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Structural Audit of Dr. JJMCOE, Jaysingpur (Building A) and Suggesting Retro-Fittings

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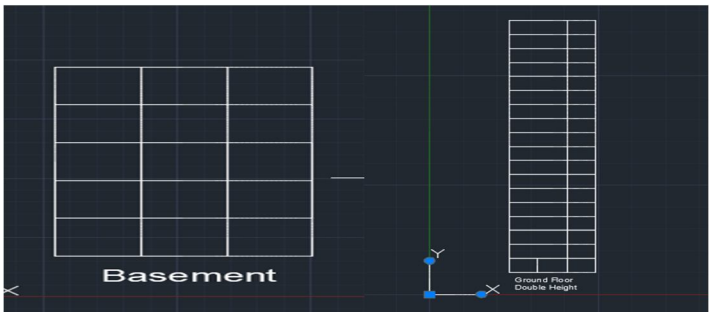
Abstract: ***Engineer design a particular structure for design life of years i.e 50 or 70 etc, But from the period handover the structure for the use and with increasing the life of structure strength of structure decrease so to tackle the problems related to the strength and keep structure safe continuous checking of structural members called as Structural Audit is necessary and this checking is done by some testings I.e NDT (Non Destructive Testing) and DT (Destructive testing).In NDTs As per the name test do not destruct the member and instrument are Rebound Hammer, Ultrasonic Pulse Velocity (UPV) and Re-bar tester. We use the Instrument Rebound hammer to test the structure of Dr. JJMCOE, Kolhapur.***
Keywords: Structural audit, NON-Destructive testing (NDT), Repair and retrofit.

I. BUILDING INFORMATION

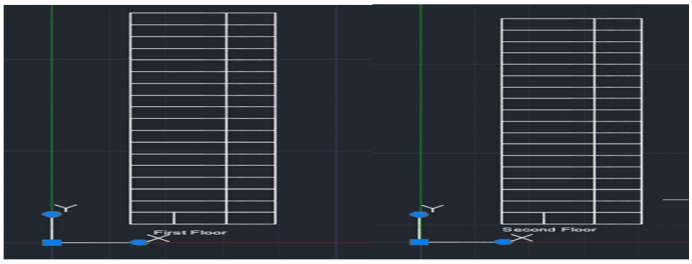
Respective building is educational building of Dr.JJMCOE,Kolhapur (ETC and ETRX building) located at Shirol-wadi road constructed in year 2000 and age of the building in current is 19 years.This building is having basement and three floor in superstructure including ground floor (B+G+2).Stories height of different floors is B=3,GF=8,FF=4,SF=4 (In meters). And the building is highly affected by monsoon.

Dampness due to rain water

II. STRUCTURAL PLAN OF ALL FLOORS OF THE BUILDING.



Basement Ground Floor



First Floor Second Floor

III. VISUAL INSPECTION

Visual inspection taken to highlight the critical areas which in sever condition and most affected by rainwater and corrosion and draft the visual inspection report.

A. Visual Inspection Report

Room/Lab Name/Number	Structural Members	Non-structural members
CCF(Central computing facility) room	Full sealing	-
Battery room	Crack beneath beam Crack to beam and reinforcing bars are exposed	-
Refrigeration and Air conditioning lab	Cracks near to column	Cracks to wall plaster
Machine measurement and control lab	Crack beneath beam Cracks near to column Crack to beam and reinforcing bars are exposed	Cracks to wall plaster
Heat transfer lab	Crack to beam and reinforcing bars are exposed	Cracks to wall plaster
Industrial hydraulics lab	Reinforcement of slab is exposed Leakage to beam and slab	Dampness to wall
Xerox room	Leakage to slab	-
Electronics lab	-	-
A-102	Crack to column	-
A-103	-	-
A-104	-	-
A-105	-	Dampness to external wall
A-106	-	-
A-107	-	-
A-108	-	Crack to plaster
A-109	-	Dampness to external wall
A-202	-	-
A-203	-	Cracks beneath beam
A-204	-	Cracks beneath beam
A-205	Slab leakage	Cracks beneath beam
A-206	Slab leakage Beam deflected	Cracks beneath beam
A-207	Reinforcement of slab is exposed Leakage to Slab deflected Cracks to column	-
A-208	Slab deflected Beam deflected Slab leakage	Cracks beneath beam
A-209	Slab deflected Beam deflected Slab leakage	Cracks beneath beam Dampness to wall
E&TC HOD cabin	-	Dampness

