

Evaluating Structural Integrity of Concrete Structures by using Non-Destructive -Testing

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Abstract concrete being a high durable construction Material Shows some signs of deterioration in its whole Life span. Damage may occur from a variety of causes like accidental overloading, foundation settlement, poor Workmanship And corrosion of concrete cover which Leads to cracking and Spalling of concrete cover. These Deteriorations effect the structural integrity of a structure which leads a way towards structural failure. Thus concrete Structures that are in use need to be Specifically inspected to determine the extent of damage and Integrity of such Structure's. Non -Destructive Testing is one of the technique that can be used for Evaluating the structural integrity of such concrete structures that are in use. With the help of this technique we can rule out the various damages present in our structures. By this technique we can find the structural Stability of our existing structures. This technique helps us in assessing The condition of our structure's which gives an idea about What steps should be taken to save a structure from any kind of failure in future. Without destroying whole structure NDT gives us the result whether the structure is stable or not.



Fig 1 . Residential houses of sector 30



Fig 2 . Conducting Non-destructive testing

Key words; Concrete, Non Destructive testing, Structural failure, Deterioration, stability, repairing etc.

1. Introduction

The objective of the investigation was to carry out Non-destructive testing on single storey houses in sector 30 Of Chandigarh so as to assess the present strength of R.C.C members and various masonry structures.

Non - destructive testing of various members along with the condition survey was carried out to assess integrity of these residential houses.

Investigations were carried out to locate cracks, leakage points, concrete quality, corrosion in reinforcing bars, carbonation of concrete and ingress of salts in concrete. The strength , integrity of concrete ,presence of voids , cracks or other imperfections were found by using various Non-destructive tests like rebound hammer test, Ultra sonic pulse velocity test etc. The visual Examination was carried out to find out dampness and other defects in the houses.

2. SCOPE OF THE STUDY

The aim of the investigation was;

- To identify the cause of damage and source Of problem.
- To determine the extent of damage .
- To assess the safety and serviceability of the structure.
- To provide recommendations on remedial And preventive measures.

3. METHODOLOGY

3.1 Intial visual inspection

Visual inspection is the starting point of any investigation. Cracks, rust staining and spalling are the most obvious defects which can be identified by visual inspection. Often the location of these can give a good indication of the cause of the problem. Visual defects may be related to poor workmanship or material deterioration.

These show up as excessive deflection and flexural cracking, while foundation movements may cause diagonal cracks. Material deterioration is normally indicated by cracking and spalling .

Examination of crack pattern often suggests the most probable cause of the problem. Potential problems associated with cracking, excessive deflections, water permeability and evidence of corrosion should be specially noted. By observing the site and examining pertinent drawings and records, the probable cause of damage was deduced and the area's of serious concern were located.

2 condition survey

The purpose of the survey was to collect sufficient data to pinpoint the cause and source of the of the problem and to determine the extent of damage . Depending on the probable cause of damage, the site work involves a combination of following processes.

1. Detailed inspection
2. Survey of cracks , spalls and other defects
3. Drilling of holes for carbonation test and making grid for USPV test

3.3 physical and mechanical inspection

This comprises of a series of Non- destructive Tests conducted physically on the structure to assess its condition . The various tests conducted were as

- Rebound hammer test
 - Ultra-sonic pulse velocity test
 - Carbonation test
 - Ingress of chloride & Sulphide test
- Rebound hammer test and ultra sonic pulse

Velocity tests were carried out to find the strength of concrete.



Fig 3. Rebound hammer testing

4. DATA COLLECTION

4.1 visual inspection

The visual inspection was carried out in the following sequence;

- Observation of cracks
- Honeycombing in concrete
- Dampness of surface
- Defects in masonry walls
- Leakage points
- Spalling of concrete
- Cracks in joints
- Signs of corrosion

