDINGS

KEY POINTS – BLOCK A

Observation Summary:

- Cracks were found in balcony beams, stairwall beams, and passage beams and also in some columns Seepage observed in shaft areas across all floors.

Technical Reasoning:

- Likely due to thermal movement, environmental exposure, structural fatigue, and inadequate maintenance.

Construction Errors:

- Not considered the cause. Deterioration attributed to service-related and environmental factors.
- Cracks: Epoxy grouting, or jacketing based on severity.
- Seepage: PU injection, waterproofing renewal, and plumbing checks.
- General: Initiate a regular structural maintenance plan.

Implications:

- Cracks may reduce structural capacity; seepage can cause corrosion, electrical risk, and health concerns.

Relevant IS Codes:

- IS 456:2000, IS 3370, IS 15988:2013, NBC 2016 (Part 3 & 4).

1. Cracks in Balcony Beams – 1st and 3rd Floor

Observation:

- Linear cracks were observed in the balcony beams on the 1st and 3rd floors. Cracks appear near the cantilever ends, mostly on the soffit (bottom surface), suggesting flexural stress-induced failure.

Probable Causes:

- These cracks have developed due to prolonged cantilever loading, thermal expansion/contraction, and exposure to weathering.

Long-Term Impact:

- Continuous widening of cracks can lead to water seepage, corrosion of embedded reinforcement, spalling of concrete, and eventual reduction in load-bearing capacity of the cantilever elements.

Preventive & Remedial Measures:

- Inject epoxy grout into cracks.
- For significant distress, use carbon fiber reinforced polymer (CFRP) wrapping.
- Apply waterproofing and slope correction to drain water away from beam surfaces.
- This location contains all three types of cracks—minor, moderate, and major. Kindly refer to the repair methodology and recommended treatments as detailed on Pages 87 to 92 &114 to 120 of this report. Apply appropriate solutions based on the crack severity observed at each location.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013, IS 3370:2009

2. Seepage in Shaft Areas – All Floors

Observation:

- Visible damp patches and calcification marks were present in all floor-level shaft walls. Water dripping was observed in some cases, particularly near plumbing interfaces.

Probable Causes:

- Seepage is due to aging or failed waterproofing, poor sealing of plumbing joints, or degradation of shaft wall surfaces over time.

Long-Term Impact:

- Continuous seepage can weaken the concrete, corrode reinforcement, damage utilities, and increase the risk of fungal growth and foul odors inside the shafts.

Preventive & Remedial Measures:

- Apply (PU) injection grouting to seal active leaks.
- Replace old pipe gaskets and refit joints with water-tight sealants.
- Use internal waterproof coatings and external membranes for protection.
- Recommended treatments as detailed on Pages 87 to 92 &114 to 120 of this report.




Relevant IS Codes:

- IS 456:2000, IS 3370 (Parts 1 to 4), NBC 2016 – Plumbing & Services

3. Beam Cracks – Ground Floor Passage Between Type A1 and Type A2

Observation:

- Diagonal and flexural cracks were observed in RCC beams in the passage connecting sections type A1 and type A2. Cracks were most visible near beam-column junctions and mid-spans.

Probable Causes:

- Cracks are due to accumulated structural loading over time and differential deflection between wings.

Long-Term Impact:

- Potential weakening of load paths in a key circulation area. Prolonged inaction can result in deflection, instability, or even progressive cracking along connected members.

Preventive & Remedial Measures:

- Strengthen using steel jacketing Or RC jacketingr or polymer mortar repair/micro concrete.
- Refer repair methodology and recommended treatments as detailed on Pages 987 to 92 &114 to 120.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013.

4. Beam Cracks Around Stair Wall – All Floors

Observation:

- Horizontal and vertical cracks were noticed in beams supporting stair walls on each floor. These cracks were mostly continuous at the same level on every floor, showing consistent stress impact.

Probable Causes:

- Cracks likely developed due to vibration from regular use, long-term shrinkage, and rigid wall-beam connections lacking movement tolerance.

Long-Term Impact:

- Cracks may propagate into adjacent walls and lead to loss of load-sharing capacity between stairs and core beams, posing evacuation and safety concerns.

Preventive & Remedial Measures:

  - Apply sealants in cracks.
  - Retrofit stair beams with additional rebar or polymer mortar repair or micro concrete.
  - Pages refer 87 to 92 &114 to 120.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013, NBC Part 4 – Safety of Staircases

5. Beam Crack at Passage End – 1st Floor

Observation:

- A significant crack was identified at the end of the passage beam at the 1st floor junction, where differential structural movement appears to have concentrated stress.

Probable Causes:

- This is a service-related crack due to edge restraint, unequal support stiffness, or improper load transfer over time.

Long-Term Impact:

- Stress concentration may induce torsional cracking or lead to eventual shear failure if left unattended.

Preventive & Remedial Measures:

- Add additional reinforcement if exposed (by weld method).
- Retrofit stair beams with additional rebar or polymer mortar repair or use micro concrete.
- Monitor with strain gauges for movement tracking.
- Refer to the repair methodology and recommended treatments as detailed on Pages 87 to 92 &114 to 120 of this report.

Relevant IS Codes:

- IS 456:2000, IS 13920:2016

6. Shaft Wall Cracks – TYPE-B1,(All Floors)

Observation:

- Vertical cracking with spalling of cover concrete was found in shaft walls across floors. In some areas, visible reinforcement corrosion was also noted.

Probable Causes:

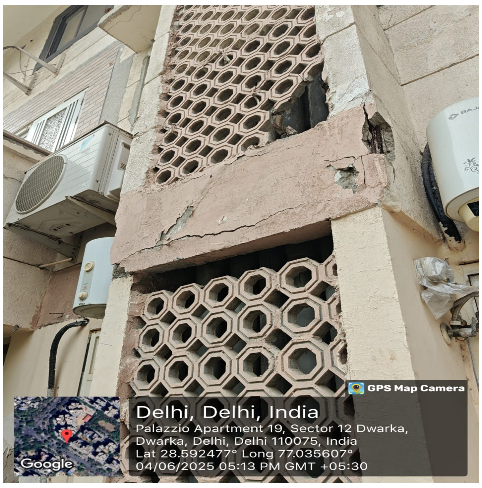
- The cause is expansion and contraction of conduits, unprotected openings, and long-term water ingress.

Long-Term Impact:

- Weakening of shaft enclosure, collapse of non-structural walls, exposure of reinforcement to accelerated corrosion.

Preventive & Remedial Measures:

  - Apply waterproof mortar coating.
  - Isolate plumbing to reduce dynamic stress.
  - Refer Pages 87 to 92 &114 to 120 of this report.



Relevant IS Codes:

- IS 456:2000, IS 3370.

7. Balcony Crack – TYPE-C2 (1st Floor)

Observation:

- A wide flexural crack was seen at the base of the balcony slab near the wall connection.

Probable Causes:

- Crack likely due to cantilever stress, temperature fluctuation, and insufficient drainage leading to water retention.

Long-Term Impact:

- Sagging of balcony slab, detachment risk, reinforcement exposure.

Preventive & Remedial Measures:

  - This location contains all three types of cracks—minor, moderate, and major. Kindly refer to the repair methodology and recommended treatments as detailed on Pages 87 to 92 &114 to 120 of this report. Apply appropriate solutions based on the crack severity observed at each location.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013

8.Passage Area (Multiple Floors)

Observation:

- Seepage marks and damp patches were observed on the floor slabs and sidewalls of the passage areas on multiple levels. Numerous potted plants are placed along the passage, and excessive watering was noted. Rust stains are also visible on some ceiling surfaces, indicating ongoing reinforcement corrosion.

Probable Cause of Deterioration:

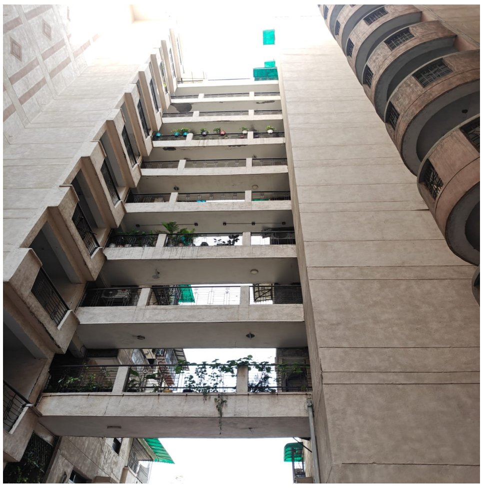
- Continuous and excessive watering of potted plants has resulted in water accumulation and seepage through slab joints and cracks. Lack of waterproofing and proper drainage has allowed moisture to reach embedded reinforcement.

Long-Term Impact:

- Corrosion of reinforcement leading to expansion and cracking of concrete.
- Gradual weakening of the slab and reduced load-bearing capacity.
- Fungal/mold growth affecting aesthetics and hygiene.
- Degradation of plaster and paint layers.

Preventive & Remedial Measures:

- Relocate plants or place waterproof trays below pots.
- Perform anti-corrosive treatment and patch repair where rusting is evident.
- Apply waterproofing treatment to slab surfaces.
- Replaster and repaint with moisture-resistant materials.
- Regular monitoring for corrosion signs in affected zones.



Relevant IS Codes:

- IS 456:2000 – Durability and corrosion protection in RCC.
- IS 2645:2003 – Integral waterproofing additives.
- IS 13311 (Part 1):1992 – UPV test to assess concrete quality and delamination due to rusting.

KEY POINTS – BLOCK B

Observation Summary:

- Cracks were observed in balcony beams, passage beams, slab areas, stair wall beams, and multiple columns across various floors. Seepage and shaft cracks were found consistently on all floors.

Technical Reasoning:

- The deterioration is likely due to environmental exposure, structural fatigue, thermal movements, and lack of preventive maintenance over time.

Construction Errors:

- Construction-related errors are not considered the cause. Defects are attributed to service-related degradation and natural aging of structural components. **:**

Implications:

- Cracks may reduce load-bearing capacity, especially in beams, columns, and slab edges. Seepage can lead to corrosion, structural damage, and health hazards due to moisture retention.

Relevant IS Codes:

- IS 456:2000, IS 3370, IS 15988:2013, NBC 2016 (Part 3 & 4).

1. Shaft Seepage and Beam Cracks – Type B2 (All Floors)

Observation:

- Damp patches and cracking were noted in the beams adjacent to the shaft walls across all floors. Leakage from plumbing lines was visible in some shafts.

Probable Cause of Deterioration:

- Failed waterproofing, plumbing leaks, and long-term exposure to damp conditions.

Long-Term Impact:

- Rusting of embedded reinforcement, reduction in concrete strength, interior damage.

Preventive & Remedial Measures:

- PU injection grouting.
- Plumbing replacement and shaft re-waterproofing.
- Coating inner shaft walls with crystalline sealants.
- Retrofit beams with additional polymer mortar repair.
- Refer Pages 87 to 92 &114 to 120 of this report.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013.

2. Balcony Beam Crack – Type B2

Observation:

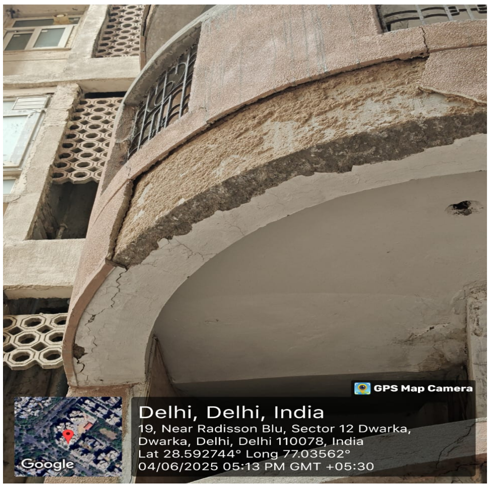
- Crack visible along soffit and cantilever end of the balcony beam on upper floors, with minor concrete delamination.
- Probable Cause of Deterioration:
- Environmental exposure, overloading of cantilever, and concrete fatigue.

Long-Term Impact:

- Sagging, spalling, and risk of concrete fragment fall.

Preventive & Remedial Measures:

- Seal cracks with epoxy.
- Provide adequate water drainage on balcony slab.
- Retrofit beams with additional polymer mortar repair or with additional rebar .
- Refer Pages 87 to 92 &114 to 120 of this report.



Relevant IS Codes:

- IS 456:2000, IS 15988:2013

4. Balcony Beam Cracks – Type D (2nd and 4th Floors)

Observation:

- Diagonal and horizontal cracks were observed in the balcony beams at the 2nd and 4th floors, indicating distress from flexure and rotation.

Probable Cause of Deterioration:

- Cantilever fatigue, water stagnation, and weathering.

Long-Term Impact:

- Localized failure, detachment risk, and water seepage into rooms.

Preventive & Remedial Measures:

  - Polymer-modified mortar repair.
  - steel rebar reinforcement by welding in case existing bar is rusted.
  - Retrofit beams with polymer mortar repair.
  - Refer Pages 87 to 92 &114 to 120 of this report.

Relevant IS Codes:

- IS 456:2000, IS 3370

5. Cracks in Passage Columns – Type-D (Ground, 1st, 5th, 6th, 7th Floors)

Observation:

- Vertical cracks and micro-spalling were found in columns supporting the passage corridor slabs.

Probable Cause of Deterioration:

- Load cycles from pedestrian traffic, reinforcement corrosion, and settlement.

Long-Term Impact:

- Reduced load capacity, potential instability in corridor support system.

Preventive & Remedial Measures:

  - Column jacketing with RCC/Retrofit column with additional polymer mortar repair.
  - Application of corrosion inhibitors.
  - Refer Pages 87 to 92 &114 to 120 of this report.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013

6. Passage Beam Cracks – All Floors

- **Observation:**
- Hairline to moderate cracks were seen in passage beams throughout all floors, particularly near mid-span and wall supports.
- Probable Cause of Deterioration:
- Overuse, thermal cycling, and lack of expansion joints.

Long-Term Impact:

- Risk of structural fatigue, slab settlement, and widening of cracks.

Preventive & Remedial Measures:

  - Repair cracks with epoxy grouting.
  - Add steel reinforcements by welding method .
  - Refer Pages 87 to 92 &114 to 120 of this report.
  - Retrofit beams with additional bars or polymer mortar repair.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013.

7. Shaft Column Cracks – Type B2 (1st and 2nd Floors)

Observation:

- Shaft-supporting columns showed diagonal and vertical cracks, with exposed reinforcement and moisture stains.

Probable Cause of Deterioration:

- Continuous damp conditions, lack of proper ventilation, and corrosion of rebars.

Long-Term Impact:

- Loss of axial capacity, increased seismic vulnerability.

Preventive & Remedial Measures:

- Jacketing of columns.
- Apply anti-corrosion treatment.
- Improve ventilation and isolate pipes from concrete surface.
- Refer Pages 87 to 92 &114 to 120 of this report.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013.

8. Balcony Slab Ceiling and Beam Cracks – Type C2

Observation:

- Cracks were observed in both the balcony slab and beam, with visible efflorescence and minor concrete surface wear.