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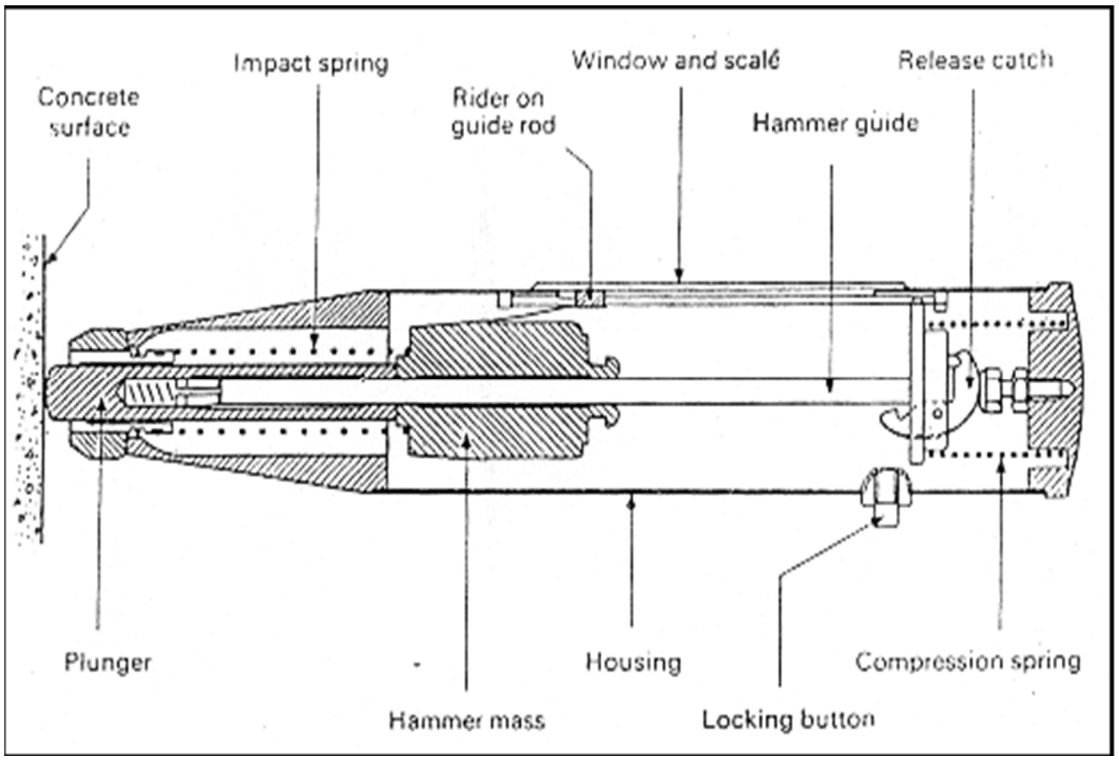
IV. TESTING BY REBOUND HAMMER

Rebound hammer works in tapping system due to plunger and spring arrangement and it requires smooth surface to rebound hence it is necessary to remove the plaster from structural member to create smooth surface otherwise it gives stiffness of plaster.



Parts of Rebound Hammer

Plaster removed Structural members.

As the body is pushed, the main spring connecting the hammer mass to the body is stretched. When the body is pushed to the limit, the latch is automatically released and the energy stored in the spring propels the hammer mass towards the plunger tip. The mass impacts the shoulder of the plunger rod and rebounds.

