A CASE STUDY ON REHABILITATION AND RETROFITTING OF CHEETAL MARRIAGE ACCOMMODATION OF INDIAN ARMY HISSAR

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Abstract:- *The aim of the project is to investigate the structure (Cheetal marriage accommodation (P-1001 to P-1009 & P-1208 and P-1211) of Indian army Hissar) through NDT methods and test the structural integrity of building by assessing the deterioration with respect to quality and strength of concrete, permeability, corrosion, cracks and other defects causing distress and apply suitable remedies or retrofit the structure and give it proper strengthening, Increase in the ductility of the structure.*

Key Words: NDT, Structural Integrity, Deterioration, Strengthening, Ductility.

1. INTRODUCTION

To keep a good life of structural safety, durability and performance of the concrete structure everywhere in the world, time to time structural assessment, maintenance is required. The quality surety during and after the construction of new structures and after reconstruction processes and the description of material properties and damage as a function of time and environmental influences is more and more becoming a serious concern. As time passes structure need to improve the ability of the present structure to withstand the weathering action, fire, seismic forces etc. which may cause damage to the structure or reason for the poor health of the structure. On many cases, corrosion of reinforcement may cause off cracking and spalling of concrete, united with drop in the strength of the structure. In that states repairs of affected zones and sometimes for the replacement of the entire structure is needed. On these situations Non-destructive testing (NDT) methods are used to determine the problem. A variety of advanced NDT methods are available.

Therefore, the solutions for RCC structure or structural elements are essential and for this different technique are utilized. Strength sensitivity of a present structure or any element of structures is crucial to cover all the criteria in which maintenance is required.

1.1 Structural Health Monitoring

Structural health monitoring is at the front of structural and materials study. Structural health monitoring systems allow inspectors and engineers to collect material statistics of structures and structural elements used for study. Ultrasonic can be applied to structural monitoring programs to acquire such information, which can be exclusively valuable because the wave features and properties can be used to obtain material features and properties.
This testing approach may be used to judge the consistency and comparative superiority of the concrete, to specify the existence of voids and cracks, and to assess the usefulness of crack repairs. It can be used to show variations in the properties of concrete, and in the study of structures, to guess the sternness of weakening or cracking. Declines in ultrasonic waves hustles over time can expose the beginning of harm before noticeable deficits become obvious. This allows inspectors and engineers to implement repair suggestions before minor deficiencies become safety risks.

1.2 Structural Health Monitoring using Non-Destructive Testing

The successive testing of structure will basically dependent upon the effect of initial testing done with the suitable NDT procedure.

The NDT being fast, easy to use at site and relatively less expensive can be used for

I. Testing any amount of points and locations.

II. Determining the structure for various distressed conditions.

III. Measuring damage because of fire, chemical attack, impact, age etc.

IV. Observing cracks, fractures, honeycombs and feeble locations.

V. Judging the real condition of reinforcement.

2. NON DESTRUCTIVE TESTING

A number of NDT methods have been established and are accessible for study and assessment of different parameters related to strength, durability and quality of concrete. Each technique has some strong point and some limitation. Consequently, judicious method should be to used more than one method in blend so that the strength of one pay off the limitation of the other. The several NDT methods for testing concrete bridges are–

A. For strength estimation of concrete

(i) Rebound hammer test
(ii) Ultrasonic Pulse Velocity Tester
(iii) Combined use of Ultrasonic Pulse Velocity tester and rebound hammer test
(iv) Pull off test
(v) Pull out test
(vi) Break off test

B. For assessment of corrosion condition of reinforcement and to determine reinforcement diameter and cover

(i) Half-cell potentiometer
(ii) Resistively meter test
(iii) Test for carbonation of concrete
(iv) Test for chloride content of concrete
(v) Profometer
(vi) Micro cover meter

C. For detection of cracks/voids/ delamination etc.

(i) Infrared thermographic technique
(ii) Acoustic Emission techniques
(iii) Short Pulse Radar methods
(iv) Stress wave propagation methods –
   a) pulse echo method
   b) impact echo method
   c) response method

3. TEST METHODOLOGY

The objective of the investigation is to test the structural integrity of structure by assessing the deterioration with respect to quality and strength of concrete, permeability, corrosion, cracks and other defects causing distress.

