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Retrofitting of Reinforcement in Column

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Abstract- **The field of civil engineering has seen very revolutionary changes in the last two decades. In particular to construction industry, conventional cement concrete ingredients were slowly and safely replaced by new and more efficient advanced materials such as admixtures, which have opened a wide scope for research on their specific uses. Structures may need to be strengthened for different reasons among which a change in function, implementation of additional services or to repair the element of civil engineering structural damages and to Rehabilitate the same with different innovative strengthening techniques with materials like Polymers, Epoxy resin and conplast etc. Once the concrete has subjected to any kind of external force, the deterioration or decay of concrete will start. It is very useful for an engineer to have an idea about the residual strength of the structural elements which is helpful in the field of Repair and Rehabilitation. Improper structural design, use of poor quality materials, inadequate construction techniques adopted, weathering and environmental effects and natural calamities which leads to the initiation of damage in the civil engineering structures. Extensive research has been going on in the field of repair and rehabilitation. Hence attempt has been made to study the use of innovative materials such as low viscosity epoxy resins in the present investigation on repair and rehabilitation of flexural member. Rehabilitation and Retrofitting of concrete structures is to obtain a minimum understanding of the most important deterioration processes and their governing parameters. In certain cases such basic Knowledge is a precondition for the ability to take correct decision at the right time when seeking the required durability when a structure or a member is subjected permanently to some unforeseen stress exceeding its load bearing capacity, the structure may be termed unsafe with distress. A building or any part of it may be considered in distress, then it is not capable of sustaining the designed stress and it's early failure is anticipated In adequate or no maintenance in correct manner or bad use of building, poor workmanship during construction, Natural wear and tear, adoption of defective construction.**

I. INTRODUCTION

RC structures require retrofitting because of deterioration of structural strength due to various reasons. Up grading of seismic zones and design codes, poor quality of constructions or designs, and higher load carrying capacity demand due to increased service needs are some other important reasons for using epoxy retrofitting. However, retrofitting methods depend on construction strength desired, type and state of damage. Before the arrival of epoxy, RC structural retrofitting used such methods as guniting, post tensioning, externally bonded steel plates, steel or concrete jacketing. Many structures have successfully used these conventional methods. Epoxy injection, newly developed methods such as advanced techniques for corrosion affected RCC and methods of modifying structural properties using active or passive mass damper for high-rise buildings are also available for structural retrofitting. Epoxy Retrofitting offers many advantages. These are discussed in the following section. However using epoxy is not limited to retrofitting RC structures alone. Application of this composite includes retrofitting of timber structures, masonry, steel, aluminum or concrete structures. For new construction, epoxy bars and pre-stressing tendons are being used to replace steel. Use of epoxy resin in construction is bound to increase because of their unique properties .more research is needed for building confidence and overcoming limitations in their large scale use \ By building more manufacturing capacity , the increased indigenous availability of the material . Epoxy resin consists of hardener & base, then both mixed thoroughly with a proportion of hardener is more than the base .The structural engineering community would then be in a position to tap the full potential of retrofitting RC structures. A Structure when designed properly and

constructed to requisite standards of workmanship and proper specifications adopted and materials used are of good quality that is, if all the parameters related to the construction of the structure are in ideal conditions, its life can be predicated and the load bearing capacity of the structure can guaranteed assuming that the elements of the structure would not be put under undue and unforeseen stresses. In reality, this ideal condition exists very rarely. The construction of a Structure involves a large quantity and large number of materials, which have to be collected in stages and subjected to great difficulties in maintaining the quality. Further the construction activity itself involves human factor at every stage. The structure would remain in service for a considerably long period and guaranteeing that during this long period there would be no addition and alteration and overloading of any part causing unforeseen stresses is difficult. Further, there would be the influence of environment, which is getting aggressive with the passage of time due to various reasons and would degrade the materials and affect the durability of the structures. Due to complex nature of environmental effects on structures and the corresponding response, it is believed that true improved performance cannot be achieved by improving the material characteristics alone but must also involve the elements of architectural and structural design, process of execution and inspection and maintenance procedures, including preventive maintenance. Rehabilitation and Retrofitting of concrete structures is to obtain a minimum understanding of the most important deterioration processes and their governing parameters. In certain cases such basic Knowledge is a precondition for the ability to take correct decision at the right time when seeking the required durability.
When a structure or a member is subjected permanently to some unforeseen stress exceeding its load bearing capacity, the structure may be termed unsafe with distress. A building or any part considered in distress, then it is not capable of sustaining the designed stress and it s early failure is anticipated In adequate or no maintenance in correct manner or bad use of building, poor workmanship during construction, Natural wear and tear, adoption of defective construction practices, action of atmospheric agencies and physical influences are some of the factors that cause the distress/decay of a structure or member, Early corrective measure of a structures may help to increase the life span of the civil Engineering structures.