A. Rebound Hammer Readings

ROOM NAME	STRUCTURAL COMPONENT			HAMMER READINGS in M pa					MEAN
	Column	Beam	Slab	1	2	3	4	5	
				BASEMENT					
Electronics Lab	1			49	50	51.5	34	48	46.5
	2			45.5	39	34	50.5	42	42.2
	3			44.5	31	47.5	39.5	52.5	43
	4			48	53	53	33	53	48
	5			36.5	40.5	35.5	57.5	49	43.8
	6			36	40	35	59.5	48	43.7
	7			47	62	40	42	43	46.8
	8			46	65.5	41	43	41.5	47.4
	9			45.5	43	45.5	49	53	47.2
	10			47	62	40	42	43	46.8
	11			53.5	65.5	41	43.5	41.5	49
	12			40	43	45.5	49	53	46.1
	13			19.5	18	22	34	23.5	23.4
	14			33	35	39	22.5	36	33.1
	15			46	33.5	40	52	29	40.1
	16			143.5	34	23.5	46	32.5	55.9
	17			47	43	40	36.5	46	42.5
	18			23.5	46	41	39	33	36.5
	19			46	23.5	25.5	42	41.5	35.7
	20			49	50	51.5	34	48	46.5
	21			33.5	37.5	43	50.5	59.5	44.8
		1		21.5	19.5	33.5	34	22	26.1
		2		30.5	33.5	33.5	34.5	35	33.4
		3		47.5	42.5	39.5	9.5	52.5	38.3
		4		25	25.5	23.5	19	23.5	23.3
		5		35	25	17.5	21.5	39.5	27.7
		6		33	24.5	18	20	35.5	26.2
		7		25	22.5	21	33.5	17.5	23.9
		8		23.5	30	19	35	16	24.7
		9		23	24	36	39	40	32.4
		10		46	65.5	41	43	41.5	47.4
		11		41	43	39.8	40	41	40.96
		12		40.5	36.5	31.5	39.5	38	37.2
		13		51.5	41	19.5	29	26	33.4
		14		46	65.5	41	43	41.5	47.4
		15		50.5	52	52.5	50.5	51.5	51.4

		16		48	53	52.5	33	50.5	47.4
		17		45.5	41.5	41	54	58	48
		18		44	42	40	50	55	46.2
		19		47.5	42.5	39.5	9.5	52.5	38.3
		20		46	43	40	26	53	41.6
		21		33	24	35	23	17	26.4
		22		51.5	41	19.5	29	26	33.4
		23		44.5	31	47.5	39.5	52.5	43
		24		27	21.5	45.5	40	40	34.8
		25		36	25	27	34	19	28.2
		26		48	53	52.5	33	50.5	47.4
		27		43.5	40	45.5	38	53	44
		28		26	37.5	45.5	48.5	31	37.7
		29		42	40.6	41	37	41	40.32
		30		15.5	37	23	40	39	30.9
		31		40.5	36.5	31.5	39.5	38	37.2
			1	14	39	36	33.5	31	30.7
				GROUND FLOOR					
Exam Office	1			46	48	41	43	41.5	43.9
	2			51.5	41	31	29	26	35.7
	3			26.5	30.5	20.5	28.5	29	27
	4			47	43	40	39	46	43
	5			31	30	37.5	36	30	32.9
	6			49	34	35	46	32.5	39.3
	7			21.5	19.5	33.5	34	22	26.1
	8			30.5	33.5	33.5	34.5	35	33.4
	9			36	25	27	34	19	28.2
	10			45	49.5	42	39.4	45	44.18
	11			35.5	17	13	41	22	25.7
	12			36	43	37.5	37	38.5	38.4
	13			33.5	37.5	43	50.5	59.5	44.8
	14			17	21	21	18	16	18.6
		1		46	51	41	43	41.5	44.5
		2		22	39	37	35	32.5	33.1
		3		37.5	33.5	18.5	36.5	31	31.4
		4		36	25	27	34	31	30.6
		5		46	39	41	43	41.5	42.1
		6		38.5	34	35	35.5	37	36
		7		15	16	14.5	16.5	18	16
		8		33.5	37.5	43	50.5	59.5	44.8
		9		44	34.5	26	34.5	33	34.4