Probable Cause of Deterioration:

- Prolonged exposure to moisture, inadequate drainage, and structural aging.

Long-Term Impact:

- Surface delamination, steel corrosion, and slab failure risk.

Preventive & Remedial Measures:

- Surface waterproofing.
- Crack injection and surface restoration.
- Provide edge protection.
- Retrofit with additional polymer mortar & additional reinforcement if required.
- Pages refer to 87 to 92 &114 to 120.

Relevant IS Codes:

- IS 456:2000, IS 3370

9. Beam and Column Cracks – Type C1 (2nd & 3rd Floor Beams, 1st Floor Columns)

Observation:

- Flexural beam cracks and column surface cracking were observed. Minor rust streaks suggest steel exposure.

Probable Cause of Deterioration:

- Creep, concrete degradation, and loss of protective cover.

Long-Term Impact:

- Structural weakening, water ingress, and eventual failure under peak loading.

Preventive & Remedial Measures:

- Crack sealing and corrosion protection.
- Column jacketing & Retrofit beams with additional polymer mortar repair/Micro concrete.
- This location contains all three types of cracks—minor, moderate, and major. Refer to the repair methodology and recommended treatments as detailed on Pages 87 to 92 &114 to 120 of this report. Apply appropriate solutions based on the crack severity observed at each location.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013

10. Stair Wall Beam Cracks – All Floors

Observation:

- Continuous cracking was observed along beams supporting stair walls, especially near landings and turns.

Probable Cause of Deterioration:

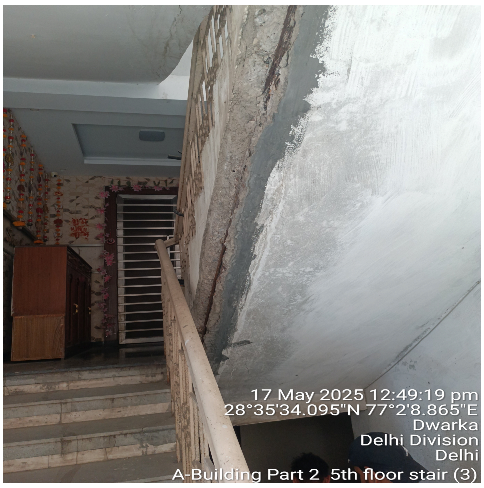
- Dynamic foot traffic loads, shrinkage, and aging reinforcement.

Long-Term Impact:

- Risk to stair structural integrity, unsafe evacuation during emergencies.

Preventive & Remedial Measures:

  - Epoxy sealing of cracks.
  - Strengthen with steel or RCC jacketing around the cracked beam area.
  - Retrofiting with additional polymer mortar repair/ micro concrete.
  - Page refer to 87 to 92 &114 to 120.



Relevant IS Codes:

- IS 456:2000, NBC 2016 – Part 4

11. Block B – Passage Area (Multiple Floors)

Observation:

- Damp patches, seepage lines, and minor plaster deterioration observed in ceiling and slab areas where numerous plant pots are kept. Rust stains and exposed rebars were seen in some areas, especially near ceiling edges.

Probable Cause of Deterioration:

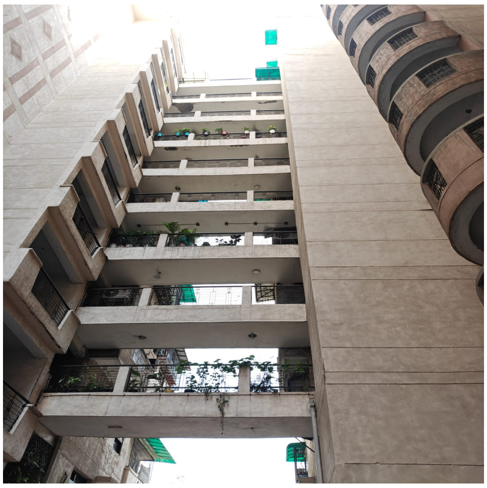
- Prolonged moisture exposure due to daily overwatering of plants without waterproofing or drainage provisions has allowed water to reach steel reinforcement, causing corrosion.

Long-Term Impact:

- Accelerated reinforcement rusting, leading to spalling of concrete.
- Loss of structural integrity in slab and beam edges.
- Health hazards from moisture retention and mold.
- Slippery surfaces creating safety risks.

Preventive & Remedial Measures:

- Shift plants to alternate locations or install proper water-collection trays.
- Clean rust-affected steel and apply protective coatings.
- Carry out RCC patch repair where rebars are exposed.
- Improve surface slope and drainage in the passage area.




Relevant IS Codes:

- IS 456:2000 – Concrete durability and exposure classification.
- IS 9077:1979 – Corrosion protection for reinforcement.
- IS 1346:1991 – Maintenance practices in residential buildings.

KEY POINTS – BLOCK C

Observation Summary:

- Cracks were observed in beams across 1st, 2nd, and 3rd floors, including balcony beams. Additional cracks were found in stair beams and columns across multiple floors. Seepage was detected in shaft areas, and balcony cracks were noted on higher and lower levels.

Technical Reasoning:

- The structural issues are attributed to long-term environmental exposure, thermal effects, aging of materials, and lack of systematic upkeep.

Construction Errors:

- Construction defects are not considered a contributing factor. Observed deterioration is consistent with service life stresses and maintenance deficiencies.

Recommended Measures:

  - Cracks: Use epoxy injection or polymer-modified repair mortar .

  - Seepage: Seal shaft areas using PU injection and improve waterproofing layers; inspect and repair service lines where needed.
  - General: Initiate a regular monitoring and maintenance program for structural and waterproofing systems.

Implications:

- Unattended cracks can reduce structural reliability, especially in beams and columns. Shaft seepage can accelerate reinforcement corrosion and compromise durability.

Relevant IS Codes:

- IS 456:2000, IS 3370, IS 15988:2013, NBC 2016 (Part 3 & 4).

1. Beam Cracks – Type A (1st, 2nd, and 3rd Floors)
Observation:

- Cracks were noted on the underside (soffit) of RCC beams across the 1st, 2nd, and 3rd floors of Type A. These included mid-span flexural cracks and inclined shear cracks near beam-column junctions. The cracks showed signs of widening and mild rust streaks in some areas.
- **Probable Causes:**
- Long-term sustained loading from supported slabs and walls, loss of stiffness due to micro-cracking, and concrete creep. Temperature fluctuations and vibration loads have exacerbated beam distress.

- **Long-Term Impact:**
- Decrease in flexural and shear capacity, risk of slab sagging or deflection, and possible failure of floor elements in extreme conditions.

Preventive & Remedial Measures:

- Inject epoxy into visible cracks after cleaning.
- Monitor crack width periodically and limit imposed loads during remediation.
- Strengthen the beam with additional polymer mortar repair/micro concrete & additional reinforcement with section enlargement if required.
- page refer to 87 to 92 &114 to 120.




Relevant IS Codes:

- IS 456:2000, IS 15988:2013, IS 13311 (NDT)

2. Balcony Crack – Type A (3rd Floor)

Observation:

- The cantilever slab of the balcony at the 3rd floor showed transverse and edge cracks, some over 3 mm in width. Surface spalling was visible near the front edge, and signs of seepage and weathering were evident.

Probable Causes ;

- Flexural fatigue from prolonged cantilever stress, inadequate water drainage leading to pooling, and thermal stress cycles causing concrete degradation.

Long-Term Impact:

- Structural weakening of the balcony, leading to reduced safety margins, reinforcement corrosion, and potential falling hazards.

Preventive & Remedial Measures:

- Repair the cracks using polymer-modified concrete.
- Strengthen the cracks with a additional reinforcement by weld method if required.
- This location contains all three types of cracks—minor, moderate, and major. Kindly refer to the repair methodology and recommended treatments as detailed on Pages 87 to 92 &114 to 120 of this report. Apply appropriate solutions based on the crack severity observed at each location.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013, IS 3370 (Part 2)

3. Shaft Seepage – Type B1 (All Floors)

Observation:

- Vertical shafts exhibited continuous dampness, visible pipe joint leaks, and peeling of internal surface coatings. In several areas, calcified deposits and fungal patches were noted.

Probable Causes :

- Failure of waterproofing and insulation, cracked or aged service pipes, thermal expansion of conduits stressing wall seals, and lack of shaft ventilation.

Long-Term Impact:

- Compromised integrity of shaft walls, corrosion of embedded reinforcement, pipe degradation, and poor hygiene conditions.

Preventive & Remedial Measures:

  - Apply PU-based injection grouting in cracks.
  - Replace leaking joints and provide pipe sleeves.
  - Use breathable yet water-tight shaft coatings.
  - Improve shaft airflow via mechanical or passive ventilation.

Relevant IS Codes:

- IS 456:2000, IS 3370, NBC 2016 Part 4 – Plumbing & Services

4. Balcony Cracks – Type B1 (2nd and 8th Floors)

Observation:

- Balcony slabs on these floors showed diagonal cracks and surface deterioration. Crack width was between 1–4 mm and appeared deeper near the outer corners.

Probable Causes :

- Lack of slope, continuous exposure to weather, and improper detailing at cantilever edges allowing water ingress and reinforcing bar corrosion.

Long-Term Impact:

- Risk of edge failure, reinforcement corrosion leading to further cracking, and potential water seepage into interiors below.

Preventive & Remedial Measures:

  - Repair cracks using high-adhesion epoxy mortar.
  - Strengthen the cracks with a additional reinforcement by weld method .
  - Monitor for slab deflection using optical or laser methods.
  - Page refer 87 to 92 &114 to 120.

Relevant IS Codes:

- IS 456:2000, IS 3370, IS 15988:2013

5. Stair Beam Cracks – Type C1

Observation:

- Cracks in stair-supporting beams were found on multiple landings. Cracks ran transversely and diagonally from beam ends toward the mid-span.

Probable Cause of Deterioration:

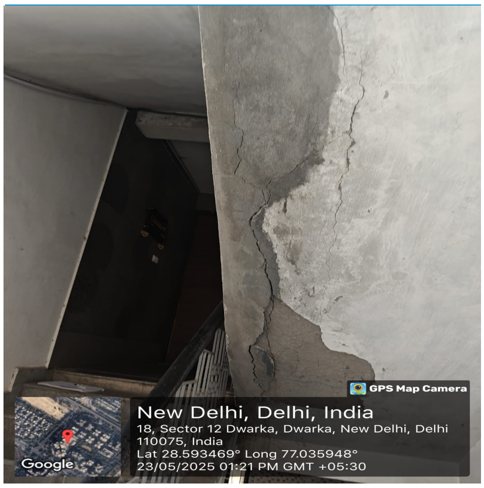
- High-frequency footfall vibrations, differential movement between stairs and supporting walls, and environmental exposure leading to tension stress in landing beams.

Long-Term Impact:

- Reduction in support strength, risk of disconnection between stairs and structural core, and unsafe conditions for emergency evacuation.

Preventive & Remedial Measures:

  - Repair with crack injection and polymer-concrete overlays.
  - Strengthen the beam with a additional reinforcement by weld method if bar is badly rusted.
  - Retrofit stair beams with polymer mortar/micro concrete repair.
  - Page refer to 87 to 92 &114 to 120.



Relevant IS Codes:

- IS 456:2000, IS 15988:2013, NBC 2016 – Stair Design

6. Column Cracks – Type C2 (All Floors)

Observation:

- Vertical cracks up to 5 mm wide were observed along the faces of columns from ground to top floors. Rust streaks and cover spalling were visible in some areas.

Probable Cause of Deterioration:

- Weathering of external columns, loss of protective cover, carbonation, and internal corrosion of longitudinal rebars.

Long-Term Impact:

- Degradation of load-bearing capacity, risk of structural instability during lateral events (wind, seismic), and eventual rebar failure.

Preventive & Remedial Measures:

- Retrofit with polymer mortar repair/Micro concrete.
- Jacketing using steel bars for damaged columns.
- page refer to 87 to 92 &114 to 120.




Relevant IS Codes:

- IS 456:2000, IS 15988:2013, IS 1343:2012

7. Balcony Crack – Type C2 (1st Floor)

Observation:

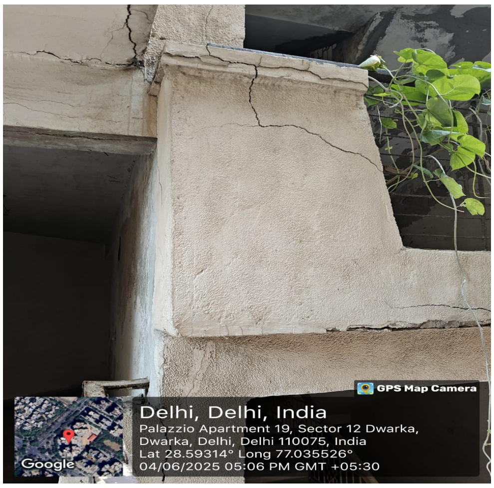
- Bottom-face cracks were noted on the 1st-floor balcony slab. Minor root growth and plaster peeling suggest long-term moisture exposure.
- Probable Cause of Deterioration:
- Poor waterproofing and finishing, accumulated organic deposits, and concrete cover loss due to dripping water.

Long-Term Impact:

- Risk of slab fragment falling, water seepage into lower units, corrosion, and aesthetic degradation.

Preventive & Remedial Measures:

- Remove vegetation and biofilm.
- Seal cracks with PU based injection.
- Resurface slab with new waterproof layer.
- This location contains all three types of cracks—minor, moderate, and major. Kindly refer to the repair methodology and recommended treatments as detailed on Pages 87 to 92 &114 to 120 of this report.



Relevant IS Codes:

- IS 456:2000, IS 3370, IS 15988:2013

8. Beam Cracks – Type B1 (1st and 3rd Floors)

Observation:

- Beams displayed multiple longitudinal cracks and minor deflection at the mid-span. Steel exposure was noted at crack sites, with water stains nearby.
- Probable Cause of Deterioration:
- Aging of concrete, bar corrosion causing cracking through expansion, and long-term service loading.

Long-Term Impact:

- Flexural failure under high loads, widening of cracks, water infiltration into lower floors.

Preventive & Remedial Measures:

- ∘ Retrofit beams with additional bars & polymer mortar repair/micro concrete.
- ∘ Replace exposed and rusted rebars and weld new bars.
- ∘ Page refer to 87 to 92 &114 to 120.

Relevant IS Codes:

- IS 456:2000, IS 15988:2013

9. Seepage in Passage Area (Multiple Floors)

Observation:

- Seepage stains, damp ceiling patches, and salt deposits (efflorescence) noted in several locations under potted plant zones. Rust streaks and localized concrete delamination were also observed, indicating corrosion of internal reinforcement.

Probable Cause of Deterioration:

- Continuous watering of plants without drainage control has allowed water to percolate into the slab, initiating corrosion in rebars and degrading surface finishes.