3.1 Initial Visual Inspection

The visual examination was carried out in the following sequence:

i. Observations for cracks
ii. Honeycombing in concrete
iii. Dampness of surface
iv. Leakage points
v. Signs of corrosion
vi. Spalling of concrete
vii. Cracks in joints
viii. Leakages from joints

ix. Defects in masonry walls
x. Settlement of floor
xi. Settlement cracks on walls

3.2 Condition Survey

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

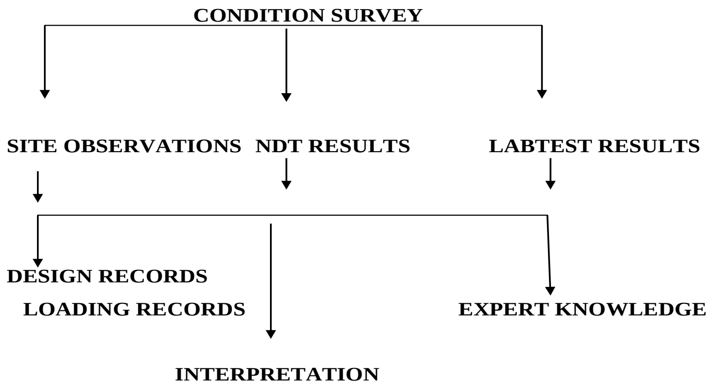

Figure 1:- Distressed condition of the building p-1001

Figure 2:- Spalling of concrete and corroded reinforcement of building P-1003

Figure 3:- Rebound Hammer Testing of a Specimen

4. OBSERVATIONS

I. Vertical cracks on exterior columns of all the buildings.

II. Cracks and spalling of concrete from the balcony of all the building

III. Dampness and efflorescence on walls at generally at the lower level of all the buildings.

IV. Spalling of concrete and exposed corroded reinforcement in exterior columns, balconies and cantilever of the buildings (P-1001 to P-1009)

V. Termite attack on the ground floor and 1st floor of the building.

VI. The reinforcement of external members of buildings (P-1001 to P-1009) i.e. Columns, balconies and cantilevers (exposed) are corroded more than 60%.

VII. The Ph value of concrete becomes very low in (P-1001 to P-1009) buildings.

VIII. Minor cracks along the openings of the windows and doors.

Figure 4:- USPV tester used in the Project

5. TEST RESULTS AND SUMMARY

Non Destructive Testing is done on the (Cheetal marriage accommodation (P-1001 to P-1009 & P-1208 and P-1211) of Indian army Hissar). Some of the test results are shown below:-

Table 1:- RH VALUES, COMPRESSIVE STRENGTH & CARBONATION TEST (PH) OF P-1002 BUILDING

Location	Avg RH	Compressive Strength	Carbonation (pH)	Corrected Compressive Strength (f_{ck}) N/mm^2
Front side column	16.41	17.23	Between 5-6	10.34
Back side outer column	17.12	17.98	Between 5-6	10.79
Beam	18.125	19.03	Between 5-6	11.42
Beam	16.43	17.25	Between 5-6	10.35
Slab	19.5	20.48	Between 5-6	12.29

Table 2:- RH VALUES, COMPRESSIVE STRENGTH & CARBONATION TEST (PH) OF P-1208 BUILDING

Location	Avg. RH	Compressive Strength	Carbonation (pH)	Corrected Compressive Strength (f_{ck}) N/mm^2
Front side column	40.6	42.63	Between 5-6	25.58
Back side outer column	36.02	37.83	Between 5-6	22.70
Beam	43.68	45.87	Between 5-6	27.52
Beam	37.3	39.17	Between 5-6	23.50
Slab	38.05	39.96	Between 5-6	23.97

Table 3:- UPV Values OF P-1003 BUILDING

Location	UPV Values (m/s)		Average UPV Values(m/s)	Direct Proportionate Velocity (IS, 5.4.1 13311 part 1)	Quality of concrete
Front side column	2250	3100	2675	3076.25	Medium
Back side outer column	3000	1850	2425	2788.75	Doubtful
Beam	1550	2300	1925	2213.75	Doubtful
Beam	2400	1850	2125	2443.75	Doubtful
Slab	1750	2500	2125	2443.75	Doubtful

Table 4:- UPV Values OF P-1211 BUILDING

Location	UPV Values (m/s)		Average UPV Values(m/s)	Direct Proportionate Velocity	Quality of concrete
Front side column	2800	3200	3000	3450	Medium
Beam	2850	3100	2975	3421.25	Medium
Beam	3200	2700	2950	3392.5	Medium
Slab	3150	2200	2675	3076.25	Medium

Table 5:- Concrete resistivity test result (kilo- ohm/cm) Values OF P-1007 BUILDING.

Location	Concrete resistivity test result (kilo- ohm/cm)	Result Value	Possible Corrosion Rate
Front side column	23,27,19.6,20.5	22.52	Moderate risk of corrosion
Back side outer column	18.3,16.5,15.7,15.9,13.5	15.98	Moderate risk of corrosion
Beam	18.1,16.4,15.5,15.3,13	15.66	Moderate risk of corrosion
Beam	23,27,20.5,20.3	22.7	Moderate risk of corrosion
Slab	25,28.7,18.5,20	23.05	Moderate risk of corrosion

Summary:-

1. Some of members shows deterioration in the form of cracks, spalling, carbonation, corrosion of rebar. Most of the structure are carbonated fully; bars are exposed by severe corrosion.