II. LITERATURER SURVEY

The present investigation deals with the studies on repair and rehabilitation of flexural member using synthetic resins such as epoxy, polyester, acrylic, polyurethane,
Latex modified concrete, polymer modified concrete, whose use has been rapidly increasing in civil engineering, activities especially in cement concrete constructions in repair and rehabilitation. Amongst the Epoxy resins when cured with different hardeners offer a wide range of application to bond plastic concrete to hardened concrete. To bond rigid materials to each other, For patch work, For coating over concrete to give colour, resistance to chemicals, water penetration, abrasion etc. epoxy coatings are available for marine, underwater moisture resistance conditions.
The relevant literature review available in this area has been critically studied and discussed on the use of polymers (Epoxy) For Repairs and Rehabilitation of RCC Structures
V.K. Singh(35) Polymer being the costliest input in any repair and rehabilitation job, the selection of an appropriate brand assumes importance. Due to the rapid deterioration of concrete structures, more and more repair and rehabilitation works are being taken up. Most widely used polymers for the application in cementations repair work are urethane, acrylic and modified acrylics, poly vinyl acetates, styrene butadiene rubber, chloroprene rubber (CR) poly acrylic ester(PAE), poly ethylene vinyl acetate (EVA or VAE), poly styrene acrylic ester (SAE),using polymer latex in cementations mixture improves a host of properties of such as enhanced resistance to crack propagation, increased tensile, flexural and bond strength resistance to alkalies and chlorides, abrasion resistance, impermeability to chloride ions, moisture, carbon-dioxide and oxygen etc.
Paolo Gazzarrini (23) As an injection material, epoxy resin is traditionally used for filling cracks in concrete structures. The function of the injected material is mainly twofold - fill the crack to prevent water ingress and act as a filler to transfer loads across the crack. The perceived benefit of “gluing” a

crack together is largely misconception as tensile properties of cured injected epoxy usually surpass that of concrete. Without understanding why a crack initially develops, and then implementing appropriate remedial procedures to prevent a recurrence, simply using epoxy as a crack bonding agent frequently results in crack propagation at another location. The functions of epoxy injection to act as both crack filler and structural component were exploited for innovative repairs during the construction of a new research facility at a high security establishment.

Sawaide and I. Takano (25) For repairing of concrete slabs deteriorated due to the recent remarkable increase of traffic roads, the reinforcement process of those defective slabs by bonding steel plates from underside using epoxy resins are recently becoming popular.

From both technical and economical viewpoints, the authors have noticed the serviceability of a foamed epoxy resin taking the place of conventional epoxy resin in process. Through various comparative tests on the sample conventionally reinforced and others repaired by using the foamed epoxy resin would be promising.

Alexander M. Vaysburd and peter H. Emmons (02) :To realistic appraise the position of concrete repair technology the majority of faults and problems are caused by lack of attention to design details specifications and poor in – situ workmanship. Material, although important is less of an evil. Material per se, does not perform: the end product made from a material- the repaired structure- performs.

T.C. Liu and T.B. Husbands(33) The majority of structures surveyed have been repaired, using a variety of technologies with varying degrees of success. Repair materials included conventional concrete, fiber- reinforced concrete, polymer concrete. In many instances, materials have been prototype repairs with limited or no laboratory evaluation of their effectiveness in the particular application. This survey showed a definite need for such material evaluations.

