Volume : 3 | Issue : 4 | April 2014 • ISSN No 2277 - 8160

Research Paper | Engineering

A Study of Rehabilitation of Exisisting Concrete Structures

Prof. Y. R. Suryavanshi	Professor Civil Department, Imperial College of Eng. & Research, PUNE.
Mr. Vardan Chandnani	B.E civil, Imperial College of Eng. & Research, PUNE.
Mr. Prasad Dhumal	B.E civil, Imperial College of Eng. & Research, PUNE.
Mr. Sohabran Singh Pundir	B.E civil, Imperial College of Eng. & Research, PUNE.
Mr. Abhishek Shah	B.E civil, Imperial College of Eng. & Research, PUNE.

ABSTRACT

Infrastructure and buildings play an important role in the economical development of nation. Many structures suffer from durability distress within a life period of 13 years or so. Concrete is one of the basic materials used in construction industry, but it requires proper care in the form of regular maintenance. Instead of dumping the materials used in abandoned buildings their repair and rehabilitation can save lots of money. The first step in repairs and rehabilitation is the proper diagnosis for successful rehabilitation works.

Various options in terms of techniques and materials are available for executing repair/ rehabilitation jobs. Selecting a most appropriate, material and repair/rehabilitation methodology is very important to achieve durable, effective and economic repair/rehabilitation. Matching the response of repaired sections with the main structure is of foremost importance. Efficiency of materials and matching specifications are essential in any repair jobs.

KEYWORDS : Structures, distress, durability, repair, rehabilitation

Introduction

Cement is of the most commonly used materials worldwide. Its main consumption is for making concrete & other structural components like brickwork, plaster & flooring. It was expected that the service life of concrete structures would be seventy to hundred years. There are many old structures that have successfully lived their service life & are still not affected. However in the last thirty years there was a quantum leap in cement manufacturing process which led to higher grades of cement like OPC 43 & 53 grades. This was at the cost of finer grinding which increased the reactivity of cement & increase in Tri-calcium Silicate C3S content.

As a result the new generation cements became more susceptible to Atmospheric & Environmental exposures. The net outcome of this exercise was to bring the cement deterioration problem on our doorstep. The service life of structures was severely affected. Severe reduction in the service life of structures due to concrete deterioration resulted in serious research & investigation into the causes of deterioration & remedial measures. Investigations revealed three basic flaws in the cement & concrete which are starting points of the deterioration process.

Since demolition and reconstruction are expensive and often critical in terms of environmental impact (especially in congested or historical areas) new materials (like fiber reinforced polymers and ultra-high performance cementitious composites) are increasingly used for structural strengthening/ rehabilitation / protection as well as for improving structural resistance to severe environmental conditions (seismic load, impact vibration, high temperature etc.)



Fig1: LIC's JeevanJyot, MUMBAI

Now-a-days impendence based non-destructive evaluation of concrete covering both strength prediction and damage assessment is also being used. The thrust areas of research are SHM (structural health monitoring) and non-destructive evaluation of concrete based on smart materials namely fiber-optic sensor.

Thus, it is a moral responsibility of people to understand that instead of demolishing the structures we should try for their maximum repair and the use of materials to save the expenses of a new construction.

CASE STUDY

Methodology

Several methods, materials and procedures are used for the repair and construction of existing structures. Polymer modified mortar (PMM) is one of the material having low cost as compared to carbon fiber wrapping and jacketing method of repairing. Also PMM is very easy method

of repairing. It does not permit the use of epoxy, so that it is not susceptible to fire. But it is not useful for structural failure and also does not increase much strength of number.

The RC jacketing strengthening method, unlike other techniques, leads to a uniformly distributed increase in strength and stiffness of columns. The durability of the original column is also improved, in contrast to the corrosion and fire protection needs of other techniques where steel is exposed or where epoxy resins are used. Finally, this rehabilitation procedure does not require specialized workmanship. All those reasons make RC jacketing an extremely valuable choice in structural rehabilitation. The structural behavior of a building rehabilitated by RC jacketing of the columns, like any other strengthening technique, is highly influenced by details.