		10		45	36	41	43	42	41.4
		11		46	50	55	43	41.5	47.1
		12		40.5	36.5	31.5	39.5	38	37.2
		13		51.5	41	19.5	29	26	33.4
		14		46	52	41	43	41.5	44.7
		15		46	56	41	45.5	41.5	46
		16		30	39	37	35	32.5	34.7
		17		30.5	52	37.5	49	31	40
		18		30	32	52.5	33	50.5	39.6
		19		32.5	33.5	30	41.5	47	36.9
		20		26	35	24	41.5	47	34.7
		21		24	23.5	30	36	49	32.5
		22		23.5	30	30	36	49	33.7
		23		22	25.5	26	33.5	20	25.4
		24		20	32	52.5	33.5	50.5	37.7
		25		32.5	32.5	44	52	46	41.4
		26		18	32	26	23.5	46	29.1
		27		26.5	26.5	53	34	50	38
			1	32	52	36	35	45	40
CCF Lab (with Sealing)	15			39.5	20	32	52.5	25	33.8
	16			34.5	34	43	36	34	36.3
	17			46	50	41	43	41.5	44.3
	18			39.5	25.5	32.5	21.5	27	29.2
Refrigeration Lab	17 c			46	48	41	43	41.5	43.9
	18 C			39.5	25.5	32.5	36	27	32.1
	19			46	51	41	43	41.5	44.5
	20			38.5	34	35	35.5	37	36
	21			15	16	14.5	16.5	18	16
	22			33.5	37.5	43	50.5	59.5	44.8
	23			44	34.5	26	34.5	33	34.4
	24			46	51	41	43	41.5	44.5
	25			35.5	52	41	25	26	35.9
		28		33.5	24	26	32	25	28.1
		29		25	33.5	36	36.5	12	28.6
		30		36.5	25	26.5	45	56	37.8
		31		21	35	23.5	12.5	45	27.4
		32		26.5	25.5	26.5	45	23.5	29.4
		33		25	42	23.5	52.5	45.5	37.7
		34		26.5	26	32	35	14.5	26.8
		35		12	22.5	36	53	34.5	31.6

			2	32	23.5	25.5	26.5	12.5	24
Measurement lab	26			16.5	45	52	42	23.5	35.8
	27			21.5	23.5	36.5	25	23	25.9
	28			32	52	52	42.5	53	46.3
	29			23	26.5	23.5	22	25	24
	30			25	45	25.5	32.5	23	30.2
	31			16.5	15	22.5	13	32.5	19.9
		36		25.5	23.5	36.5	42.5	23.5	30.3
		37		26	23.5	45	23.5	46	32.8
		38		25.5	35	31	32.5	32	31.2
		39		43.5	23	52.5	26.5	23	33.7
		40		23	42.5	23.5	22	21	26.4
		41		42	32	52.5	42.5	21	38
		42		16.5	18.5	19	28.5	25	21.5
		43		25	42	23.5	46	38.5	35
			3	26.5	23	36	28.5	23.5	27.5
Heat Transfer Lab	32			52.5	21.5	23.5	45	52	38.9
	33			45	52.5	23.5	23	43	37.4
	34			30.5	23.5	23	25	23.5	25.1
	35			22.5	24	25.5	33.5	22.5	25.6
	36			25.5	50	51.5	34	48	41.8
	37			45.5	32.5	34	50.5	42	40.9
		44		23.5	31	47.5	35.5	32.5	34
		45		48	25	26	33	53	37
		46		36.5	40.5	35.5	57.5	49	43.8
		47		65	40	35	59.5	52.5	50.4
		48		41	33	22.5	31.5	29.5	31.5
		49		21.5	32	27	32	22	26.9
		50		32	52.5	52	36.5	53	45.2
		51		23	26.5	23.5	22	25	24
			4	56	56	25.5	21	23	36.3
Hydraulics and Pneumatic Lab	38			44	31	53.5	39.5	33.5	40.3
	39			23.5	30.5	28	32.5	23.5	27.6
	40			46	51	33.5	43	41.5	43
	41			23.5	36	22	21.5	23.5	25.3
	42			31.5	25	23.5	33.5	14.5	25.6
	43			23	25	22.5	34	19	24.7
		52		26.5	51	41	23.5	40	36.4