Long-Term Impact:

  - Rusting of reinforcement, causing cracking and section loss.
  - Increased maintenance costs and potential structural safety concerns.
  - Formation of damp, unsightly surfaces with health and slip hazards.

Preventive & Remedial Measures:

  - Remove plants from critical slab zones or use controlled irrigation methods.
  - Conduct detailed assessment for corrosion extent using NDT methods.
  - Repair affected concrete and provide rust inhibition treatment.
  - Apply waterproof coatings and ensure future moisture isolation.

Relevant IS Codes:

  - IS 456:2000 – Guidance on cover requirements and corrosion control.
  - IS 2645:2003 – Waterproofing additives.
  - IS 13311 (Part 2):1992 – Rebound Hammer for surface concrete integrity.

KEY POINTS – PARKING BUILDING

Observation Summary:

- Clear cover in RCC slab is deteriorated at several locations, leading to exposed and rusted rebars.
- Multiple cracks observed in beams, potentially due to aging or load effects.
- Columns show minor plaster damage, but no visible structural cracks or core deterioration.

Technical Reasoning:

- Structural issues appear to be caused by long-term environmental exposure, moisture ingress, aging of materials, and lack of regular maintenance.
- No signs of sudden or recent structural failure mechanisms.

Construction Errors:

- Construction defects are not considered a cause. Deterioration is consistent with typical wear and tear and environmental service conditions.

Recommended Measures:

- Slab: Remove loose concrete, clean and treat rebars, and repair cover with polymer-modified mortar & replace badly rusted bars; apply protective waterproof coating.
- Beams: Inject epoxy in cracks; steel bars jacketing where required.
  Columns: Replaster damaged areas and apply waterproof/protective paint.
- General: Schedule periodic inspections and initiate a preventive maintenance
- program for structural and waterproofing systems.

Implications:

- If not addressed, deterioration may lead to progressive structural weakening, corrosion spread, and safety hazards in high-traffic parking zones.

1.Element: RCC Slab

Observation:

- Clear cover has deteriorated at several locations in the slab, leading to exposed and rusted reinforcement bars. Spalling and delamination are visible around affected zones.

Probable Cause of Deterioration:

- Prolonged exposure to moisture, carbonation of concrete, and inadequate maintenance led to corrosion of rebars. Aging and environmental effects have reduced the effectiveness of the cover.

Long-Term Impact:

  - Progressive corrosion of rebars, reducing cross-sectional area and structural capacity.
  - Cracking and falling concrete posing safety risks.
  - Accelerated deterioration if left unaddressed.

Preventive & Remedial Measures:

- Concrete steel bars are prone to rust when exposed; use rust removers to clean the exposed reinforcement before repair.
- Remove all loose or delaminated concrete until a sound and firm base is reached.
- Use a high-pressure water jet to clean the concrete. Keep the surface moist, but avoid water accumulation.
- If the reinforcement bars are heavily rusted or pitted, remove the damaged section and replace it by welding new bars to the existing reinforcement as per lap length requirements.
- For moderate cracks and uneven surfaces, fix galvanized chicken mesh to the area using U-clamps or steel nails, then apply polymer-modified cement mortar.
- For minor cracks, apply polymer-based cement mortar directly after cleaning and surface preparation.
- Fill the prepared mortar around the reinforcement, compact properly, and level the surface before final setting.
- Maintain curing for 7 days using water spray or curing compound.
- Refer to Pages 87 to 92 &114 to 120 of this report for detailed methodology and illustrations.

Relevant IS Codes:

- IS 456:2000 – Reinforcement cover and durability.
- IS 9077:1979 – Corrosion protection.
- IS 13311 Part 1 & 2 – NDT for concrete assessment.

2. Element: RCC Beams

Observation:

- Cracks were observed in several beams across the parking area. Some appear diagonal and may be indicative of flexural or shear distress.

Probable Cause of Deterioration:

- Aging-related material fatigue, possible overloading, and minor corrosion-induced expansion may have led to these cracks.

Long-Term Impact:

- Potential reduction in flexural or shear strength of beams.
- Increased moisture ingress and corrosion risk.
- Structural instability if cracks propagate or deepen.

Preventive & Remedial Measures:

- Inject epoxy into active structural cracks for minor cracks.
- Retrofit beams with additional bars & polymer mortar repair or micro concrete. Replace exposed and rusted rebars and weld new bars if existing bar is badly rusted.
- Monitor cracks for future widening or structural activity.
- page refer to 87 to 92 &114 to 120.

Relevant IS Codes:

- IS 456:2000 – Crack width control and repair standards.
- IS 516:2018 – Structural testing methods.
- IS 15988:2013 – Guidelines for FRP strengthening.

3.Element: RCC Columns

Observation:

- Minor damage observed on surface plaster of a few columns. No visible structural cracks or signs of distress in core concrete or rebars.

Probable Cause of Deterioration:

- Environmental wear and tear, accidental impact from vehicles, or aging surface degradation.

Long-Term Impact:

- Reduced aesthetics.
- May allow ingress of moisture leading to long-term deterioration if left unrepaired.

Preventive & Remedial Measures:

- Remove damaged plaster and reapply cement mortar or use micro concrete with waterproofing additive.
- Replace exposed and rusted rebars and weld new bars if existing bar is badly rusted.
- Periodic inspection to ensure no hidden cracks develop.
- refer to the repair methodology and recommended treatments as detailed on Pages 87 to 92 &114 to 120.of this report.

Relevant IS Codes:

- IS 2395:1994 – Plastering guidelines.
- IS 456:2000 – Maintenance and repair practices.

Classification of Cracks in Beams and Columns with Remedial Measures :

1. Minor Cracks
Crack Width: ≤ 0.8mm
Nature: Superficial surface cracks (shrinkage, thermal or settlement-induced)
Structural Impact: Negligible; does not compromise structural integrity
Recommended Remedial Measures:

1. Surface Preparation

- Clean the cracked surface thoroughly using a wire brush or compressed air to remove dust, loose particles, or paint.
- Remove any efflorescence or superficial laitance to expose a sound substrate.

2. Crack Opening (if required)

- For hairline or very fine cracks, slightly widen the cracks (~5 mm) using a grinder or chisel to ensure better bonding with the repair material.

3. Application of Bonding Agent

- Apply a cementitious or polymer-based bonding agent to the prepared crack area to improve adhesion between the old surface and new mortar.

4. Rich Mortar Repair

- Prepare rich cement mortar (typically in the ratio 1:3 or 1:2.5 cement to sand) with water-reducing admixtures if required.
- Apply the mortar using a trowel and press firmly into the crack groove.
- Finish with a float or trowel to match the surrounding surface.

5. Curing

- Begin curing 6–8 hours after application using wet hessian cloth or water spray.
- Maintain moist curing for at least 7 days to achieve effective bonding and prevent shrinkage.

Additional Solutions & Best Practices

- **Protective Coating:** After curing, apply an elastomeric or acrylic-based waterproof coating to prevent moisture ingress and environmental exposure.
- **Monitoring**: Mark and monitor the repaired areas over time to detect any propagation.
- **Sealing Fine Surface Cracks:** For micro-cracks <0.2 mm, apply penetrative crack sealers like low-viscosity silane/siloxane sealers.
- **Prevent Recurrence:** Identify and correct root causes (e.g., shrinkage, moisture movement, inadequate cover) through better waterproofing and drainage.

Moderate Cracks
Crack Width: 0.8 mm to 1.4 mm
Nature: Flexural or diagonal cracks that may extend into the concrete core.
Structural Impact: Moderate; may initiate corrosion or reduce durability.
Recommended Remedial Measures:

1. Surface Preparation

- Clean the cracked surface thoroughly using a wire brush and air blower to remove dust, paint, or debris.
- Slightly widen the cracks (~5–10 mm) using a grinder or chisel to create a groove for repair material.

2. Bonding Agent Application

- Apply a polymer-modified bonding agent or slurry (cement + SBR latex) to the groove and surrounding surface to ensure proper adhesion.

3. Epoxy Injection (if structural bonding is required)

- For cracks with depth or where bonding across the crack is critical, inject low-viscosity epoxy resin under pressure to fill internal voids and restore monolithic behavior.

4. Installation of Chicken Mesh (for walls only)

- Fix a layer of galvanized chicken mesh (6–10 mm opening) over the cracked area with mechanical fasteners or bonding adhesive.
- This helps distribute stresses and prevent future crack reopening.

5. Rich Mortar Application

- Prepare polymer-modified rich cement mortar (typically 1:3 with SBR or acrylic polymer additive).
- Apply over the chicken mesh and crack groove using a trowel, ensuring full coverage and compaction.

6. Surface Finishing

- Smoothen the repaired area to match adjacent finishes.
- Optional: Apply a skim coat for a uniform appearance.

7. Curing

- Begin moist curing after initial set (~6–8 hours) and continue for 7–10 days using wet hessian or curing compound.

Additional Solutions & Recommendations

- **Protective Coating:** After curing, apply a UV-resistant waterproofing coating or elastomeric paint to prevent ingress of moisture and CO_2.
- **Preventive Measures:** Improve drainage, waterproofing, or load redistribution if cracks are recurring due to structural or service load issues.
- **Inspection:** Schedule follow-up inspections to ensure the repaired zone remains stable and uncracked

3. Major Cracks

- Crack Width: > 1.4 mm

Nature: Structural cracks indicating distress in load-bearing components

Structural Impact: Significant; potentially compromises load-carrying capacity.

Recommended Remedial Measures:

1. Structural Assessment

- Conduct a detailed structural evaluation to determine the extent of damage and whether the structural integrity is compromised.
- Perform load analysis and check for rebar corrosion, deflection, or loss of section.

2. Crack Opening and Cleaning

- Carefully chisel and widen the cracks to expose the full depth.
- Clean the area using water and compressed air to remove all dust, loose concrete, and corroded material.

3. Jacketing of Structural Members

- For severely distressed beams or columns, provide RC or steel jacketing:
  - RC Jacketing: Roughen the existing surface, In case the existing reinforcement is rusted or corroded, weld additional bars to restore the required reinforcement continuity.

5. Retrofitting Measures

- Where member strength is significantly reduced, implement retrofitting using appropriate techniques and materials:
  - Section enlargement to increase load-carrying capacity of beams and columns using M25 micro-concrete.
  - Stitching of cracks using steel bars for added confinement and integrity.
  - For wall retrofitting, use polymer-based cement mortar in combination with chicken mesh to improve bonding and surface restoration.

6. Rebar Treatment

- Expose rebars, clean corrosion with wire brush/grinder.
- Apply zinc-rich primer or corrosion inhibitor.
- Replace bars if cross-sectional loss exceeds 25%.

7. Concrete Restoration

- Apply high-strength polymer-modified repair mortar in layers.
- Ensure proper compaction and bonding to parent concrete.

8. Curing

- Cure using wet hessian cloth or curing compound for a minimum of 10–14 days.

Additional Recommendations

- **Protective Surface Coating:** Finish with a breathable anti-carbonation coating or elastomeric waterproof paint.
- **Load Redistribution:** Modify loading arrangements temporarily if structural safety is affected.
- **Drawings:** Attach detailed strengthening and jacketing drawings to support the repair process.
- **Monitoring:** Conduct post-repair monitoring using crack gauges or sensors.

SOLUTION FOR SLAB CRACKS (WATERPROOFING) :---

APPLY PROCEDURE OF WATER PROFING AGENT (DR. FIXIT PIDIFIN 2K 112)

1. **SURFACE PREPRATION**

Make sure the concrete or masonry is fully cured and there is no oil, grease, wax, dirt, etc on the surface.

Substrate should be reach a "Saturated Surface Dry" (SSD) condition (damp, without standing water)

Fig1; SURFACE PREPRATION

2. **Mixing**
   Using a Portland mechanical mixer, prepare a smooth and homogenous slurry mixture by adding the powder to the liquid part. Leave it for 5 to 10 minutes before using. (Refer Precaution PIDIFIN 2K 112 bag.)

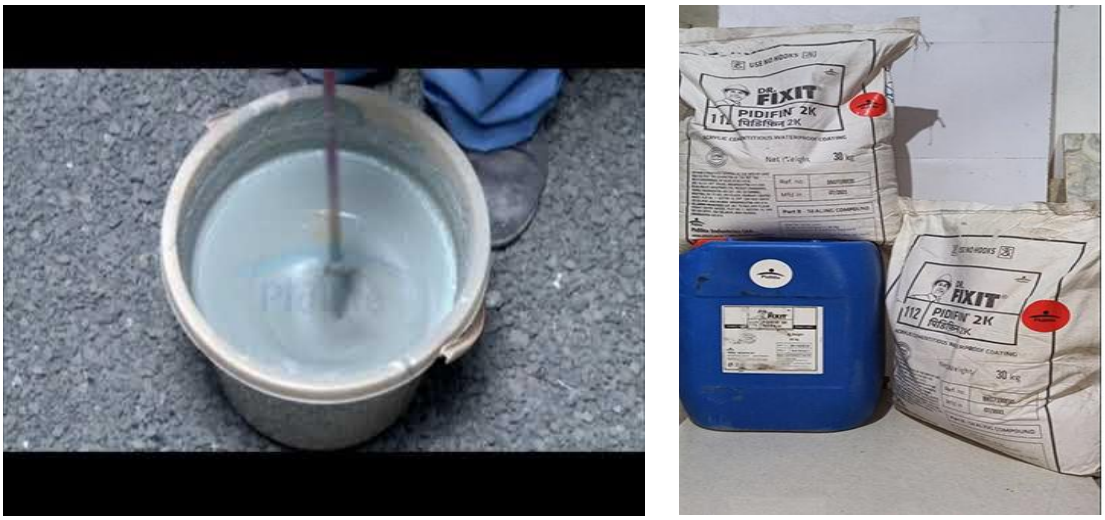


Fig2; Mixing of DR. FIXIT PIDIFIN 2K 112.

3. **Applications:**
Start applying the mixture with a brush and make **sure not to dilute it with water**. Before applying another coat, make sure the first coat is left to dry for at least an hour.

Fig; Surface coating.

Recommended coverage rate is approximately 1.1 kg./m2 /coat for 0.8 mm. thick of wet film thick (minimum 2 coat) . 1st coat Left To Right and 2nd coat up to down direction.

Allow the slurry to cure for at **least 2 hour** before applying a second coat.

4. PCC COATING:
After applying the second coat, let it dry for at least 12 to 24 hours. Dr Fixit Pidifin 2K needs a week before PCC, Coating 50mm with mixing water proofing agent (Dr. FIXIT PIDIROOF 101 LW+).

Summary of Preventive & Remedial Measures

1. Crack Injection (Epoxy or PU Grouting)

- **Purpose:** To seal and strengthen structural cracks.
- **Materials:** Low-viscosity epoxy for dry cracks; PU grout for active/seepage cracks.
- **Procedure:**
  a. Clean the crack and surrounding surface.
  b. Install injection ports at intervals.
  c. Seal the crack line with epoxy paste.
  d. Inject epoxy (or PU) under pressure through ports.
  e. Allow curing as per manufacturer's instructions.