F. A. Finger(14)-Institute for Building Material Science is it to examine the long-term behaviour and/or the durability from polymer-modified building materials ,this contains the additive from thermoplastics and duroplastics to the otherwise cement-bound system. Further the employment of polymer building materials for special applications is examined. A substantial component is the investigation of the correlation between forming microstructure and their macroscopic effect on the durability of the PCC. Test method for evaluation Plastic-modified, cement-bound mortars and concrete are used mainly in the range of the repair of existing buildings. By means of a polymer modification both the fresh mortar/fresh concrete characteristics (e.g. workability, water retention property) can be improved and the hardened mortar/hardened concrete characteristics (e.g. strength properties, creeping, shrinking, chemical stability) can be substantially increased.

Joao A. Rossignolo , Marcos V.C. Agnesini(17) studied about the behavior of Polymer-modified concrete (PMC) has been a popular construction material due to its excellent properties in comparison with ordinary concrete. It is produced using polymer in order to improve its workability, drying shrinkage, strength and durability. However, there are a few studies about the use of polymer on lightweight aggregate concrete (LWAC).On the other hand, there is worldwide environmental, economic and technical impetus to encourage the structural use of LWAC. LWAC has been used successfully for structural purposes for many years. For structural applications of lightweight concrete, the structural efficiency is more important than only a consideration of strength. A decreased density for the same strength level reduces the self-weight, foundation size and construction costs. several investigations on high-performance lightweight concrete have been reported SBR-modified LWAC is an ideal material for precast components due to its low weight, high strength and high performance under severe service conditions. However, very little information is available on the properties of SBR-modified LWAC ith Brazilian lightweight aggregate (rotary kiln expanded clay).Accordingly, a pilot research project has been developed To broaden the scope of this investigation, corrosion resistance, chemical resistance and water absorption of SBR-modified LWAC has been investigated and compared with unmodified LWAC. The present study is part of a comprehensive investigation carried out on the use of polymers in concrete. The 7-daycompressive strength and the dry concrete density varied from 39.5 to 51.9 MPa and from 1460 to 1605 kg/m3, respectively

R. D. Maksimov, L. Jirgens,J. Jansons, and E. Plume(25) conducted investigation about The properties of a polymer-concrete composed of polyester matrix and locally available rock aggregate are investigated. The formula of the concrete is found by an experimental-calculation approach in such a way as to attain a closer packing of the aggregate particles on the one hand, and to ensure the needed processing characteristics (placeability) of the mix on the other. It is shown experimentally that the material obtained has a rather high compression strength. Under prolonged compression loads, the polymer-concrete exhibits a noticeable creep behavior with a linear relation between the creep strains and stresses. After the action of half the ultimate load over3000/ h, the total strains exceed the instantaneous ones by 2.0 to 2.2 times.

David E. Snider and Heather M. Ramsey of Sauereisen Inc.(09)

A large copper mine and refinery in the western United States had a dilemma. The refinery's standard repair procedure was to remove corrosion products from the concrete and steel and then to top them with a polymer-modified Portland-cement mortar. They decided upon anew approach using a polymer concrete (PC), which is a bisphenol A based-epoxy. This material is designed for maximum flowability, mechanical properties and chemical resistance. The PC repair system utilizes the polymer concrete for encapsulation, chemical protection, mechanical support and resistance to physical abuse. Stainless steel rebar was imbedded into the concrete floor using an epoxy mortar. Channels were saw-cut vertically in the concrete column. These channels provide a recess into which the rebar was bent and then secured into place with the epoxy mortar. Grouting of there bar with this high strength epoxy mortar also served to provide tensile stress relief. By lowering stress relief, corrosion rates are reduced. To further ensure structural integrity and to upgrade seismic capabilities, the company chose to use fiberglass reinforcement (FRP) strips and wraps under the PC. The strips were installed vertically on the columns and a fiberglass fabric was wrapped around the columns horizontally. The columns were formed and the polymer concrete was poured into place completely encapsulating the columns, the rebar and the FRP. This method required two days per column.