		53		51.5	41	45.5	29	26	38.6
		54		23	30.5	22.5	43.5	12	26.3
		55		32.5	43	33	39	36.5	36.8
		56		25	30	37.5	23.5	32	29.6
		57		49	25.5	23	46	45.5	37.8
		58		45.5	33	33.5	33.5	33.5	35.8
		59		32.5	33.5	25.5	34.5	35	32.2
			5	36	25	23	34	19	27.4
Thermos-dynamic s Lab	44			46	39	41	43	41.5	42.1
	45			22.5	17	13	27.5	24	20.8
	46			36	43	37.5	37	38.5	38.4
	47			33.5	37.5	43	50.5	45.5	42
	48			23.5	36	23.5	43	25.5	30.3
	49			25	25	19.5	25.5	26.5	24.3
		60		25.5	33.5	34	21.5	27.5	28.4
		61		36	24.5	27	25.5	18.5	26.3
		62		46	41	41	43	41.5	42.5
		63		49	36	37.5	49	31	40.5
		64		48	53	52.5	33	50.5	47.4
		65		23.5	33	24	21	47	29.7
		66		25.5	54.5	24	41.5	33.5	35.8
		67		33	25.5	30	33	49	34.1
			6	35.5	21.5	30	23	15.5	25.1
				FIRST FLOOR					
Programming Lab 1	1			14	29.5	32.5	32	33	28.2
	2			23.5	30	17.5	21.5	39.5	26.4
	3			14	25.5	27.5	21	30.5	23.7
	4			20	35	47.5	21.5	35.5	31.9
	5			23	45	46	20	37	34.2
	6			49.5	53.5	61	39	52	51
	7			46	41	41	43	41.5	42.5
	8			33.5	37.5	43	50.5	59.5	44.8
	9			34	38	40	47	54	42.6
	10			48	53	50	35	50	47.2
		1		31	42.5	24.5	46.5	44.5	37.8
		2		32	43	25	33	40	34.6
		3		31	42.5	24.5	25.5	44.5	33.6
		4		33.5	38.5	37.5	34	28.5	34.4
			1	36	25	27	34	19	28.2
A-108	11			51	51.5	48.5	53	50.5	50.9

	12			50.5	52	52.5	50.5	51.5	51.4
	13			48	53	52.5	33	50.5	47.4
	14			45.5	41.5	41	54	58	48
	15			44	42	40	50	55	46.2
		5		47.5	42.5	39.5	9.5	52.5	38.3
		6		46	43	40	30	53	42.4
			2	33	24	35	23	17	26.4
A-107	16			51	51.5	48.5	53	50.5	50.9
	17			50.5	52	52.5	50.5	51.5	51.4
	18			14	45	47.5	21.5	35.5	32.7
	19			48	53	52.5	33	50.5	47.4
	20			45.5	41.5	41	54	58	48
	21			46	40	43	55	55	47.8
		7		47.5	42.5	39.5	9.5	52.5	38.3
		8		46	42	40	10	50	37.6
			3	36	25	27	35	19	28.4
A-106	22			45.5	53	52.5	33	50.5	46.9
	23			43	44.5	43.5	28.5	42.5	40.4
	24			35	32	33.5	49	47	39.3
	25			21.5	52	50	32	50	41.1
	26			27	21.5	45.5	40	40	34.8
	27			48	53	52.5	33	50.5	47.4
		9		35.5	38	40.5	43	60	43.4
		10		35.5	39	40	40	55	41.9
			4	36	25	27	34	19	28.2
A-105	28			48	53	52.5	33	50.5	47.4
	29			53.5	40	45.5	38	53	46
	30			26	37.5	45.5	48.5	31	37.7
	31			48	53	52.5	33	50.5	47.4
	32			21.5	37	23	40	39	32.1
	33			29	37	23	40	39	33.6
		11		14.5	16	28.5	18	13.5	18.1
		12		24.5	16	25.5	12	15	18.6
			5	36	24	27	32	21	28
A-104	34			21.5	53	52.5	33	50.5	42.1
	35			23	25.5	42.5	43.5	37	34.3
	36			49	36	37.5	49	31	40.5
	37			48	53	52.5	33	50.5	47.4
	38			25.5	10	24	41.5	47	29.6
	39			25.5	54.5	24	41.5	47	38.5
		13		49	49	30	36	49	42.6

