

Making up Strength of Old Reinforced Concrete Structure through Retrofitting

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ABSTRACT: In this present situation the structural engineering sector is creating ultramodern building structures; at the same time the old structures are losing their strength with its age. This paper is going to indicate the process through which a RCC structure of aged more than 25 years can gain its previous strength. This process will provide the strength of the concrete for further 10-15 years.

KEYWORDS: Retrofit, Corrosion Treatment, Non Metallic Fibre Treatment, Ultrasonic Pulse Velocity Test

I. INTRODUCTION

Structure repair and rehabilitating is a process whereby an existing structure is enhanced to increase the probability that the structure will survive for a long period of time. This can be accomplished through the addition of new structural elements, the strengthening of existing structural elements and/or the addition of base isolators. Deterioration of concrete and corrosion of embedded reinforcement structure might make the R.C.C structure structurally deficient. Corrosion can be controlled to some extent by fixing of chloride or protective coating.

Before any repair work is put in hand, the cause of damage must be identified as clearly as possible. This principle may seem self-evident but it is surprising how often it is disregarded, with the result that further repairs have to be carried out within a short time. Sometimes the cause is obvious as, for example, in many cases of accidental damage but, more often than not, careful investigation is required. The next step must be to consider the objective of the repair, which will generally be to restore or enhance one or more of the following:

- Durability
- Structural strength
- Function
- Appearance.

Here the process of retrofit is applied in a project of an old hospital building repairing at Kolkata.

II. THE PROCESS OF RETROFIT

The process of making up the lost strength of a RCC structure is going through a long chain process. These are the following steps through which it can gain its previous strength:

Chipping:

Chip off loose and carbonated concrete from surface of existing structural elements with help of chisel and hammer till sound concrete is encountered. Remove laitance oil etc. present on concrete surface by grinding/sand blasting. Descale the surface of exposed reinforcement with help of brush to remove the rust scales carbonated concrete if left in structure shall initiate deterioration process.

Corrosion Treatment:

a) Application of Concrete penetrating corrosion inhibitor on concrete surface

Carry out application of Bi-polar migratory corrosion inhibitor on concrete surface by brush in two coats. This inhibitor has migratory kind of property which permits the material to migrate to a virtual extent of 100mm through, pores of concrete inhibiting the corrosion and de-passivation of the Electro-chemical reaction. It has property to attack anode as well as cathode which is purely alkaline in nature (pH-9.5) so it has no carcinogen activity with concrete and material shall confirm to ASTM.

Grout the corrosion inhibitor in case of excessively damaged RC sections by drilling 50 to 75mm deep holed at the spacing of 350mm c/c concrete body

b) Treatment to corrosion damaged existing steel reinforcement

i) Application of rust converting alkaline primer

Thoroughly clean the corroded reinforcement/steel rebar by wire brush or rotary grinder. Remove all the corrosion scales present on the bare and reach up to sound steel. Apply of rust converting alkaline primer on corrosion affected steel bars after removing all the scales. It is alkaline in nature and convert both hematite & magnetite compounds in to stable compounds. The material shall pass salt spray test as per ASTM-B-117.

ii) Application of two coats of IPNet-RB anticorrosive epoxy coating on steel rebar

Application of primer shall be followed with application of two coats of IPNet-RB (confirming to CBRI requirement) anticorrosive epoxy coating for bar protection against future corrosion. Coating is for old as well as newly provided steel. This system (Interpenetrating polymer network system for rebar: IPNet-RB) once applied on the steel shall provide extended protection against future carbonation and chloride attack.



Fig.1. Application of IPNet-RB

Making up of Lost Steel Area due to Corrosion by Additional Steel:

By providing additional steel reinforcement the lost steel area made up its strength. The steel shall be specified as per IS. Anchor the steel rebar in sound concrete body up the desired depth by structural GRADE adhesive. Fixing of rebar is to be with pre left binding wires with existing steel at regular grid after aligning concrete profile with new mortar up to existing steel face.

Making up Lost Strength of Core Concrete by Low Viscosity Monomer:

Strengthen up the core concrete shall be with grouting of low viscosity (2-5cps as per ASTM-D-2196) monomer. Due to its low viscosity it effectively fills up all micro-cracks and voids up to full depth of concrete. Grouting with this system shall provide gain in core strength by 15 to 20%. Beside enhancing existing binding matrix this shall also enhance in ductility property of elements.

Description of Grout:

- Drilling of holes 12mm diameter and about 1/3rd of element deep into concrete along the cracks or in honeycombed and deteriorated areas, fix the perforated nozzles and seal the sides with Epoxy sealant.
- Epoxy sealant: This is a non-shrink sealant. It is built in resilience to absorb impact and movements in joints.
- Inject very viscous injection resin into pre-drilled nozzles with pressure of 4kg/cm² using compressed air and injecting gun. Seal the nozzles with epoxy after injection is completed.

Modified Mortar:

For replacing the carbonated part of concrete and repairing the damage surface of concrete usage of formulated mortar is recommended.

Mix:

- Cement => 50kg
- Sand => 150kg
- Polymer Latex => 2.5 to 5kg
- Water => 15-20Ltrs.

Grouting of Structural Cracks by Low Viscosity Epoxy Grout:

Grout the wide structural cracks in the concrete by grouting of low viscosity grout (200cpc as per ASTM-D-2196). Cut a V-groove along the crack of proportionate size Drill the holes along the crack at desired spacing. Seal the remaining portion by non-shrink epoxy putty to avoid any leakages of grout material. Grout the low viscosity material through epoxy injection gun under pressure of 3 to 4 kg/cm². Seal the nozzles after 24hrs of application of grouting.