III. METHODLOGY OF TESTING

The compressive strength of concrete i.e. ultimate strength or concrete is defined as the load which causes failure of the specimen divided by the area of the crosssection in uni-axial compression, under a given rate of loading. To avoid large variation in the results of compression test, care should be taken during the casting of the test specimens and loading as well. It is however realized that in an actual structure,the concrete at any point is in a complex stress condition and not in uni-axial compression. However it is customary to conduct the test in uni-axial compression only. Concrete under tri-axial state can offer more resistance and will fail only after considerably large deformations. The use of 150mm cubes have been made as per I.S code of practice IS 456. The advantage of selection of IS 516-1959 cube as the standard test specimen is that two plane and parallel surfaces can always be found between which the load can be applied. The cubes were tested in 200T capacity compressive testing machine. Placed the specimen in the machine then apply the continuously, uniformly and without shock. The rate of loading is continuously adjusted through rate control valve by hand to 400 KN/minute. The load is increased until the specimen fails and record the maximum load carried by specimen during the test. The test results are given in results and discussions. The compression strength is calculated using the formula,

$$Compressive\ Strrngth = \frac{Load}{Area}\ N/mm^2$$

Split Tensile Strength

The split tensile strength of the concrete is defined as the load which causes failure of the specimen divided by the area of the cross section in uni-axial compression, under a given rate of loading. To avoid large variation in the results of split test, care should be taken during the casting of the test specimens and loading as well. The specimen is placed horizontally in the testing machine and the rate of loading is continuously adjusted through rate control valve by hand to 400 KN/minute. The load is increased until the specimen fails and record the maximum load carried by specimen during the test. The split tensile strength is calculated using the formula. The test results are given in results and discussions.

To Calculate the splitting tensile strength of the specimen

$$f_{st}^{'} = \frac{2P}{\pi\ ld} \text{ N/mm}^2$$

where P is the maximum load at failure in N and l and d are the length and diameter of the cylindrical specimen, respectively, in mm.

TEST PROGRAMME

The beams were supported on two rollers (30mm Φ). The effective span of the beam was kept as 2000mm and is tested under two point loading. Two rollers of each 30mm Φ served as the loading points were kept on the beam at a distance of 730mm from either supports. All beams were tested in the loading frame of capacity 300 KN and the loading increment was applied to the test specimen from a 200 KN capacity jack. Plate 1: Test setup for two point loading condition

TEST PROCEDURE

First a small increment of load is applied to bring the surface of the test beam in contact with all attachments and then the load is released. A further small increment of loads is applied and all the measurements for each load took about 5 to 7minutes. First cracking load and ultimate load were observed. The entire testing of one specimen required 2 to 3 hours.

Horizontal And Vertical Cracks

LEAKAGE OF WATER

POOR MAINTAINENCE

VI. CASE STUDY –BALAJI (COMPLEX OWNER)

The severely affected residential building (IDF 4) located at the premises of Balaji(complexowner), Bhagya nagar ANANTAPUR comprises of various buildings, viz shop floor, ware house, administration block which are interconnected. The shop floor is located in between admin building and ware house and was covered with Ms Sheet roofing supported on structural steel trusses resting on R.C. Columns. The ware house portion of the building comprises of ground plus one upper floor with R.C. framed construction with flat slab in most of the regions and with conventional R.C. slabs with a mezzanine floor in a part. The admin building is a conventional RC frame structure with ground floor in a part. The admin building is a conventional R.C frame structure with ground floor only. It is reported that the above buildings were constructed about five years back and since then they were in service. It is reported that the cracks developed in the structure which leads to damage of structure &failure may occurs.severe exposure conditions likedue to thermal changes there may be expansion &contraction of reinforcement takesplace which leads to the separation of concrete from reinforcement.structure may be under creep the failure may be takesplace.Due to the failure of structure it disturbs the beauty of the structure, it looks acquard to see. In vie of the above, a reference was made to us by the concerned authorities to carry out a detailed investigation to assess the extent of distress and to suggest appropriate remedial measures to render the building serviceable. In response to this, a detailed investigation was carried out by us during January & february 2017 involving various non-destructive and semi-destructive tests to assess the extend of distress/damage on account of severe exposure and to workout necessary measures. This report, in brief, summarizes the outcome of the investigation, and recommended measures thereon.