The high strength, high fatigue resistance, lightweight, and corrosion resistance of composites are highly desirable characteristics for repair applications. These new technologies are direct transfer of aerospace industry.

At the present time, the direct use of fiber composites from the aerospace industry is not cost effective as compared to conventional materials in bridge applications. Keeping aside the cost constraint factor, this method has proved to be a system which has many added advantages over conventional strengthening processes, which has been proved in laboratory as well in real civil projects that this system is effective and is useful in today's time. With moving economy and infrastructure development is catching its pace, with increase in demand for fiber reinforced polymer in civil construction is slowly increasing and becoming acceptable.

In order to determine the strength of existing structure we had carried out, three different Non Destructive Tests (NDT) along with various other visual and minor inspections on various structural members to determine their strength, extent of deterioration. As per the results application of various strengthens increasing procedures and materials.

VISUAL SURVEY

The structure being a R.C.C. framed structure was investigated grid to grid for ease in observations. Each column, beam and slab within the section was observed for a range of defects such as cracks, seepage and peeling of paints. The defects, which were reported but not visible, have also been incorporated in the report. These defects were noted on the observation sheets, which formed the bulk of the data collected.

Carbonation Test

Carbonation is one of the major causes of corrosion and it brings about various physical changes in the quality of concrete. It affects the alkalinity of the concrete which brings down alkalinity. Generally, the pH of good concrete which is in thevicinity of 12.5 to 13 come down to around 9. This loss in ph. causes reinforcing steel to become susceptible to corrosion.

The carbonation plane moves into the concrete from the outer surface as a result of external attack. It is dependent upon the content of concrete too. This plane moves rapidly when relative humidity is between 50to 70 percent. One can find out the depth of carbonation from a formula:

$d = K_c t^{0.5}$

Where,

d = depth of carbonation reaction plane in mm, after time t years K_c = Coefficient of carbonation is related to the permeability of the concrete, the amountof available free time, relative humidity and thecarbon dioxide content of the given environment.

Corrosion Risk | Potential

>95%	More negative than:350mV
50%	-200 mV to -350 mV
<5%	More positive than -200mV

Ultrasonic Pulse Velocity Test

The ultrasonic velocity test determines the propagation velocity ofa pulse of vibration energy through a concrete member.A computer system of stress waveshas been developed which includes longitudinal, transverse and surface waves. Thereceiving transducer detects the onset of the longitudinal waves which is test. Thetransducer contact with the surface of concrete is made with grease or petroleum jettytoavoid any entrapped air, thus causing loss of account energy at the interface. The timeof travel (T) between the initial onset and reception of the pulse is measured in differentways electronically. The average velocity (V) of wave propagationcan be established as:

V = L/T;

Where
L = Path-length traveled by the waves
T = Time of travel between the transducers

Rebound Hammer Test

Schmidt's hammer test works on the principle of measuring surface hardness of concrete by measuring rebound of spring controlled mass, when plunger is pressed against the surface of concrete. This test is a complex-problem of impact loading and stress wave propagation. The energy absorbed by the concrete depends on the stress-strain relationship of concrete.

Thus, a low strength, low stiffness concrete absorb more energy than high strength, high stiffness concrete and will give a lower rebound number.

Test Results

Carbonation Test

R.C.C. Member	Half-cell potential (mV)	Average half cell potential (mV)	Probability of corrosion
At Ground floor, C 79	222, 232, 220, 216, 225, 218.	222	< 50%

For UPV Test

R.C.C MEMBER COLUMN	VELOCITY	VELOCITY	AVERAGE VELOCITY
	1 (Km/Sec)	2 (Km/Sec)	
C79	1.42	1.50	1.460

For Rebound Hammer Test

R.C.C. MEMBER COLUMN	R1	R2	R3	R4	R5	AVERAGE READING	COMP STRENGTH Kg/cm^2
C 79	36	38	35	39	37	37	350

Repair Method

Though there do already exist various strengthening methods such as:
1. Ordinary or rapid hardening Portland cement
2. Polymer latex
3. Polyester resins
4. Polyvinyl acetate
5. Epoxy resins
6. Fine and /or coarse aggregate filler

Selection of repair Materials

There are a number of methods to repair and rehabilitate a structure but the selection of one particular procedure is finalized by enumerated reasons:
1. Ease of application
2. Cost
3. Available labor skills and equipment.
4. Shelf life of the material
5. Pot life of the material.