Table 1 . VISUAL INSPECTION OF TYPE 13 HOUSES IN SECTOR 30

S.No.	House No.	DEFECT	Type of defect
1.	No. 509	No Defects	No Defects were observed.
2.	No. 510	No Defects	No Defects were observed.
3.	N0. 512	Dampness	Dampness was found in the walls of entrance room
4.	No. 656	Dampness cracks seepage	Dampness was observed over the walls Vertical cracks on outer wall was observed Seepage patches over the roof was also observed
5.	N0.3635	No defects	No defects were observed
6	No .3254	Cracks settlement	Diagonal cracks on the walls were observed Settlement was observed in the floor of backside area of the house

3.2 Non- destructive –testing

The results of non - destructive testing performed on various houses of sector 30 are mentioned below

Table 2. UPV, RH VALUES & CARBONATION TEST OF HOUSES IN SECTOR 30

S.NO	Location	RH Number	UPV	Compressive Strength	Carbonation
1.	Slab of house No. 509	42,40,33,33,38,34,32,45,26,37=37	ID- 3577	16.5	Green
2.	Slab of house No. 510	42,47,42,31,35,40,40,34,33,35=38	ID- 2140	17.5	Green
3.	Slab of house No. 511	54,52,44,68,62,59,48,49,51,69=55	ID-3125	20	Green
4.	Slab of house No. 512	25,24,38,34,32,29,33,26,25,30=30	ID-2235	11.5	Green
5.	Slab of house No. 533	44,50,48,44,48,57,54,46,48,48= 49	ID-3957	29	Green
6.	Slab of house No. 656	48,48,54,56,58,56,58,61,56,45=54	ID- 2336	37.5	Green
7.	Slab of house No. 655	64,55,70,59,60,62,60,57,60=61	ID-2439	52	Green

Table 3 . RH VALUES (P-TYPE) TEST OF SECTOR-30 HOUSES WALLS.

S.NO	Location	Rebound Numbers P-Type						Avg.	Quality
1.	Walls of house No. 509	69	90	74	86	65	103	81	Excellent
2.	Walls of house No. 510	95	72	85	90	85	85	85	Excellent
3.	Walls of house No.511	95	110	86	60	111	108	95	Excellent
4.	Walls of house No.512	91	83	106	119	111	94	82	Excellent
5.	Walls of house No.533	94	80	87	104	88	62	85	Excellent
6.	Walls of house No.656	59	105	75	81	73	78	78	Excellent
7.	Walls of house No.655	109	94	100	104	93	103	100	Excellent

TABLE-4 SULPHATE/CHLORIDES INGRESS TEST

Sr.No.	Location	Chlorides		Sulphates	
		By weight of concrete (%)	By weight of Cement (%)	By weight of concrete (%)	By weight of Cement (%)
HOUSES AT SECTOR 30 CHANDIGARH					

1	Sample -1	0.012	0.07	0.25	1.54
2	Sample -2	0.007	0.05	0.04	0.26
3	Sample -3	0.008	0.05	0.04	0.26
4	Sample -4	0.009	0.06	0.06	0.30
5	Sample -5	0.007	0.05	0.05	0.28

Results

1. Cracks were observed at few locations in some houses.
2. Spalling of concrete was observed at some Locations such as cantilever over windows & beams.
3. Dampness was observed in most of the houses.
4. Overall quality & strength of concrete was found to be good.
5. Settlement was observed in some houses .

6. Repairment

6.1 Repairment of spalling concrete at cantilever areas.

S.NO	Description
1	Support & Surface Preparation
1.1	Providing and erecting steel props (up to full height, braced at center, resting on wedge and block to support the structure provisionally during repair work and maintaining them in position till required and as directed by the Engineer- in-charge.
1.2	Chipping of unsound weak concrete / cover of reinforcement over slab, column, and walls or as per site requirement by chiseling maximum up to 30 mm depth and disposal of malwa from site as per instruction of Engineer-in-charge.
2	Corrosion Protection to Existing Reinforcement
2.1	Supply and apply of rust remover cum PASSIVATOR to remove rust from existing reinforcement. Product: SIKA RUST OFF 100. Consumption: 0.2 kg/m ² /coat. Density: 1.01 Kg/l at 300C
2.2	Supply and apply a cement based polymer modified rebar corrosion protection system to existing reinforcement. Product: SIKA TOP ®-Armatec-108. Consumption: 3.75 kg/m ² for two coats. Product requirements: carbonation resistance: 2 mm of SIKATOP ARMATEC®-108 corresponds to 20 mm of normal mortar; bond strength > 1N/mm ² according to ASTM C 882-78.
3	Fixing & Grouting of New Reinforcement
3.1	Providing extra reinforcement with TMT bars as per site design requirement including straightening, cutting, bending, placing in position, binding with Galvanized wire of 18 gauge etc. complete in all respects. Additional reinforcement with adequate lap length & rings at required spacing shall be tied with existing reinforcement using binding wire or welded complete as per site requirement and directions of Engineer -Incharge..
4	Epoxy Bonding Primer
	Providing, mixing & applying two component Epoxy resin concrete Bonding coat on prepared RCC