		14		49	21.5	30	36	49	37.1
			6	35	25	26	34	20	28
A-103	40			48	53	52.5	33	50.5	47.4
	41			17.5	27.5	44	52	46	37.4
	42			42.5	45	44	52	46	45.9
	43			48	52	53	34	50	47.4
	44			31.5	42.5	44	47	44	41.8
	45			31.5	40	42	42	43	39.7
		15		35	25	17.5	21.5	39.5	27.7
		16		36.5	24.5	18	20	40	27.8
			7	36	24	28	33.5	21	28.5
A-102	46			49	50	51.5	34	48	46.5
	47			45.5	39	34	50.5	42	42.2
	48			44.5	31	47.5	39.5	52.5	43
	49			48	53	53	33	53	48
	50			36.5	40.5	35.5	57.5	49	43.8
	51			36	40	35	59.5	48	43.7
		17		41	33	36.5	31.5	29.5	34.3
			8	30	32	27	32	22	28.6
			SECOND FLOOR						
Embedded Micro-controller Lab	1			47	41	40	42	43	42.6
	2			46	40.5	41	43	41.5	42.4
	3			40	43	45.5	46.5	53	45.6
	4			19.5	18	39	32.5	29.5	27.7
	5			33	35	39	42	36	37
	6			46	42	41	23.5	29	36.3
	7			45.5	34	35	46	32.5	38.6
	8			47	43	40	25.5	46	40.3
	9			23.5	46	41.5	32.5	33	35.3
	10			46	55	41	42	41.5	45.1
		1		12.5	52.5	21	33.5	17.5	27.4
		2		23	52	19	35	16	29
		3		33.5	24	36	39	40	34.5
			1	36	25	27	32.5	19	27.9
Programming and Network Lab	11			45	46.5	44.5	38	37	42.2
	12			53.5	38	34	54.5	25.5	41.1
	13			46	49	41	43	41.5	44.1
	14			45.5	46.5	44.5	38	37	42.3