After taking in account all these reasons it's decided to repair columns with Polymer Modified Mortar method. Below there is a detailed costing analysis for it:

Cost of polymer modified mortar repairing

I. <u>Rust removing treatment-</u>

Rusticide @ Rs 150/- per lit Cost per coat with a coverage of 70 sqft per

coat =150/70=Rs 2.14/ per coat Hence for two coats will be 2.14 x 2= Rs 4.28/- Consider 50% of application i.e. concrete to reinforcement ratio; Cost=Rs 2.14/-per sqft.....(1)

II. Rust passivation-

PolyalkFixoprime & cement @ Rs.400/- & Rs 5/- Per Kg respectively. Cost per coat with a coverage of 70 sqft per coat =405/70=Rs 5.78/ per coat Hence for two coats will be 5.78 x 2= Rs 11.57/- Consider 50% of application i.e. concrete to reinforcement ratio; Cost=Rs 5.78/-per sqft..... (2)

III. Bond cost

Cost of bond coat of Polyalk EP & cement 1:1 proportion. Polyalk EP & cement On Rs 305 & Rs 5 per Kg. Cost of bonding coat with coverage of 50 sqft per coat=3l0/50=6.2 Cost-Rs 6.2/-per sqft..... (3)

IV. Polymer modified mortar-

PMM is a mix of- 1 PolyalkEP :5 cement : 15 Quartz sand Gives a coverage of 8 sqft for a thickness of 10 mm Cost of I Kg Polyalk EP : Rs 305/- Cost of 5 Kg cement : Rs 25/- Cost of 25 Kg quartz sand : Rs 90/- Total cost : Rs 420/- Hence cost per sqft= 420/8=52.5 Cost- Rs 53/- per sqft..... (4)

Hence for 10 mm thick Polymer Modified Mortar cost per sqft. =1+2+3+4 =Rs 68 /- per sqft

Costing as per thickness

Thickness (mm)	Cost (Rs)
10	68
20	121
30	174
40	227
50	280

Economic benefits of PMM over reconstruction-

- Life of buildings increases up to 15 to 18 years
- Large investment is to be avoided instantly
- Movement of residents is avoided
- In short there is saving of reconstruction cost for some years

Hence repairing with PMM is best solution.

Conclusion:

As per the case study and methodologies adopted we can say that the demolishing of existing structures cost more than their repair. We should adopt the technologies and materials in repairing the existing structures. The repairing of columns, beams and chajjas can be easily done by using these measures.

The main advantage of using these measures is cost saving and achieving the economy of project. It is of main advantage for the people who don't want to demolish the complete structures but only change of components of building is required. The materials used in the repairing of buildings are of low cost and thus they reduce the total cost of project.

REFERENCES

[1] Michael D. Lepech, Metter Geiker & Henrik Stang, 2013, Probabilistic design and management of environmentally sustainable repair and rehabilitation of reinforced concrete structures. | [2] Woubishet Zewdu, Taffese & Esko Sistonen, 2013, Service Life Prediction of Repaired Structures Using Concrete Recasting,Finland, Procedia Engineering 57 (2013) 1138 – 1144 | [3] F. Pacheco - Torgal, Z. Abdollahnejad, S. Miraldo, S. Baklouti & Y. Ding, 2012, An overview on the potentila of geopolymers for concrete infrastructure rehabilitation, Construction and Building Material 36 (2012) 1053 – 1058 | | [4] G. Habert & E. Denarié & A. ajna & P. Rossi, 2013 "Lowering the global warming impact of bridge rehabilitations by using Ultra High Performance Fibre Reinforced Concretes |