2. Polymer Mortar or Polymer-Modified Concrete Repair

- **Purpose:** To restore concrete surfaces and patch spalled/damaged zones.
- **Materials**: Polymer-modified mortar (SBR or acrylic-based), bonding agent (Nitto Bond EP).
- **Procedure:**
  a. Remove loose concrete and clean surface.
  b. Apply bonding agent to prepared area.
  c. Place polymer mortar manually or by trowel.
  d. Finish and cure as per specifications.

3. Zinc-Rich Polymer Corrosion Inhibitor

- **Purpose:** To protect exposed steel from corrosion and enhance bond with new material.
- **Materials:** Zinc-Rich Epoxy Primer – e.g., Fosroc Nitozinc Primer, Sika FerroGard, STP ZRP 219

Procedure:

a. Expose reinforcement up to 100 mm beyond corrosion.
b. Clean rust using wire brush/sandblasting to near-white metal.
c. Apply two coats of zinc-rich epoxy primer or polymer-based inhibitor (e.g., Nitozinc Primer) over dry steel.
d. Allow curing between coats as per product data sheet.

4. Steel Plate Jacketing / RCC Jacketing

- **Purpose:** To structurally strengthen beams or columns with major cracks or section loss.
- **Materials:** Steel plates or reinforcement bars, concrete (M25), bonding agent.
- **Procedure:**
  a. Expose full perimeter of member and clean surface.
  b. Place additional steel reinforcement or steel plates.
  c. Fix formwork and pour M25 concrete.
  d. Cure and apply protective coating.

5. Chicken Mesh Application

- **Purpose:** To prevent plaster cracking and support polymer overlays in non-structural zones.
- **Materials:** Galvanized chicken wire mesh, steel nails/ties.
- **Procedure:**
  a. Place and secure mesh to the surface.
  b. Embed mesh within mortar during repair.
  c. Finish plaster flush with existing surface.

6. Flexible Joint Sealants

- **Purpose:** To accommodate movement between joints (e.g., stair wall–landing interface).
- **Materials:** Polyurethane (PU), polysulfide, or silicone-based flexible sealant.
- **Procedure:**
  a. Clean joint and remove debris.
  b. Place backer rod if required.
  c. Apply primer (if specified) and sealant.
  d. Tool finish and allow curing.

7. Surface Waterproofing / Shaft Re-Waterproofing

- **Purpose:** To prevent water ingress in wet zones (shafts, balconies, terraces).
- **Materials:** PU waterproof coatings, crystalline sealants (e.g., Dr. Fixit, Sika).

- **Procedure**:
  - Remove existing flaky coatings.
  - Apply two or more coats of waterproofing membrane/compound.
  - Allow proper curing between coats.

8. Shotcrete or Ferrocement Overlay

- **Purpose:** To restore cover concrete and protect corroded areas, especially in exposed zones.
- **Materials:** High-strength cement mortar, steel mesh, bonding agent.
- **Procedure:**
  a. Chip and clean affected area.
  b. Fix reinforcement mesh.
  c. Apply shotcrete or ferrocement using spraying/troweling method.
  d. Cure properly.

9. Slope Correction (Balconies or Ramps)

- **Purpose:** To restore drainage slope and prevent water ponding.
- **Materials:** Polymer screed or slope-adjustment mortar.
- **Procedure**:
  a. Remove damaged screed layer.
  b. Apply slope-corrected mortar.
  c. Cure and finish with waterproof coating.

10. Monitoring and Load Management

- **Purpose:** To ensure structural safety during and post-repair.
- **Procedure:**
  a. Install crack width gauges or markers.
  b. Monitor cracks monthly.
  c. Limit imposed live loads during repair period.

NOTE:-

- *All materials used must comply with IS 456:2000, IS 13620, and relevant technical datasheets.*
- *Execution should be done under supervision of a qualified structural engineer.*
- *Maintain a log of material batches, application areas, and test certificates.*

भारतीय मानक
Indian Standard

IS 516 (Part 5/Sec 1) : 2018

दृढ़ीकृत कंक्रीट — परीक्षण पद्धतियाँ

भाग 5 दृढ़ीकृत कंक्रीट का अविनाशी परीक्षण

खण्ड 1 अल्ट्रासोनिक पल्स वेग परीक्षण

(पहला पुनरीक्षण)

Hardened Concrete — Methods of Test

Part 5 Non-destructive Testing of Concrete

Section 1 Ultrasonic Pulse Velocity Testing

(First Revision)

ICS 91.100.30

भारतीय मानक ब्यूरो
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Cement and Concrete Sectional Committee, CED 02

FOREWORD

This Indian Standard (Part 5/Section 1) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

Testing plays an important role in controlling the quality of cement concrete work. Systematic testing of raw materials, fresh concrete and hardened concrete, is an inseparable part of any quality control programme for concrete. This helps achieve a higher efficiency of the materials used and greater assurance of the performance of the concrete, in regard to workability, strength and durability. The test methods used should be simple, direct and convenient to apply. This standard was prepared with this objective in view.

This standard was first published in 1959. In this first revision, it was decided to review and update the various existing test methods of concrete taking into consideration the latest international practices and developments in this field in the country, and also to introduce certain new test methods, wherever required. In the process, the various existing test methods covered in IS 516 : 1959 'Methods of tests for strength of concrete' have been revised. The revision of the standard is being brought out taking into consideration primarily the corresponding ISO standards while also examining the other best practices world over and in the country. In addition, test methods for determination of additional properties have been included in areas such as permeability, initial surface absorption, corrosion of reinforcement, carbonation of concrete (field test) and, creep of concrete. Also, for better understanding and implementation, some of the other test methods which were spread over in number of other Indian standards have been brought together under the fold of IS 516 as its various parts, such as the splitting tensile strength, ultrasonic pulse velocity test, rebound hammer test, bond in reinforced concrete, and determination of water soluble and acid soluble chlorides. This is with a view to making the standard complete in all respects, and rendering it a comprehensive source of provisions for testing of concrete and reference in other Indian Standards.

In this revision, IS 516 has been split in to twelve parts. The other parts in the series are:

- Part 1 Determination of strength of hardened concrete
- Part 2 Determination of properties of hardened concrete other than strength
- Part 3 Making, curing and determining compressive strength of accelerated cured concrete test specimens
- Part 4 Sampling, preparing and testing of concrete cores
- Part 5 Non-destructive testing of hardened concrete
- Part 6 Determination of drying shrinkage and moisture movement of concrete samples
- Part 7 Determination of creep of concrete cylinders in compression
- Part 8 Determination of modulus of elasticity in compression
- Part 9 Determination of wear resistance
- Part 10 Determination of bond in reinforced concrete
- Part 11 Determination of Portland cement of hardened hydraulic cement concrete
- Part 12 Determination of water soluble and acid soluble chlorides in hardened mortar and concrete

This standard (Part 5/Section 1) describes Ultrasonic Pulse Velocity test method for use on hardened concrete.

This test method shall be applicable as and when published, in place of the corresponding IS 13311 (Part 1) : 1992 'Methods of non-destructive testing of concrete: Part 1 Ultrasonic pulse velocity', which shall be superseded after the publication of this standard.

(*Continued on third cover*)

Indian Standard
HARDENED CONCRETE — METHODS OF TEST
PART 5 NON-DESTRUCTIVE TESTING OF CONCRETE
Section 1 Ultrasonic Pulse Velocity Testing
(First Revision)

1 SCOPE

This standard (Part 5/Section 1) specifies non-destructive test methods for use on hardened concrete. This standard covers the principles, apparatus and test procedures of ultrasonic pulse velocity testing. In addition, influence of test conditions and some general guidance on the interpretation of test results are also given.

NOTE — In view of the limitations of each method of non-destructive testing of concrete, it is essential that the results of tests obtained by one method shall be complimented by other tests and each method shall be adopted very carefully.

2 ULTRASONIC PULSE VELOCITY TEST

2.1 Principle

The ultrasonic pulse is generated by an electroacoustical transducer. When the pulse is induced into the concrete from a transducer, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves is developed which includes longitudinal (compressional), shear (transverse) and surface (Raleigh) waves. The receiving transducer detects the onset of the longitudinal waves, which is the fastest. Because the velocity of the pulses is almost independent of the geometry of the material through which they pass and depends only on its elastic properties, pulse velocity method is a convenient technique for investigating in-situ concrete. The underlying principle of assessing the quality of concrete is that comparatively higher velocities are obtained when the quality of concrete in terms of density, homogeneity and uniformity is good. In case of poorer quality, lower velocities are obtained. If there is a crack, void or flaw inside the concrete which comes in the way of transmission of the pulses, the pulse strength is attenuated and it passes around the discontinuity, thereby making the path length longer. Consequently, lower velocities are obtained. The actual pulse velocity obtained depends primarily upon the materials and mix proportions of concrete. Density and modulus of elasticity of aggregate also significantly affect the pulse velocity.

2.2 Apparatus

The apparatus for ultrasonic pulse velocity measurement shall consist of the following.

2.2.1 *Electrical Pulse Generator*

2.2.2 *Transducers — One Pair* — Piezoelectric and magneto-strictive types of transducers may be used, the latter being more suitable for the lower part of the frequency range.

Frequencies as low as 10 kHz and as high as 200 kHz can sometimes be used. High-frequency pulses have a well-defined onset but, as they pass through the concrete, they become attenuated more rapidly than pulses of lower frequency. It is therefore preferable to use high-frequency transducers (60 kHz to 200 kHz) for short path lengths (down to 50 mm) and low frequency transducers (10 kHz to 40 kHz) for long path lengths (up to a maximum of 15 m). Transducers with a frequency of 25 kHz to 100 kHz are found to be useful for most applications.

2.2.3 *Standard Calibration Bar* — Two standard calibration bars, as per details given in **2.3.1** shall be provided by the manufacturer of the apparatus for calibrating the apparatus.

2.2.4 *Amplifier*

2.2.5 *Electronic Timing Device* — It shall be capable of measuring the time interval elapsing between the onset of a pulse generated at the transmitting transducer and the onset of its arrival at the receiving transducer. Two forms of the electronic timing apparatus are possible, one of which uses a cathode ray tube on which the leading edge of the pulse is displayed in relation to the suitable time scale, the other uses an interval timer with a direct reading digital display. If both the forms of timing apparatus are available, the interpretation of results becomes more reliable.

2.3 Performance Requirement of Apparatus

2.3.1 The apparatus shall be capable of measuring transit times to an accuracy of ±1 percent over a range of 20 microsecond to 10 millisecond. For this, it is necessary to check the overall performance by making measurements on two standard reference specimens in which the pulse transit times are known accurately. The two reference specimens (usually steel bars) shall have pulse transit times of about 25 microsecond to 100 microsecond respectively; these times being specified by the supplier of the equipment to an accuracy of ±0.2 microsecond. The shorter of the reference specimens shall be used to set the zero for the apparatus and the longer one shall be used to check the accuracy of transit time measurement of the apparatus. The measurement obtained shall not differ from the known value for the reference specimen by more than ±0.5 percent.

NOTE — It is advisable to follow the equipment manufacturer's instructions for calibration of the equipment.

2.3.2 Along with the calibration of the equipment as described in **2.3.1,** it is also advisable to perform a zero time check on the unit by applying a coupling agent to the transducers and pressing the faces together. Check the zero adjustment on regular intervals.

2.3.3 The electronic excitation pulse applied to the transmitting transducer shall have a rise time of not greater than one quarter of its natural period. This is to ensure a sharp pulse onset.

2.3.4 The interval between pulses shall be low enough to ensure that the onset of the received signal in small concrete test specimens is free from interference by the reverberations produced within the preceding working cycle.

2.3.5 The apparatus shall maintain its performance over the range of ambient temperature, humidity and power supply voltage as stated by the supplier.

2.3.6 When using long leads (above 20 m) caution shall be taken during transit time measurement that the leads do not come into close contact with each other. In case the leads are close together, it may pickup unwanted signals from the transmitter lead resulting in incorrect and unstable readings.

2.4 Procedure

2.4.1 *Surface Preparation*

At the point of observation, the concrete surface shall be suitably prepared and any plaster or other coating shall be removed to expose the concrete surface. For this purpose, the use of carborundum stones or grinders may be adopted. However, care shall be taken to avoid any damage to concrete surface or concrete structure.

2.4.2 *Ultrasonic Measurements*

Place the two transducers on opposite faces (direct transmission), or on adjacent faces (semi-direct transmission), or on the same face (indirect or surface transmission) (*see* Fig. 1). Although the direction in which the maximum energy is propagated is at right angles to the face of the transmitting transducer, it is possible to detect pulses that have travelled through the concrete in some other direction. Direct transmission method of ultrasonic pulse velocity measurements is the most efficient method and shall be adopted, if possible. However, sometimes, it may be necessary to place the transducers on opposite faces but not directly opposite each other. Such arrangements shall be regarded as a semi-direct transmission [*see* Fig. 1B].

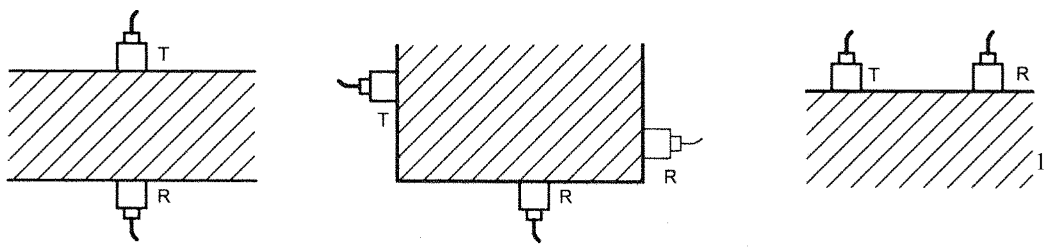
The third method for measurement of ultrasonic pulse velocity is the indirect transmission method [*see* Fig. 1C]. The indirect transmission arrangement is the least sensitive and shall be used when only one face of the concrete is accessible, or when the quality of the surface concrete relative to the overall quality is of interest. The method for measurement of ultrasonic pulse velocity by indirect transmission is explained in Annex A.

2.4.3 *Determination of Ultrasonic Pulse Velocity for Different Transducer Arrangements*

2.4.3.1 *Factors influencing pulse velocity measurements*

There are various factors which influence pulse velocity measurements, such as,

a) surface condition and moisture content of concrete;
b) path length, shape and size of concrete



1A Direct transmission   1B Semi-direct transmission   1C Indirect transmission

Key
T = transmitter
R = receiver

FIG. 1 POSITIONING OF TRANSDUCERS

member;

c) temperature of concrete;
d) stress to which the structure is subjected;
e) reinforcing bars;
f) contact between the transducer and concrete; and
g) cracks and voids.

The effect of various factors on pulse velocity measurement is explained in Annex B. In order to provide an accurate measurement of pulse velocity, it is necessary to take into account the various factors that influence the measurements as explained in Annex B.