4.1	surfaces as per manufacture specification including preparation of surface by chipping and thoroughly cleaning of surface complete wherever required and as per directions of Engineer-in-charge. Product: SIKADUR®-32LP Consumption: 0.4 kg/m ² . Product requirements: Complies with ASTM C 881 Type II Grade 2 Class B+C.
5	Jacketing with Micro Concrete
5.1	Providing and fixing water tight centering and shuttering including bolting, strutting, propping etc. including removal of form work from column, beam etc. complete as per site requirement and directions of Engineer-in-charge.

6.2 Repair of thin hairline cracks in the brick walls

S. No	Description
1.1	Making 'V' groove of 3mm wide and 3mm deep over crack line by electrically operated angle grinder with diamond concrete saw blade and cleaning it by air blower as directed by Engineer-in-charge.
1.2	Supply and apply of rust non shrink repair mortar for non-moving cracks in plaster and walls. Product :SIKA® CRACKSIL Consumption: 25 RMT/ kg for crack size of 6mm x 6mm. Density: 0.85 Kg/l at 27°C

6.3 Repair of dampness and efflorescence at ground level and sunken areas

S. No	Description
1	Surface Preparation
1.1	Chipping of unsound weak concrete / cover of reinforcement over slab, column, and walls or as per site requirement by chiseling maximum up to 30 mm depth and disposal of malwa from site as per instruction of Engineer-in-charge.
2	Waterproofing coating
2.1	Supply and apply a glass fiber reinforced acrylic modified cementitious coating system. Base coat: SIKA Top® Seal-107 Consumption base coat: 1.5 kg/m ² Reinforcement: SIKA ® Fab-1 Top coat: SIKA Top® Seal-107 Consumption top coat: 1.5 kg/m ² System requirements: density: 2.00 kg/LT; compressive strength: 20 N/mm ² ; bond strength: 2.0 N/mm ² ; approved for potable water contact.
3	Patch repair mortar
3.1	Supply and apply a epoxy resin based solvent free bond coat. Product: SIKADUR ®-32 LP. Consumption: 0.4 kg/m ² . Product requirements: Complies with ASTM C 881 Type II Grade 2 Class B+C.

7. Recommendation

1. Contact of water with soil below the foundation should be completely prevented by providing proper plinth protection and ensuring quick drainage of rain water.
2. All the traps and manholes should be repaired to prevent the seepage into the foundations from such locations.
3. Water tanks on the roof causing dampness due to overflow of water or due to leakage, should be repaired and overflow should be stopped by providing suitable float valve.
4. Exposed concrete was found to be carbonated, the carbonated concrete should be provided with anti-carbonation coating if the spalling of cover concrete has not started.
5. If the spalling of cover concrete is taking place the same should be repaired by treating the affected reinforcement and repairing the cover with micro concrete.

8. Conclusion

1. The overall stability of various structures was found to be good. The visual inspection and NDT results show that the various members are in good condition respect to their deterioration with age.
2. The defects identified should be repaired in order to prevent further deterioration.
3. These houses are old , requires regular and special maintenance. In present condition most of the houses are in good condition with proper maintenance, since these are old houses there maintenance cost may rise in the coming years. In view of this department may look into reconstruction of these houses in phased manner.
4. Overall strength of concrete was found to be good.

9. References

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