2. The carbonation depth is increasing with the age of the structure. The rate of carbonation is more than the normal concrete of sound quality. The variation is due to deficiency in field practice. And also, the temperature and relative humidity in Hissar are suitable for carbonation. And also the building by-laws and improper maintenance are some of the reasons for more carbonation than normal.

3. The actual carbonation depth is much higher than normal concrete of sound quality

4. Dampness is visible on walls of the rooms, majorly outer walls are more affected with dampness.

5. In RCC members of (P-1001 to P-1009) buildings, the carbonation has reached up to minimum cover of 300mm in beams i.e. rebar level. Once the carbonation reached up to the rebar level the corrosion process will start.

6. The high alkalinity (pH-value) of concrete surrounding the steel protects it from corrosion. From the data available, it was observed that the pH value of concrete is reducing in the structures with age. This reduction in value is due to carbonation. This reduction in value of pH leads to the corrosion. The pH value of concrete has reduced up to 5 in P-1001 to P-1009 buildings and up to 8 in P-1208 & P-1211 Buildings

7. From the results of above study, it was concluded that the deterioration in structures is due to carbonation/high chloride contents and acidic environment in building, deficiency in field practice, improper maintenance etc. Further pollution level, fluctuations in temp and humidity accelerated the above deterioration.

8. UPV investigation results reveals that there is great variation in uniformity and homogeneity in the members of structures, the characteristics velocity is also much less than 3000m/s. These structures need special attention towards repair.

9. Rebound hammer test shows that the condition of various members is poor. The external members require immediate attention.

SUMMARY OF PROBLEMS AND DEFECTS

1. Cracks:

(1) Major throughout cracks were observed at many locations in outer columns, balconies and cantilevers of the buildings.
(2) Minor cracks near openings of windows and doors in most of the locations.
(3) Cracks on parapet of terrace.

2. Rusting of bars:

(1) The corrosion was observed at almost all the exposed members of the (P-1001 to P-1009) due to spalling of concrete or carbonation of concrete.
(2) The reinforcement of outer members is corroded more than 60%.

3. Spalling of concrete:

Spalling of concrete is observed in most of the locations such as outer columns, balconies and cantilevers of the (P-1001 to P-1009) buildings.

4. Dampness & Efflorescence:

Dampness and efflorescence have been observed in most of the houses specially at ground level, near sunken area & near staircase areas.

5. Carbonation:

On test results it is observed that the concrete of (P-1001 to P-1009) buildings is fully carbonated to the full cover depth of concrete.

6. Settlement:

(1) Settlement is observed in P-1208 & P-1211 buildings.
(2) Depressed floor is observed in the ground floor of P-1208 & P-1211.
(3) Due to settlement, the settlement cracks are also observed on the walls of the buildings

6. CONCLUSIONS

6.1 General

From visual inspection and NDT results it is concluded that the present condition of concrete is of very poor quality. The cover to concrete is also not as per codal requirement which has resulted in spalling and corrosion in the building. The UPV values have indicated that concrete quality is very poor due to corrosion and spalling of concrete cover. Corrosion analysis results indicate that reinforcement in beams, and slab has corroded up-to more than sixty percent. It has resulted in increase in volume and spalling of cover concrete.

6.2 Recommendations

The main cause of deterioration is corrosion in the RCC members. The buildings were not found to have deflection beyond permissible limits. It is possible to repair the P-1005 TO P-1009, P-1208 & P-1211 buildings by method suggested above. The detailed method of repair is provided above. The estimated cost of repairs is to be worked out based on the BOQ suggested. Moreover, the repair of the existing building requires specialized experienced agency as there is excessive corrosion of bar. The corroded reinforcement needs to be replaced completely at most of the locations in beams and slabs. Any trace of corrosion in bars will lead to more corrosion afterwards. Hence proper precautions are required to be taken while carrying out repair work. Since the cost of the repair is very high, it is recommended to demolish the P-1001 to P-1004 buildings and construct new one. Moreover, it requires high quality of the repair works to rehabilitate the present building.

The repair for P-1005 TO P-1009, P-1208 & P-1211 buildings is done by the method suggested above and now the strength is increased both pervious and latest test results are provided above through NDT methods.

6.3 Limitations

Through retrofitting we increase the durability of possible destressed structure to some extent rather than to demolish the structure completely. The cost for Demolishing the whole structure and constructing the new one is costlier so, it's better to retrofit the possible structure which lower the cost of repair to some extent.

6.4 Future Scope

The strength and the reliability of the structure under attention are evaluated only on the basis of the non-destructive tests which give a symptomatic figure about the asset of the building. These assemblies can be evaluated by semi-destructive methods and destructive methods to get the actual asset of the different essentials of the assembly.

The repair method that are executed may also have substitutes.

Future scope for appraisal

a. Concrete resistivity test
b. Core test
c. Ferro-scanning

Future scope for the repair and retrofitting methods

a. FRP
b. CFRP
c. GFRP

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