2.4.3.2 *Procedure*

2.4.3.2.1 The ultrasonic pulse is produced by the transducer which is held in contact with one surface of the concrete member under test. After traversing a known path length L in the concrete, the pulse of vibrations is converted into an electrical signal by the second transducer held in contact with the other surface of the concrete member and an electronic timing circuit enables the transit time (T) of the pulse to be measured. The pulse velocity (V) is given by:

$$V = L/T$$

Once the ultrasonic pulse impinges on the surface of the material, the maximum energy is propagated at right angles to the face of the transmitting transducer and best results are, therefore, obtained when the receiving transducer is placed on the opposite face of the concrete member (direct transmission or cross probing).

However, in many situations two opposite faces of the structural member may not be accessible for measurements. In such cases, the receiving transducer is also placed on the same face of the concrete member (surface probing or indirect transmission). Surface probing is not as efficient as cross probing, because the signal produced at the receiving transducer has amplitude of only 2 to 3 percent of that produced by cross probing and the test results are greatly influenced by the surface layers of concrete which may have different properties from that of concrete inside the structural member. The indirect velocity is invariably lower than the direct velocity on the same concrete element. This difference may vary from 5 to 20 percent depending largely on the quality of the concrete under test. For good quality concrete, a difference of about 0.5 km/s may generally be encountered. For the procedure and for calculating the exact value of ultrasonic pulse velocity by surface probing (*see* Annex A).

2.4.3.2.2 To ensure that the ultrasonic pulses generated at the transmitting transducer pass into the concrete and are then detected by the receiving transducer, it is essential that there be adequate acoustical coupling between the concrete and the face of each transducer. Typical couplants are petroleum jelly, grease, liquid soap and kaolin glycerol paste. If there is very rough concrete surface, it is required to smoothen and level an area of the surface where the transducer is to be placed. If it is necessary to work on concrete surfaces formed by other means, for example trowelling, it is desirable to measure pulse velocity over a longer path length than would normally be used. A minimum path length of 150 mm is recommended for the direct transmission method involving one unmoulded surface and a minimum of 400 mm for the surface probing method along an unmoulded surface.

2.4.3.2.3 Since size of aggregates influences the pulse velocity measurement, it is recommended that for direct transmission method, the minimum path length shall be 100 mm for concrete in which the nominal maximum size of aggregate is 20 mm or less and 150 mm for concrete in which the nominal maximum size of aggregate is between 20 and 40 mm.

2.4.3.2.4 In view of the inherent variability in the test results, sufficient number of readings are taken by dividing the entire structure in suitable grid markings of 300 × 300 mm or even smaller. Each junction point of the grid becomes a point of observation. Larger grid spacing up to maximum 500 × 500 mm may be adopted for general overall assessment of larger structures having uniform cross-section showing no signs of distress. The number of individual test points or grid spacing depends upon the size of the structure, the accuracy required and the variability of the concrete. Transducers are held on corresponding points of observation on opposite faces of a structural element to measure the ultrasonic pulse velocity by direct transmission, that is, cross probing. If one of the faces is not accessible, ultrasonic pulse velocity is measured on one face of the structural member by surface probing.

2.4.3.2.5 Surface probing in general gives lower pulse velocity than in case of cross probing and depending on number of parameters, the difference could be of the order of about 0.5 km/s. In view of this, it is recommended that, in surface probing method the pulse velocity may be increased by 0.5 km/s, for values $\geq$ 3.0 km/s.

2.5 Interpretation of Results

2.5.1 The ultrasonic pulse velocity of concrete is mainly related to its density and modulus of elasticity. This in turn, depends upon the materials and mix proportions used in making concrete as well as the method of placing, compaction and curing of concrete.

For example, if the concrete is not compacted as thoroughly as possible, or if there is segregation of concrete during placing or there are internal cracks or flaws, the pulse velocity will be lower, although the same materials and mix proportions are used.

2.5.2 The quality of concrete in terms of uniformity, incidence or absence of internal flaws, cracks and segregation, etc (indicative of the level of workmanship employed) can be assessed using the guidelines given in Table 1. This table is only for concrete quality grading and shall not be used for estimating the concrete grades from ultrasonic pulse velocity values.

Table 1 Velocity Criterion for Concrete Quality Grading
(*Clause* 2.5.2)

Sl No.	**Average Value of Pulse Velocity by Cross Probing** km/s	**Concrete Quality Grading**
(1)	(2)	(3)
i)	Above 4.40	Excellent
ii)	3.75 to 4.40	Good
iii)	3.00 to 3.75	Doubtful[1)]
iv)	Below 3.00	Poor

[1)] In case of 'Doubtful' quality it may be necessary to carry out further tests.

2.5.3 Since actual values of the pulse velocity obtained, depend on a number of parameters, any criterion for assessing the quality of concrete on the basis of pulse velocity as given in Table 1 can be held as satisfactory only to a general extent. However, when the comparison is made amongst different parts of a structure, which have been built at the same time with supposedly similar materials, construction practices and supervision, the assessment of quality becomes more meaningful and reliable. Whenever the UPV values are lesser by more than 10 percent of average value of the member/part of structure, the location shall be considered as having internal flaws or segregation caused by poor workmanship or there could be micro cracks.

2.5.4 The assessment of compressive strength of concrete from ultrasonic pulse velocity values is not adequate because the statistical confidence of the correlation between ultrasonic pulse velocity and the compressive strength of concrete is not very high. The reason is that a large number of parameters are involved, which influence the pulse velocity and compressive strength of concrete to different extents. However, if actual concrete materials and mix proportions adopted in a particular structure are available, then estimate of concrete strength can be made by establishing suitable correlation between the pulse velocity and the compressive strength of concrete specimens made with such materials and mix proportions, under environmental conditions similar to that in the structure. The estimated strength may vary from the actual strength by ± 20 percent. The correlation so obtained may not be applicable for concrete of another grade or made with different types of materials. If correlation graph is not available but the velocities on concrete cubes are available, the average pulse velocities in members of structures are not expected to deviate by more than 10 to 15 percent of the pulse velocity values obtained on concrete cubes (dry surface).

2.5.5 The procedure for estimating the depth of a surface crack using ultrasonic pulse velocity measurement is given in Annex C.

2.5.6 The procedure for determining the dynamic Young's modulus of elasticity (E) of the concrete is given in Annex D.

ANNEX A

(*Clauses* 2.4.2 *and* 2.4.3.2.1)

DETERMINATION OF PULSE VELOCITY — INDIRECT TRANSMISSION

A-1 With indirect transmission, there is some uncertainty regarding the exact length of the transmission path because of the significant size of the areas of contact between the transducers and the concrete. It is therefore preferable to make a series of measurements with the transducers at different distances apart to eliminate this uncertainty.

A-2 To do this, the transmitting transducer shall be placed in contact with the concrete surface at a fixed point *x* and the receiving transducer shall be placed at fixed increments x_n along a chosen line on the surface. The transmission times recorded shall be plotted as points on a graph showing their relation to the distance separating the transducers. An example of such a setup is shown in Fig. 2 and the plot is shown in Fig. 3.

A-3 The slope of the best straight line drawn through the points [tan (ϕ)] shall be measured and its inverse be recorded as the mean pulse velocity along the chosen line on the concrete surface. Where the points measured and recorded in this way indicate a discontinuity, it is likely that a surface crack or surface layer of inferior quality is present and a velocity measured in such an instance is unreliable.

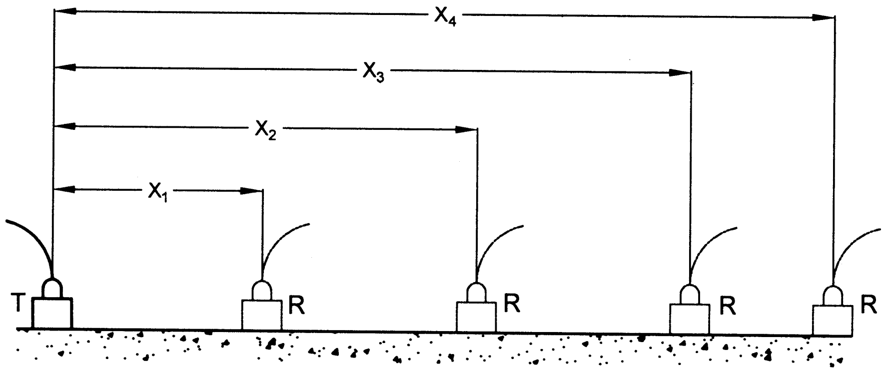
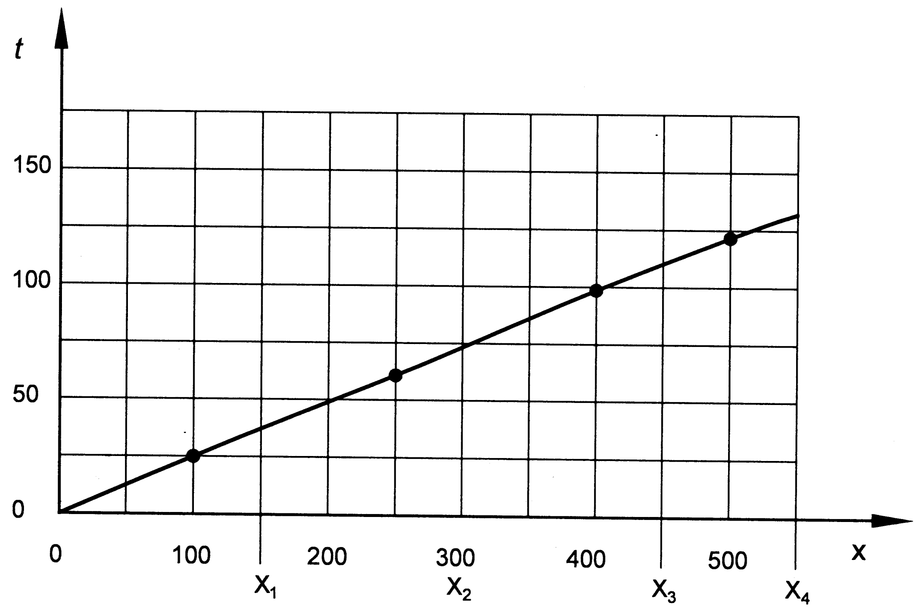


FIG. 2 TRANSDUCER SETUP



Key

x = distance, in millimetres
t = time, in microseconds
T = transmitter
R = receiver

FIG. 3 PULSE VELOCITY DETERMINATION BY INDIRECT (SURFACE) TRANSMISSION

ANNEX B

(*Clause* 2.4.3.1)

FACTORS INFLUENCING PULSE VELOCITY MEASUREMENTS

B-1 GENERAL

In order to provide a measurement of pulse velocity that is accurate and repeatable and which depends essentially on the properties of the concrete under test, it is necessary to take account of the various factors that influence pulse velocity and its correlation with various physical properties of the concrete.

B-1.1 Influence of Surface Conditions and Moisture Content of Concrete

Smoothness of contact surface under test affects the measurement of ultrasonic pulse velocity. For most concrete surfaces, the finish is usually sufficiently smooth to ensure good acoustical contact by the use of a coupling medium and by pressing the transducer against the concrete surface. When the concrete surface is rough and uneven, it is necessary to smoothen the surface to make the pulse velocity measurement possible.

In general, pulse velocity through concrete increases with increased moisture content of concrete. This influence is more for low strength concrete than high strength concrete. The pulse velocity of saturated concrete may be up to 5 percent higher than that of similar dry concrete. In general, drying of concrete may result in somewhat lower pulse velocity.

B-1.2 Influence of Path Length, Shape and Size of the Concrete Member

As concrete is inherently heterogeneous, it is essential that path lengths be sufficiently long so as to avoid any error introduced due to its heterogeneity. In field work, this does not pose any difficulty as the pulse velocity measurements are carried out on thick structural concrete members. However, in the laboratory where generally small specimens are used, the path length can affect the pulse velocity readings. The velocity of short pulses of vibrations is independent of the size and shape of the specimen in which they travel, unless its least lateral dimension is less than a certain minimum value. Below this value, the pulse velocity may be reduced appreciably. The extent of this reduction depends mainly on the ratio of the wave length of the pulse vibrations to the least lateral dimension of the specimen but is insignificant, if the ratio is less than unity. Table 2 gives the relationship between the pulse velocity in the concrete, the transducer frequency and the minimum permissible lateral dimension of the specimen.

If the minimum lateral dimension is less than the wavelength or if the indirect transmission arrangement is used, the mode of propagation changes and, therefore, the measured velocity will be different. This is particularly important in cases where concrete elements of significantly different sizes are being compared.

Table 2 Minimum Specimen Dimensions

(*Clause* B-1.2)

Sl No.	Transducer Frequency	Pulse Velocity in Concrete		
		3.50 km/s	4.00 km/s	4.50 km/s
	kHz	Minimum Permissible Lateral Specimen Dimension, in mm		
(1)	(2)	(3)	(4)	(5)
i)	24	146	167	188
ii)	54	65	74	83
iii)	82	43	49	55
iv)	150	23	27	30

B-1.3 Influence of Temperature of Concrete

Variations of the concrete temperature between 5°C and 30°C do not significantly affect the pulse velocity measurements in concrete. At temperatures between 30 to 60°C there can be reduction in pulse velocity up to 5 percent. Below freezing temperature, the free water freezes within concrete, resulting in an increase in pulse velocity up to 7.5 percent.

B-1.4 Influence of Stress

When concrete is subjected to a stress which is abnormally high for the quality of the concrete, the pulse velocity may be reduced due to the development of micro-cracks. This influence is likely to be the greatest when the pulse path is normal to the predominant direction of the planes of such micro-cracks. This occurs when the pulse path is perpendicular to the direction of a uniaxial compressive stress in a member. This influence is generally insignificant unless the stress is greater than about 60 percent of the ultimate strength of the concrete.

B-1.5 Effect of Reinforcing Bars

The pulse velocity measured in reinforced concrete in the vicinity of reinforcing bars is usually higher than in plain concrete of the same composition. This is because the pulse velocity in steel is 1.2 to 1.9 times the velocity in plain concrete and, under certain conditions, the first pulse to arrive at the receiving transducer travels partly in concrete and partly in steel. The apparent increase in pulse velocity depends upon the proximity of the measurements to the reinforcing bar, the diameter and number of the bars and their orientation with respect to the path of propagation.

B-1.6 Contact Between Transducer and Concrete

Poor contact will affect the reading. It is essential to use grease or other couplants to improve the contact between the transducer and the concrete as per **2.4.3.2.2.**

B-1.7 Cracks and Voids

When an ultrasonic pulse travelling through concrete meets a concrete-air interface, there is negligible transmission of energy across this interface. Thus, any air-filled crack or void lying immediately between two transducers will obstruct the direct ultrasonic beam when the projected length of the void is greater than the width of the transducers and the wavelength of sound used. When this happens, the first pulse to arrive at the receiving transducer will have been diffracted around the periphery of the defect and the transit time will be longer than in similar concrete with no defect.