Strengthening with Non Metallic Fiber Reinforced Composite in Selected Areas:

a) *Application of pre-engineered glass or carbon laminates:*

Wherever loss of flexural reinforcement is more and as welding of additional steel is not feasible in some area because of crude oil pipe lines, it is recommended to use are engineered glass or carbon laminates as follows.

- Surface Preparation

Grind/Sandblast repaired concrete substrate for cleaning rounding sharp edges to min 20-25mm radius.

- Profiling

Apply compatible primer on prepared substrate. Fill holes and uneven surface with thixotropic putty.

- Application of Plate

The application area are marked, then the laminate is cut to require size, compatible structural adhesive is then applied on plate in parabolic manner by using adhesive application machine, paste the laminate in desire area and orientation by using tamping to avoid any air voids.

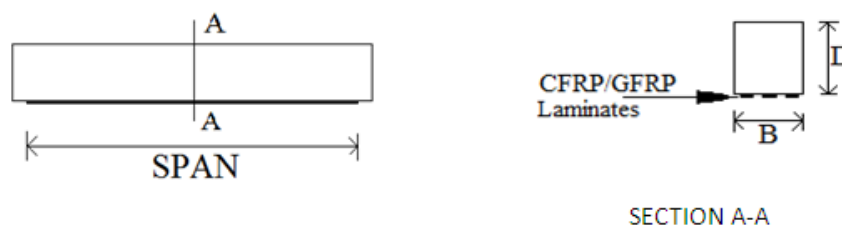


Fig.2. Strengthening of beam with GFRP/ CFRP Laminates

Procedure for wrapping with glass/carbon wraps

Wherever loss of shear and flexural reinforcement is more and as welding of additional steel is not feasible in some area because of crude oil pipe lines. It is recommended using previous fiber warps of glass and carbon in damaged areas.

- Surface preparation:

Grind/ Sandblast repaired concrete substrate for cleaning rounding sharp edges to min 20-25mm radius.

- Profiling
Apply compatible primer on prepared substrate. Fill hole and uneven surface with thixotropic putty.
- Wrapping:

Apply first coat of fiber compatible saturate, cut the fabric to size, warp the fiber sheet to structural element at desired orientation using tamping roller to avoid any air voids.

- Finishing:

Applying second coat of saturate after minimum 12hrs, rectify air voids if any.

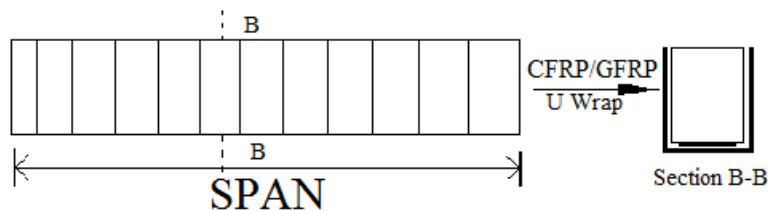


Fig.3. Providing U-Wrap for Shear- Type A

III. TEST FOR CHECKING THE STRENGTH AFTER RETROFIT

Ultrasonic Pulse Velocity Test

The pulse velocity test is conducted by the Portable Ultrasonic Non-Destructive digital Indicating Tester (PUNDIT) which is internationally reputed highly accurate pulse recording system. The ultrasonic pulse velocity method consists of measuring the time of travel (in micro seconds) of an ultrasonic pulse passing through the concrete to be tested. Two transducers are used, one to transmit the pulse and the other to receive the pulse. The distance which the pulses travel in the concrete (i.e. the path length) is also measured. The pulse velocity is determined from the relation.

$$\text{Pulse Velocity} = (\text{Path Length} / \text{Transit Time})$$

The UPV Test is applied for testing of different types of concrete. The measurement of Pulse velocity may use to check:

- Whether the concrete is homogeneous or not.
- Whether there is any crack or not.

Table 2 of IS 13311(Part I): 1992 gives a generalized pulse velocity rating for concrete.

| Pulse velocity(km/sec) | General Conditions |
|------------------------|--------------------|
| Above 4.50 | Excellent |
| 3.50-4.50 | Good |
| 3.00-3.50 | Medium |
| Below 3.00 | Doubtful |

The above may be taken as guidelines for assessing the condition of the same structure. Any weakness in the form of cracks, voids, weak concrete will result in lower pulse velocities.

IV. EXPERIMENTAL RESULTS

Here the result is of test result of some columns of the particular building on which the retrofitting process is applied.

| SL. NO. | LOCATION | TIME IN MICROSEC. | DISTANCE IN MM | VELOCITY | REMARKS |
|---------|----------|-------------------|----------------|----------|-----------------|
| 1 | C7 | 72.5 | 300 | 4.14 | INDIRECT METHOD |
| | | 70.6 | 300 | 4.25 | INDIRECT METHOD |
| 2 | C13 | 155 | 550 | 3.55 | DIRECT METHOD |
| | | 152.4 | 550 | 3.61 | DIRECT METHOD |
| 3 | C6 | 112 | 400 | 3.57 | INDIRECT METHOD |
| | | 113.3 | 400 | 3.53 | INDIRECT METHOD |
| 4 | C5 | 140.2 | 600 | 4.28 | DIRECT METHOD |
| | | 149 | 600 | 4.03 | DIRECT METHOD |

V. DISCUSSION & CONCLUSION

From the machine generated test data done at different points on the structural element as marked in the test data sheets, it is found that the velocity range is greater than 3.50km/sec., which implies that the quality of the concrete in terms of voids, micro cracks and honey-combing etc. is good. So through this process the concrete can gain its previous strength. This process can be applicable for also those kind of building designed in Working Stress Method as well as in Limit Stress Method.

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