	15			38	46	45	56.5	39	44.9
	16			23.5	42	43	38	36	36.5
	17			46	41	41	54.5	41.5	44.8
	18			39.5	25.5	32.5	36	27	32.1
	19			34.5	34	43	23.5	34	33.8
	20			46	42	41	43	41.5	42.7
	21			39.5	25.5	32.5	36	27	32.1
	22			43	44	46	45.5	39	43.5
	23			46	52.5	40	41	41.5	44.2
	24			43	50	42	39	33	41.4
		4		29.5	39	21	27.5	30.5	29.5
		5		44	44.5	32.5	38.5	44.5	40.8
		6		46.5	25	34	31.5	22	31.8
			2	25	23	20	22.5	19	21.9
TAM Analog Lab	25			41.5	36.5	22.5	27	22.5	30
	26			33.5	32	38.5	37	38.5	35.9
	27			40	34	25.5	30	26	31.1
	28			45.5	39	34	50.5	42	42.2
	29			46	39.4	41	43	41.5	42.18
		7		25	29.5	19.5	25.5	26	25.1
		8		32.5	33	34	20	27.5	29.4
			3	36	25	27	34	30	30.4
Advance Communication Lab	30			46	41	41	43	41.5	42.5
	31			35	35.5	37	38	31	35.3
	32			27	25.5	30	35	29.5	29.4
	33			44.5	31	47.5	39.5	52.5	43
	34			27.5	30.5	28	32.5	30	29.7
	35			46	43	50	43	41.5	44.7
		9		38.5	36	22	21.5	30.5	29.7
		10		31.5	25	23.5	34	14.5	25.7
			4	36	25	27	34	19	28.2
Digital Communication Lab	36			46	39	41	43	41.5	42.1
	37			51.5	41	19.5	29	26	33.4
	38			26.5	30.5	20.5	28.5	29	27
	39			47	43	40	39	46	43
	40			25	30	37.5	25.5	25.5	28.7
	41			49	34	35	46	32.5	39.3

		11		21.5	19.5	33.5	34	22	26.1
		12		30.5	33.5	33.5	34.5	35	33.4
			5	36	25	27	34	19	28.2
Optical and Microwave Lab	42			46	48	41	43	41.5	43.9
	43			28	17	13	27.5	36	24.3
	44			36	43	37.5	37	38.5	38.4
	45			33.5	37.5	43	50.5	59.5	44.8
	46			17	21	21	18	16	18.6
	47			46	43	41	43	41.5	42.9
		13		22	39	37	35	32.5	33.1
		14		37.5	33.5	18.5	36	19	28.9
			6	36	25	27	34	19	28.2
A-202 (POP)	48			46	42.6	41	43	41.5	42.82
	49			38.5	34	35	35.5	37	36
	50			15	16	14.5	16.5	18	16
	51			33.5	37.5	43	50.5	59.5	44.8
	52			44	34.5	26	34.5	33	34.4
	53			46	44.2	41	43	41.5	43.14
	54			46	41	41	43	41.5	42.5
	55			40.5	36.5	31.5	39.5	38	37.2
	56			51.5	41	19.5	29	26	33.4
	57			46	45	41	43	41.5	43.3
				STAIRCASE					
GF TO FF				35	32.5	42	43	44.5	39.4
FF TO SF				23.5	53.5	36.5	29	30	34.5
SF TO TERRACE				33.5	23.5	25	26	33	28.2

From above readings of Rebound Hammer we conclude that highlighted beams Columns and slabs seems weak due to the combined effects of carbonation, corrosion & effect of continuous drying and wetting and harsh weather condition building structure is in really bad condition.

V. SUGGESTIONS FOR RETRO-FITTINGS

A. Fibro plaster is suggested.
B. Grouting to steel which exposed due to disintegration of concrete.
C. Re-reinforce of sever rusted membe.r
D. Filling of cracks with cement mortar to reduce leakage.
E. From above observation of the building we conclude that:

Due to combined effects of carbonation, corrosion & effect of continuous drying and wetting and harsh weather condition building structure is in really bad condition and should be subjected to the repair immediately. Structural building appears to be unsound due to external and internal defects. Structural members shoes cracks due to corrosion of the RCC members. Major cracks observed accelerate the passage of water through the wall resulting in leakage of the water. Looking at the aspect of building maintainance it is recommended to repair the building in planned manner. In RCC framed structure ,RCC members are the major load taking elements so they cannot be left unattended for long period of time. Original strength of the RCC members can be restored by polymer modified mortar method

VI. CONCLUSION

A. The building is having damages and deterioration which are curable and necessary repair are to be taken up as recommended to restore the livability in the building.It is repairable and livable building.

B. The structure of the building when undergoing repairs,the student can continue occuples the premises. The repair to be carried out in phases in co-ordination with students of occupations during repair.

C. The proposed repairs will add life to the structure. The frequent repair to the building is to be taken up to every 3-5 years or as and when there is any kind of damage noticed in the building.The occupants should also take active in the same.