It is possible to make use of this effect for locating flaws, voids or other defects greater than about 100 mm in diameter or depth. Relatively small defects have little or no effect on transmission times, but equally are probably of minor engineering importance. Plotting contours of equal velocity often gives significant information regarding the quality of a concrete unit.

In cracked members, where the broken faces of the members are held tightly together in close contact by compression forces, the pulse energy may pass unimpeded across the crack. As an example, this may occur in cracked vertical bearing piles. If the crack is filled with liquid which transmits the ultrasonic energy (like in marine structures), the crack is undetectable using digital reading equipment. Measurements of attenuation may give valuable information in these cases.

A grid shall be drawn on the concrete member with its points of intersection spaced to correspond to the size of void that might significantly affect its performance. A large survey of measurements at the grid points enables a large cavity to be investigated by measuring the transit times of pulses passing between the transducers when they are placed so that the cavity lies in the direct path between them.

The size of such cavities may be estimated by assuming that the pulses pass along the shortest path between the transducers and around the cavity. Such estimates are valid only when the concrete around the cavity is uniformly dense and the pulse velocity can be measured in that concrete.

ANNEX C

(*Clause* 2.5.5)

ESTIMATION OF THE DEPTH OF A SURFACE CRACK USING ULTRASONIC PULSE VELOCITY MEASUREMENT

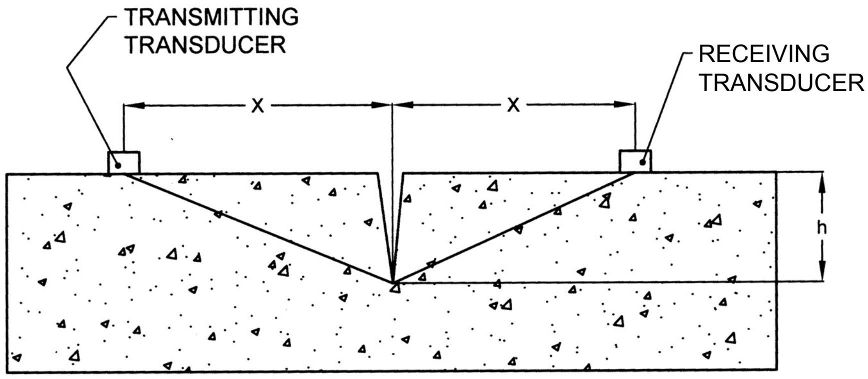


FIG. 3 MEASUREMENT OF DEPTH OF CRACK BY ULTRASONIC PULSE VELOCITY METHOD

Longitudinal pulse velocity = α

Distance travelled in uncracked concrete = $2x$ (*see* Fig. 3)

Distance travelled in cracked concrete = $2\sqrt{x^2 + h^2}$

T_c^2 (in cracked concrete) = $\dfrac{4x^2 + 4h^2}{\alpha^2}$

T_s^2 (in uncracked concrete) = $\dfrac{4x^2}{\alpha^2}$

Therefore

$$\frac{T_c^2}{T_s^2} = \frac{x^2 + h^2}{x^2}$$

Or

$$h = x\sqrt{\frac{T_c^2}{T_s^2} - 1}$$

where

T_c = travel time around the crack,

T_s = travel time along the surface of the same type of concrete without any crack, and

h = depth of crack (*see* Fig. 3).

ANNEX D

(*Clause* 2.5.6)

DETERMINATION OF DYNAMIC YOUNG'S MODULUS OF ELASTICITY USING ULTRASONIC PULSE VELOCITY MEASUREMENTS

D-1 The dynamic Young's modulus of elasticity (E) of the concrete may be determined from the pulse velocity and the dynamic Poisson's ratio (μ), using the following relationship:

$$E = \frac{\rho(1+\mu)(1-2\mu)V^2}{(1-\mu)}$$

where

E = dynamic Young's Modulus of elasticity, in MPa;

ρ = density, in kg/m^3; and

V = pulse velocity, in m/s.

The above relationship may be expressed as:

$$E = \rho f(\mu)\, V^2$$

where

$$f(\mu) = \frac{(1+\mu)(1-2\mu)}{(1-\mu)}$$

The value of the dynamic Poisson's ratio varies from 0.20 to 0.35, with 0.24 as average. However, it is desirable to have an independent measure of it for the particular type of concrete under test. The dynamic Poisson's ratio may be obtained from measurements on concrete test-beams of the pulse velocity (V) along with length (l) of the beam and the fundamental resonant frequency (n) of the beam in longitudinal mode of vibration. From these measurements, the factor $f(\mu)$ is calculated by the relation:

$$f(\mu) = \frac{(2nl)^2}{V^2}$$

where

n = fundamental resonant frequency in cycles per second; and

l = length of specimen, in m.

ANNEX E

(*Foreword*)

COMMITTEE COMPOSITION

Cement and Concrete Sectional Committee, CED 02

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In personal capacity (*E-1, 402, White House Apartments, R. T. Nagar, Bengaluru*)	Shri S. A. Reddi
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Member Secretary
Shrimati Divya S.
Scientist 'B' (Civil Engg), BIS

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Panel for Revision of Indian Standards on Test Methods for Concrete, CED 2:2/P7

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(*Continued from second cover*)

This revision has been taken up to incorporate the modifications found necessary in the light of experience gained in its use and also to bring it in line with the latest development on the subject. Significant modifications in this revision include,

a) the various provisions of IS 13311 (Part 1) have been incorporated after necessary modifications.
b) the details on the frequencies of transducers have been updated.
c) necessary caution has been included to avoid interference when using long leads.
d) more details have been included on surface preparation.
e) velocity criterion for concrete quality grading has been revised.
f) more details have been given on the effect of various factors on pulse velocity measurements.
g) a procedure for estimating the depth of surface crack using ultrasonic pulse velocity measurement has been included.

In the formulation of this standard, assistance has also been derived from ISO 1920-7 : 2004 'Testing of concrete — Part 7: Non-destructive testing of hardened concrete'.

The composition of the Committee responsible for the formulation of this standard is given in Annex E.

In reporting the result of a test or analysis made in accordance with this standard, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical-values (*revised*)'.

This Indian Standard has been developed from Doc No.: CED 02 (10900).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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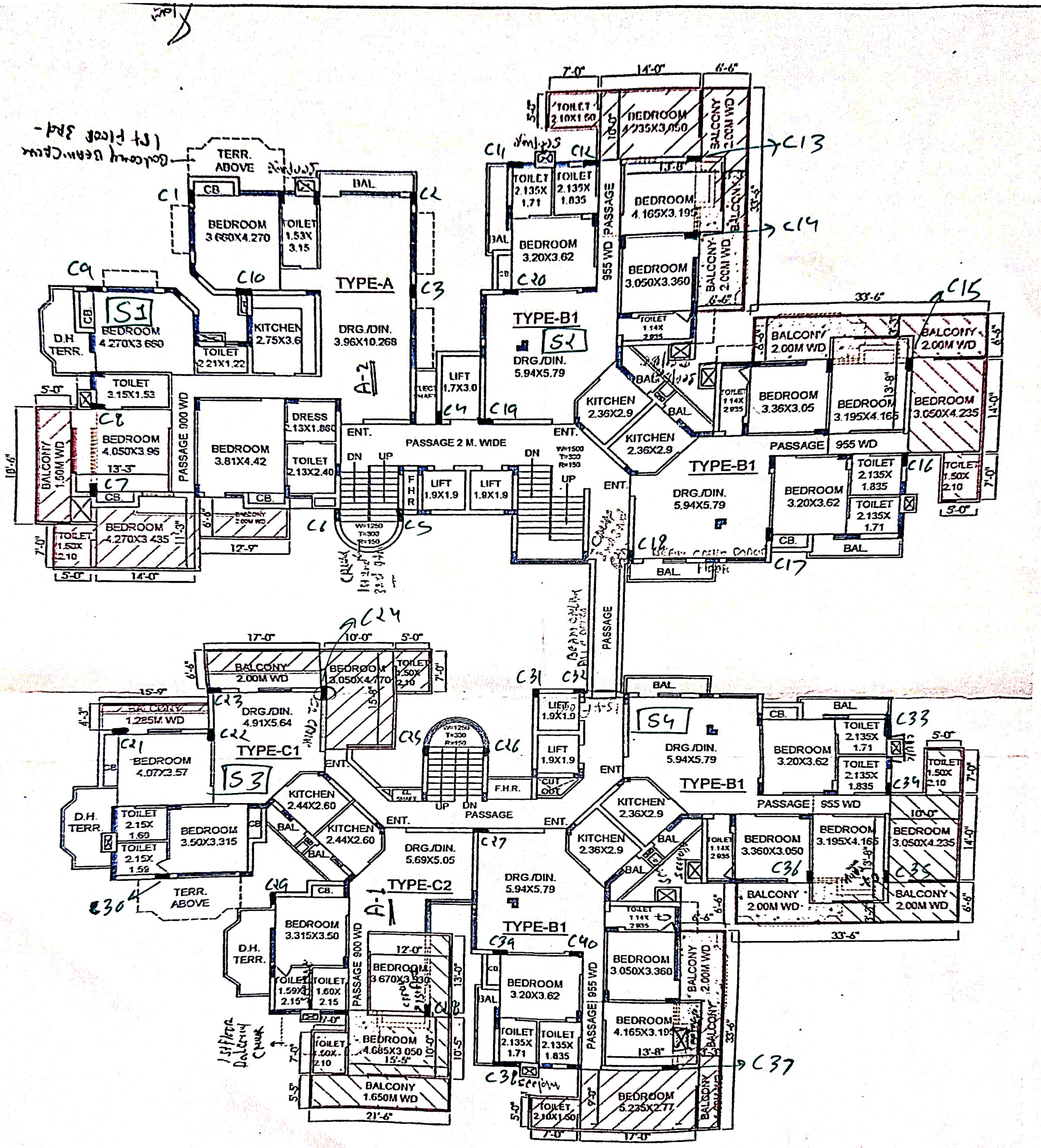

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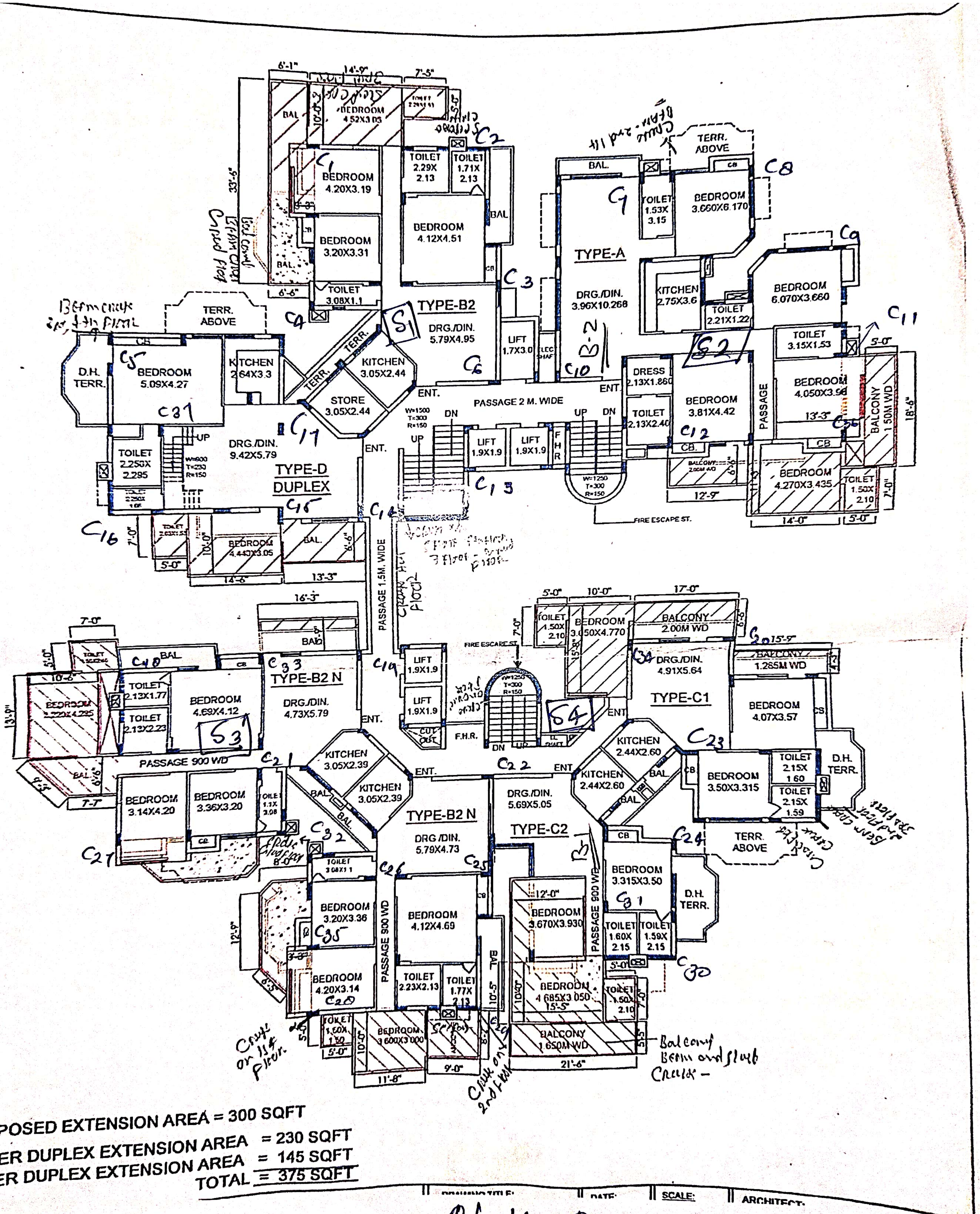