PHYSICAL OBSERVATIONS

Following are the physical observations made consequent to detailed inspection of the building.
Ware House block (Ground and First Floor)

- Severe spalling of concrete and exposure of reinforcement were observed in rc columns, column drops and in flat slab at several locations.
- Horizontal and inclined cracks were observed in most of the rc columns.
- Excessive sagging/deflection was observed in flat slab of both ground and first floor ceiling. Severe cracks were also observed in flat slab at a few locations.
- The colour of the exposed concrete in columns, beams and slabs had turned into pink/grey at affected regions.
- Debonding of plaster and cracks were observed in the infill walls at several locations.
- Deposition of soothe was observed on rc members and masonry walls, in first floor kitchen region.
- The electrical lines and fixtures were observed ot be completed burnt in the fire affected region.
- No significant distress features were observed in mezzanine floor and staircase region except deposition of sooth.
- Two footings were exposed at random and no significant distress features were observed in concrete of exposed footings.
- Shop floor
- Severe cracks delamination of cover concrete and exposure of reinforcement at top region were observed in Rc columns in most of the locations.
- Cracks were observed in masonry walls at several locations in gable region.
- The severely distorted/damaged structural steel roofing trusses, steel windows and door shutters were observed to be removed and the shop floor was open to sky at the time of inspection.
- The colour of the exposed concrete in columns was observed to be pink to grey at fire affected regions
- The rc brackets at ends supporting steel trusses were observed to be severely distorted. Further, severe cracking, spalling and exposure of reinforcement was observed at these locations.
- No significant distress/cracks were observed in the VDF rc flooring of the shop.

Administration block

- Severe spalling of cover concrete and exposure of reinforcement were observed in rc coloumns and beams on the shop floor side.

- Cracks were observed in rc retaining wall constructed in between the shop floor and admin block and infill wall constructed above the retaining wall at shop floor side.
- Cracks were observed in most of the rc beams of ground floor ceiling
- Deposition of soothe was observed over the RC members and masonry walls at a few locations.
- Two footings were exposed at random and no significant distress features were observed in concrete of exposed footings.

Investigative tests

In order to assess the extent of distress in RC members, following investigative tests were carried out:

1. Nondestructive tests to assess the quality/integrity of in-situ concrete in RC members

A.Ultrasonic Hammer test

B.Rebound Hammer Test

2. Semi-destructive test ot assess the quality/strength of in-situ concrete in RC members.

A.Core Test

B.Pull out test (Capo)

3. Differential Thermal Analysis (DTA) test on concrete samples extracted from fire affected regions.

4. Theoretical analysis

1. Non-destructive tests to assess the quality/integrity of in-situ concrete in RC members.

(a)Ultrasonic Pulse velocity test on RC columns and beams:

Ultrasonic Pulse Velocity Test was conducted on RC members of all the blocks, in order to assess the quality/integrity of in-situ concrete. The test was conducted using "PUNDIT" (portable UIltrasonic Non-destructive digital Indicating tester) equipment from M/s CNS . Farnell, U.K. as per the guidelines in Indian Standards IS:13311-(Part-I) 1992-(Reaffirmed in 2004). The results of the tests are tabulated in Table-I.

(b) Rebound hammer test on RC slab:

Rebound hammer test was carried out on the RC members of all the blocks at random, to assess the surface hardness/quality and strength of in-situ concrete. The test was conducted using Schmidt Rebound Hammer from M/s Proceq, Switzerland as per the guidelines in Indian Standard IS:13311-(Part-II)-1992-(Reaffirmed in 2004). The results of the tests are tabulated in Table-2

2. Semi-destructive test to assess the quality/strength of in-situ concrete in RC members:

(a)Core Test: In order to assess the quality/strength of in-situ concrete in RC members, semi destructive test such as core test was resorted to. The core samples were extracted from the rc footings, columns, beams and slab selected at random for laboratory tests. The extracted core samples were subjected to compressive strength test after necessary trimming and capping as per the guidelines in IS:516:1959 (Reaffirmed in 1999). The results of concrete core tests are tabulated in Table-3.