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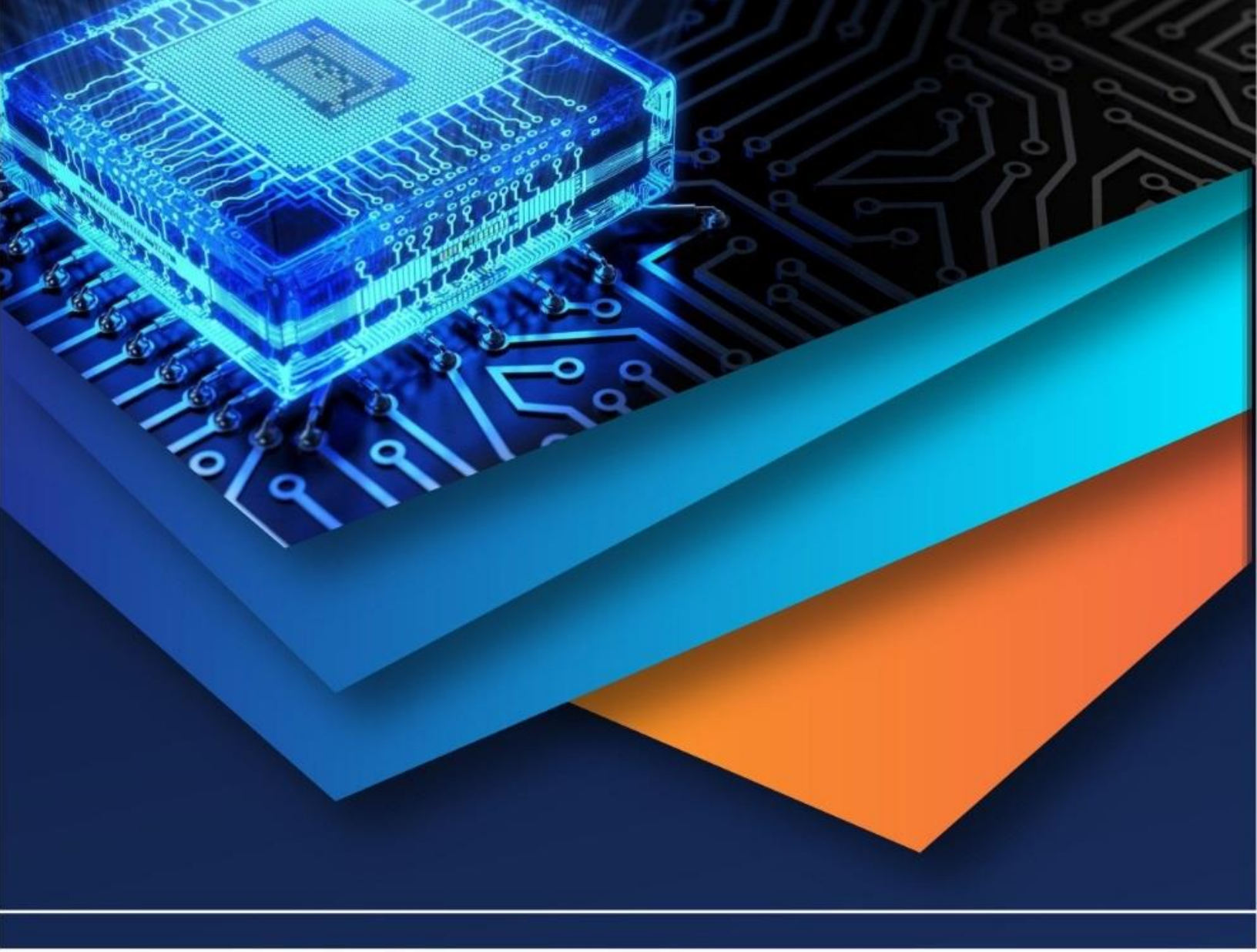

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