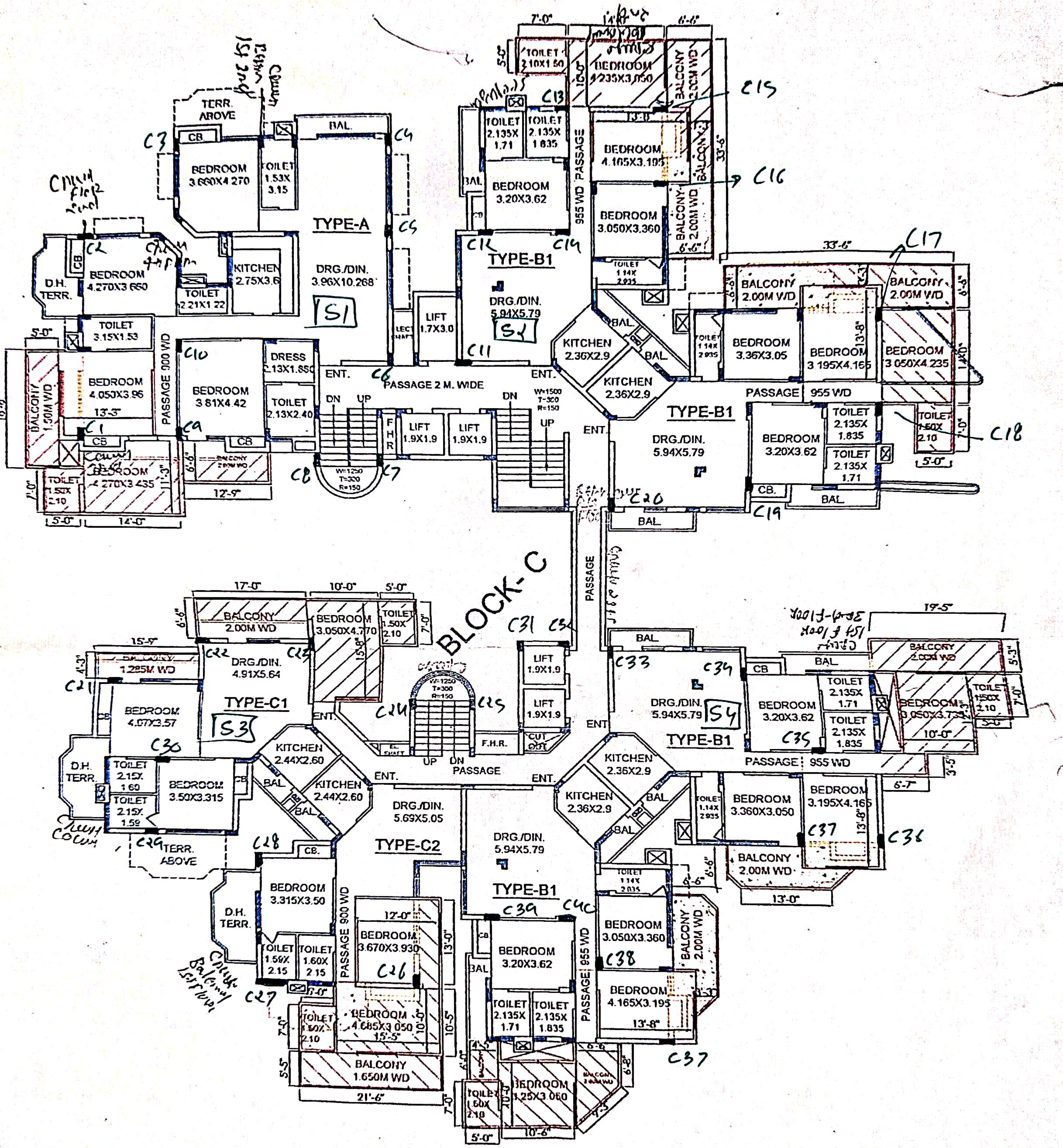
POSED EXTENSION AREA = 300 SQFT

ER DUPLEX EXTENSION AREA = 230 SQFT

ER DUPLEX EXTENSION AREA = 145 SQFT

TOTAL = 375 SQFT

Block - B



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SLAB CEILING STRENGTHENING STEPS FOR MAJOR CRACKS:–

1.Barricade the damaged area and restrict live loads on the slab.

2.Mark and identify the affected slab zone to be repaired.

3.Remove all loose/ spalled concrete using a chisel or breaker till sound concrete is exposed.

4.Expose rusted rebars minimum 200 mm beyond visible corrosion.

5.Clean rebars thoroughly using a wire brush or sandpaper.

6.Apply two coats of zinc–rich epoxy primer on cleaned reinforcement (e.g., Nitozinc Primer).

7.Fix additional 8 mm bars for reinforcement if required; weld to existing bars.

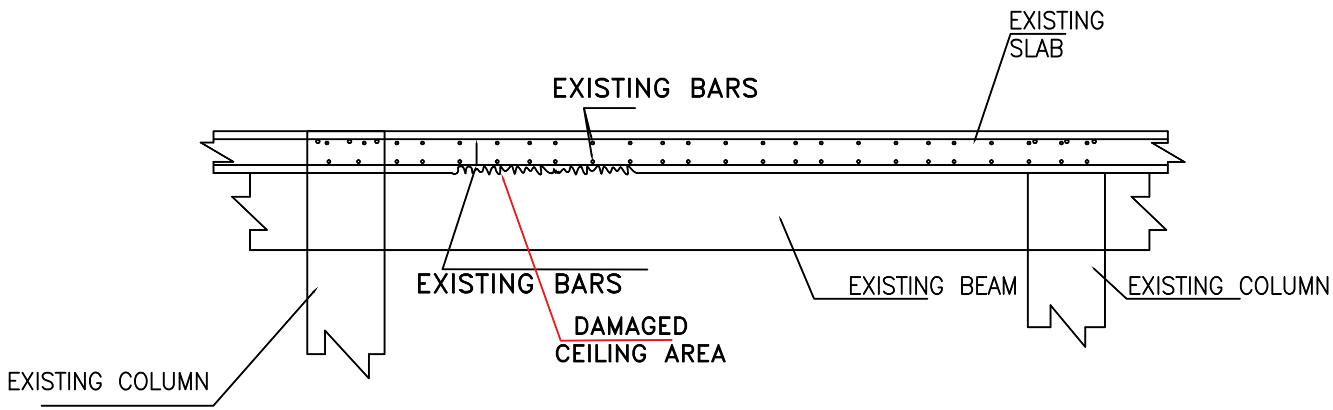
8.Apply epoxy bonding agent (e.g., Nitto Bond EP) on the concrete surface.

9.Apply PCM(Dr. Fixit Polymer Mortar)/rich cement mortar (1:3) mix to restore the slab section .

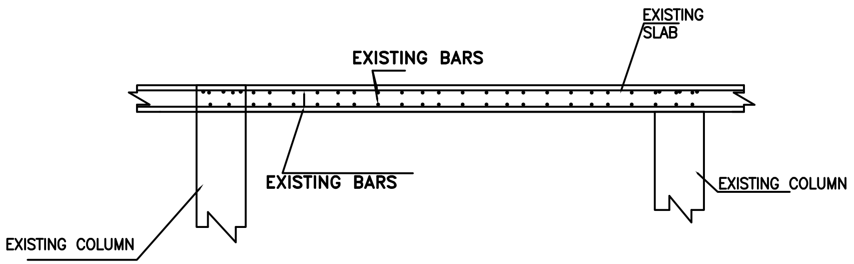
10.Two application methods are possible:
  a) Traditional hand trowel application
  b) Guniting – spray application under pressure (recommended for better compaction, adhesion, and finish)

11.Cure for 7–10 days using wet hessian cloth or curing compound.

12.Finish the slab soffit with Plaster.
13.Apply protective coating (anti–carbonation or waterproofing) on the repaired surface.



EXISTING SLAB



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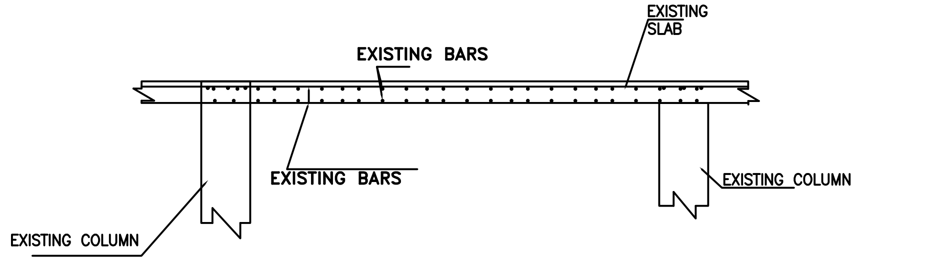
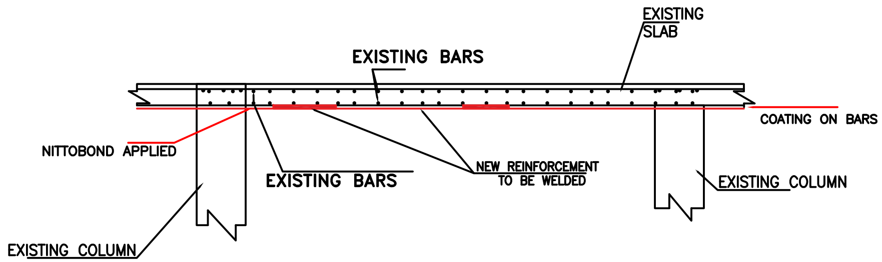
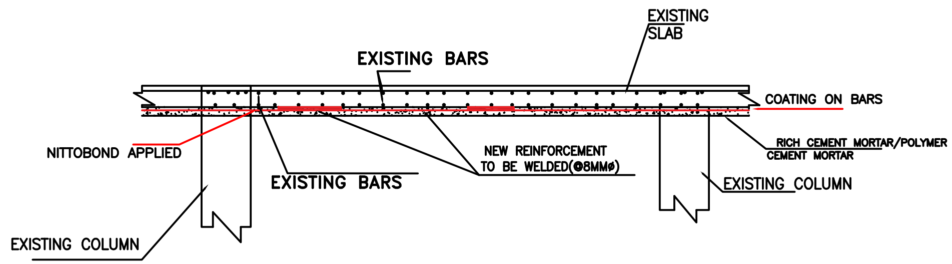


REMOVAL OF LOOSE CONCRETE(COVER)



NEW REINFORCEMENT TO BE WELDED



RICH CEMENT MORTAR/POLYMER
CEMENT MORTAR REQUIRED

SLAB CEILING STRENGTHENING DRAWING FOR MAJOR CRACKS

SLAB CEILING STRENGTHENING – PROCEDURE (FOR MODERATE CRACKS WITH SLIGHTLY RUSTED BARS):–

1.Barricade the area and restrict all live loads on the slab.

2.Mark and identify the slab zones to be repaired.

3.Remove all loose/spalled concrete using a chisel or breaker until sound concrete is exposed.

4.Expose reinforcement bars up to 200 mm beyond visible cracks, only where necessary.

5.Clean rebars thoroughly using a wire brush or sandpaper to remove surface rust.

6.Apply two coats of zinc–rich epoxy primer (e.g., Nitozinc Primer) to the cleaned rebars to protect against corrosion.

7.Apply epoxy bonding agent (e.g., Nitto Bond EP) to the prepared concrete surface.

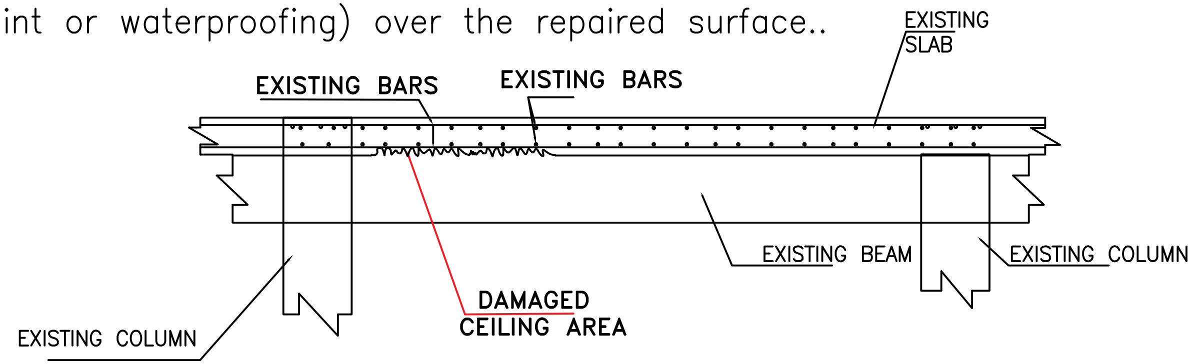
8.Apply PCM (Polymer Cement Mortar) or rich cement mortar (1:3 mix) to restore the slab soffit section.

9.Choose one application method:
a. Traditional trowel application, OR
b. Guniting (spray method) – recommended for better compaction, adhesion, and finish

10.Cure the repaired area for 7–10 days using wet hessian cloth or curing compound.

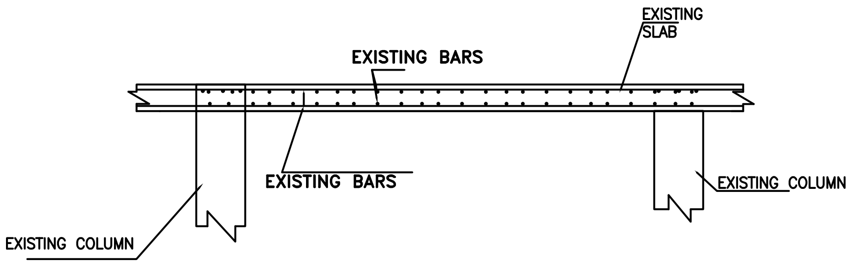
11.Finish with a smooth plaster layer, if required, to match adjacent surfaces.

12.Apply protective coating (e.g., anti–carbonation paint or waterproofing) over the repaired surface..

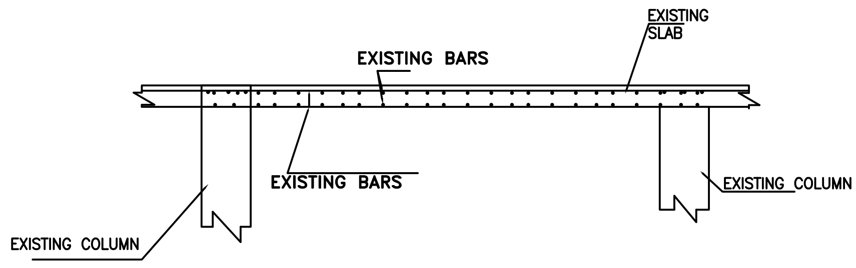


EXISTING SLAB

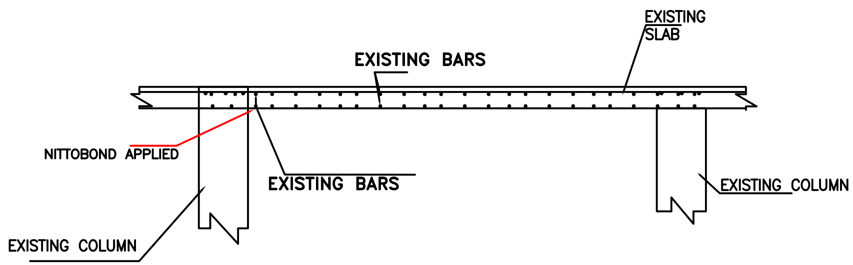
(116)



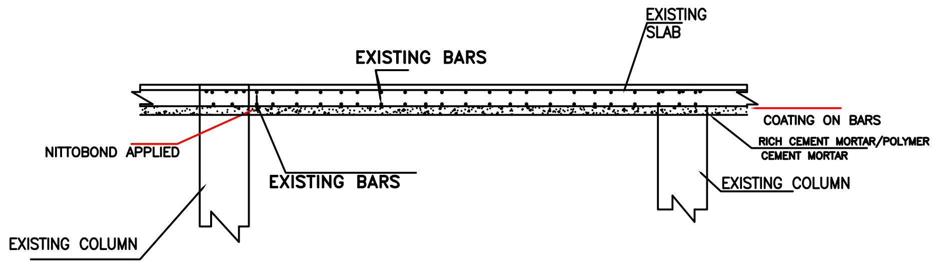
EXISTING SLAB



REMOVAL OF LOOSE CONCRETE(COVER)



NITTO BOND APPLIED



MICRO CONCRETE REQUIRED

SLAB CEILING STRENGTHENING DRAWING FOR MODERATE CRACKS

(117)

COLUMNS/BEAMS HAVING CRACKS NEED TO RECTIFY AS PER FOLLOWING STEPS.

1.Barricade the affected area and restrict live loads before starting the repair.

2.Mark and identify the damaged portion of the beam or column.

3.Remove all loose/spalled concrete using a chisel or jackhammer until sound concrete is exposed.

4.Expose corroded reinforcement bars at least 200 mm beyond visible rust.

5.Clean the reinforcement bars thoroughly using a wire brush, sandpaper, or sandblasting.

6.Apply two coats of zinc–rich epoxy primer (e.g., Nitobond Primer) to prevent further corrosion.

7.Fix additional rebars (typically 12–16 mm dia vertical bars for columns or 8–12 mm dia for beams) and weld them to the existing steel if required.

8.Apply epoxy bonding agent (e.g., Nitto Bond EP) to the prepared surface before concreting.

9.Pour M25 grade micro concrete using a funnel, hose, or gravity–fed method.

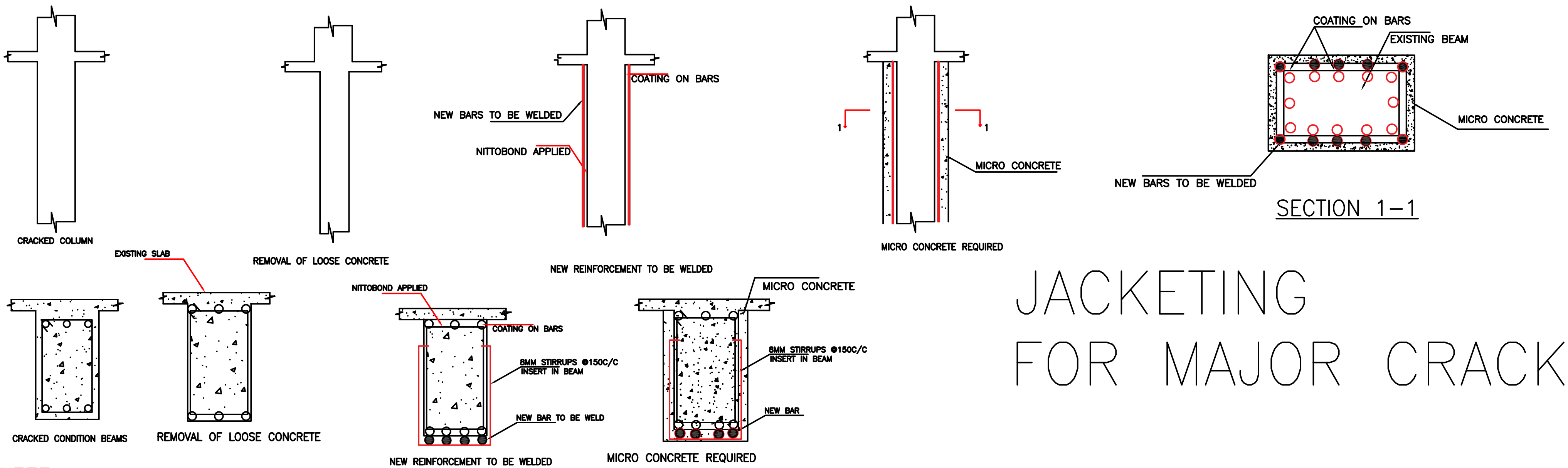
10.Ensure full coverage and eliminate voids.

11.Apply pressure grouting if honeycombing is anticipated.

12.Cure the repaired area for 7–10 days using wet hessian cloth or approved curing compound.

13.Finish with a protective plaster layer if required to match existing profile.

14.Apply protective coating such as anti–carbonation paint or elastomeric waterproofing to the repaired surface.



JACKETING FOR MAJOR CRACKS

NOTE:_

In cases where moderate/major cracks are observed in beams or columns, and the reinforcement is not rusted or only slightly corroded, then structural repair can be effectively carried out using M25 micro concrete without the need for rebar replacement.

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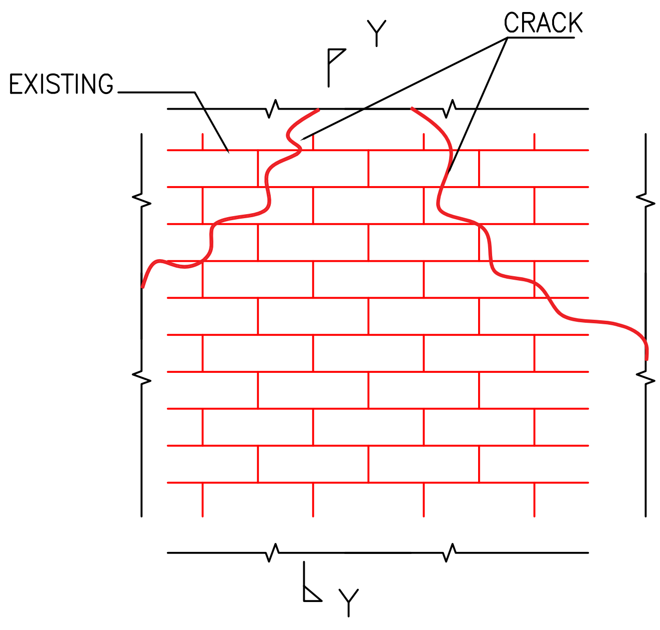
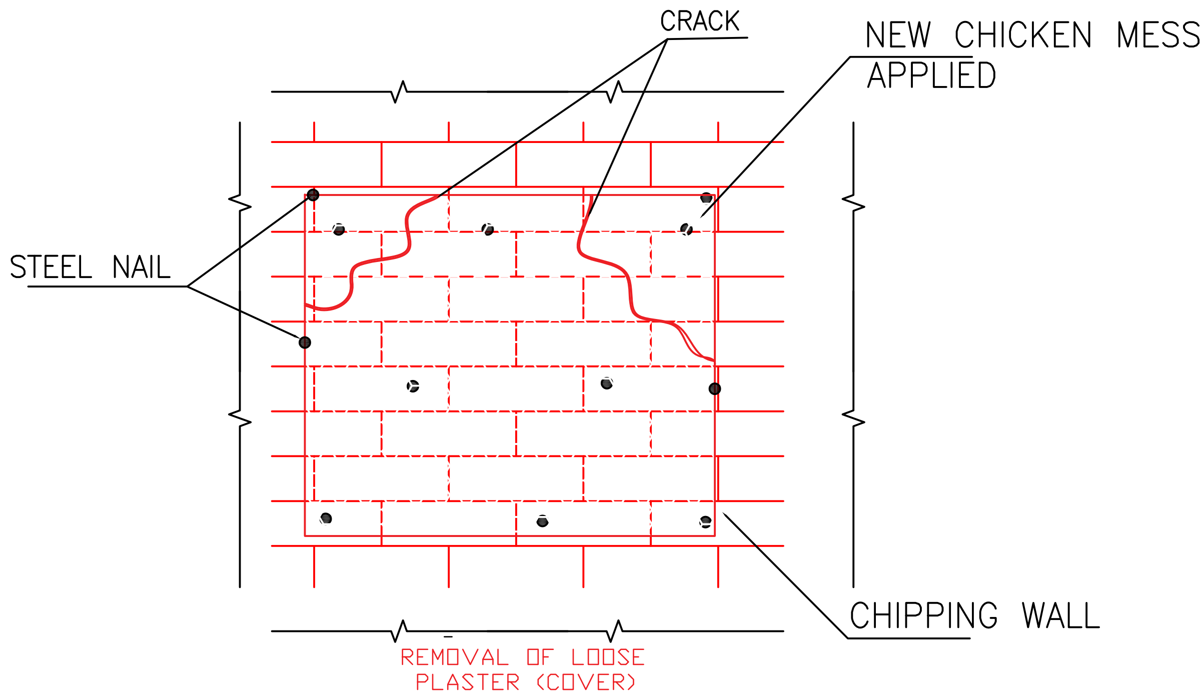
STRENGTHENING OF WALL CRACKS

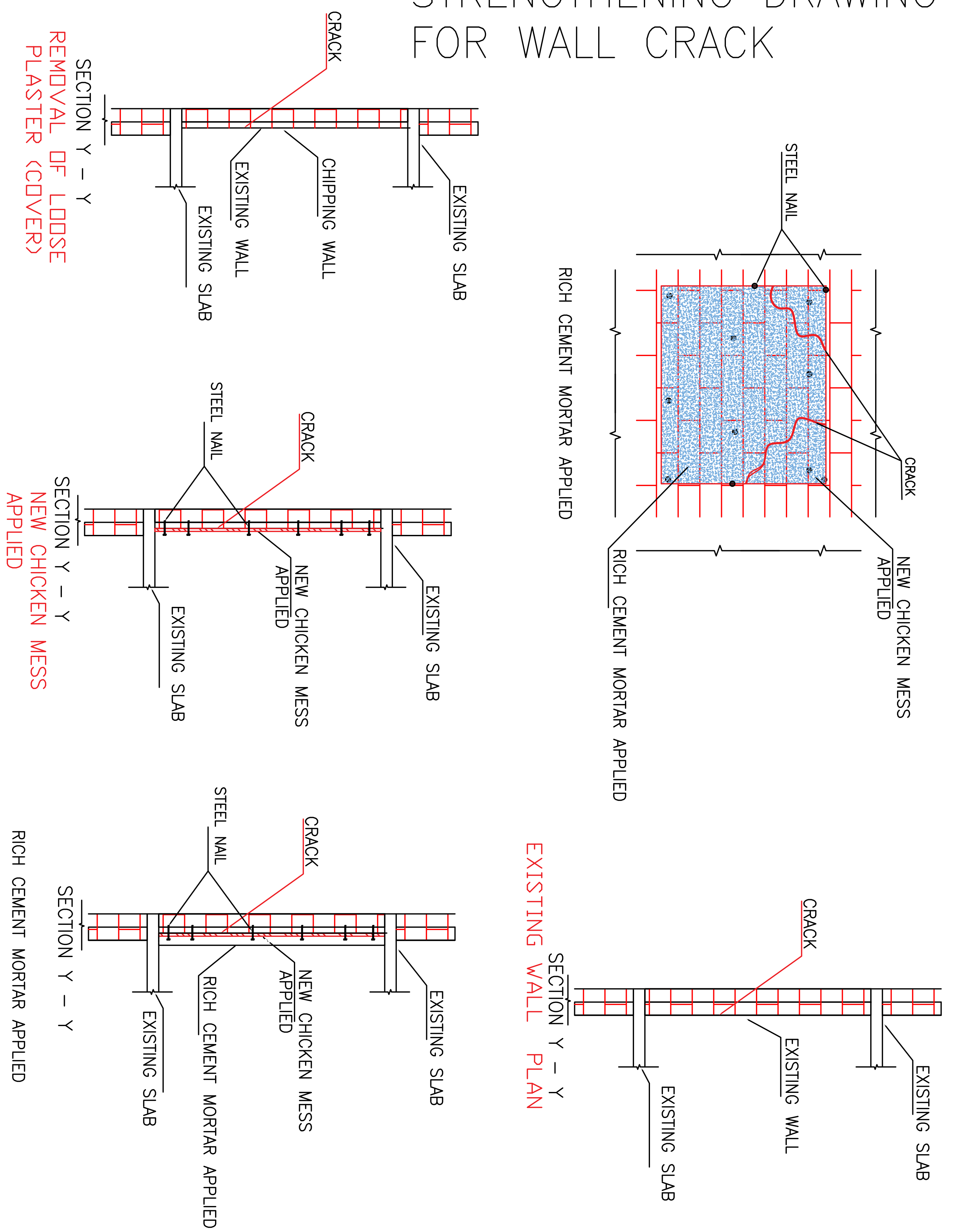
1. Barricade the damaged wall area and restrict access for safety.
2. Mark the full extent of the wall crack and any surrounding delaminated surface.
3. Remove loose plaster and deteriorated material from the wall using a hammer and chisel.
4. Clean the exposed wall surface and crack line with a wire brush or compressed air.
5. Cut galvanized chicken mesh slightly larger than the cracked portion of the wall.
6. Fix the chicken mesh securely to the wall using binding wire, or steel nails.
7. Apply epoxy bonding agent (e.g., Nitto Bond EP) on the prepared wall surface.
8. Apply polymer–modified cement mortar (1:3 mix) over the mesh, fully embedding it.
9. Finish the repaired wall surface with a trowel to match the adjacent texture.
10. Begin moist curing after initial set and continue for 5–7 days.
11. Apply anti–carbonation or waterproof coating over the wall if required after curing.



EXISTING WALL PLAN



STRENGTHENING DRAWING FOR WALL CRACK



Conclusion of Visual Inspection

The building exhibits signs of natural wear and deterioration consistent with its age, environmental exposure, and prolonged service. The visual inspection revealed widespread surface-level issues such as:

- Minor and major cracks in structural members (beams, columns, slabs)
- Localized concrete spalling
- Corroded and exposed reinforcement
- Seepage in shaft and basement areas
- Evidence of poor plaster bonding and aging

These observations are primarily attributed to age-related degradation, inadequate maintenance, and long-term environmental exposure. No direct signs of construction-related defects were observed.

The identified issues are manageable through targeted repairs and do not currently pose an immediate structural risk. However, a preventive repair and maintenance plan involving waterproofing, corrosion protection, and surface rehabilitation is strongly recommended to preserve the structure's long-term integrity and prevent further deterioration.

Final Conclusion

Based on the findings of the detailed visual inspection and results obtained from Non-Destructive Testing (Rebound Hammer and Ultrasonic Pulse Velocity tests), the overall structural health of the building is found to be satisfactory. The Rebound Hammer test results generally fall within acceptable ranges, indicating adequate compressive strength of the concrete. However, the UPV test results showed good quality in selected slab and beam areas, suggesting possible non-uniformity or material degradation due to aging or inconsistent workmanship. The identified deterioration—such as reinforcement corrosion, surface cracking, spalling, and moisture ingress—is localized and appears to be a result of long-term environmental exposure and lack of routine maintenance, not due to construction errors.

To ensure long-term performance and safety, the following action plan is recommended:

- ***Waterproofing treatment in damp and seepage-prone areas.***
- ***Repair of cracked and spalled concrete with polymer-modified mortar or micro-concrete.***
- ***Application of corrosion inhibitors and protective coatings on exposed reinforcement.***
- ***Use of additional reinforcement and jacketing where structural cracks exceed critical thresholds.***
- ***Installation of chicken mesh in areas with surface cracks to prevent delamination.***
- ***Regular monitoring using visual checks and periodic NDT testing.***

By executing these measures under qualified structural supervision, the building's service life can be extended significantly, and the need for major structural intervention can be avoided at this stage.