(b)Pull out test (Capo) on rc members:

The identified region of rc members were scanned using cover meter to locate the embedded re-bars and mark the same on the surface so as to avoid interference of embedded re-bars during Capo test. Holes of appropriate size were drilled using micro core cutting equipment. In the bottom of drilled hole, bulb of appropriate size was madew using a specially designed tool for fixing 'special steel insert'. Further, specially steel insert along with expandable ring was driven into the hole and fastened. The projected end of insert was pulled off using pulling device until failure of concrete. The force required to pull the insert along with concrete was recorded which is indicated in the pulling device. Type of failure was also observed and recorded. The results of the test are tabulated in enclosed table 4.

3. Theoretical Analysis: Based on the data collected at site, results of test and proposed modification drawings furnished by the authorities, an independent theoretical analysis was carried out. From the analysis it is revealed that the existing column footings can be retained for the proposed loading. Further, the footings along grid 'F' need to be verified for the wind uplift force with appropriate factor of safety considering soil fill.

D. Discussions on test results:

Following are the results of detailed tests:

(a)From the results of the Ultrasonic Pulse Velocity test, it is inferred that quality of concrete in affected RC members falls under the category of “Doubtful Concrete”, whereas in unaffected region it falls under the category of “Medium to Good Concrete” as per Table-2 of IS:13311-(Part I)-1992. However, the quality/integrity of concrete in RC columns and beams in the affected region of various blocks is observed to be not satisfactory, due to micro cracking.

(b)From the reulsts of Rebound Hammer test, it is inferred that the estimated strength of concrete in the tested RC members at the unaffected regions is in the range of 25.0 N/sq.mm to 30.0N/sq.mm whereas in the affected regions it is in the range of 14.0.N/sq.mm to 18.0 N/sq.mm Also , at a few locations cover concrete was observed to debonded due to severe exposure.

(c)The core test results in columns of ware house at affected region is in the range of 17.5N/sq.mm to 21.0N/sq.mm. in shop floor and administrative block region it is in the range of 16.4 N/sq.mm to 24.1N/sq.mm in affected regions. Whereas in unaffected region it is in the range of 27.5 N/sq.mm to 32.7 N/sq.mm. the strength of concrete in tested rc columns of various blocks is found to be widely varying from 16.0N/sq.mm to 32.0N/sq.mm as against required strength of 30.0 N/sq.mm. the strength of concrete was not deteriorated in the lower regions of the column as much as in the upper regions. This is due to the fact that the fire fumes predominantly travel upwards and affect the upper reaches.

(d)The core test results in the slab of ware house indicate equivalent cube compressive strength of 23.6 N/sq.mm. in affected regions and 36.0 N/sq.mm. in the unaffected regions, whereas the design strength was 26.60 N/sq.mm. this indicates considerable degradation in strength from it’s original strength.

(e)In a few core samples, cracks which were observed on the surface of core, were extended in the interior concrete also. Hence, such cores samples could not be tested.

(f)The strength of concrete cores extracted from column footings is the range of 24.0 N/sq.mm to 30.0N/sq.mm as against required strength of 26.60N/sq.mm and hence satisfactory. There is no degradation in the concrete strength in footings due to fire.

(g)From the results of pull out (capo) the estimated strength of concrete in affected columns is in the range of 10.0 to 15.0 N/sq.mm. whereas in unaffected columns and footings it is in the range of 25.0 to 28.0 N/sq.mm. the lower values in the affected regions is mainly due to the fact that capo test gives the strength of peripheral concrete.

E. Inferences

Following are the inferences drawn, based on the physical observations, results of investigative tests and theoretical check:

(a)Most of the R.C members in shop and ware house area, except footings have undergone severe distress due to exposure and the strength of in-stu concrete is considerably reduced. Cracks have also developed in the interior concrete due to elevated temperature.

(b)Considering the extent of damage, it is recommended to dismantle and redo the severely affected regions of the building in ware house and shop floor, retaining the column footings.

F. Recommended measures

Based on the detailed investigation and results of investigative tests, following measures are recommended for affected regions.

1.Removal and redoing of severely affected regions of building

2.Encasement of columns and

3.Treatment for cracks in retaining wall

4.Removal and redoing of in-filled walls in distress.

Following are the detailed step by step procedure for carrying out the recommended measures:

1.Removal and redoing of severely affected regions of building

The severely affected region of the building shall be dismantled (except footings) without disturbing the adjacent members which are to be retained. Adequate temporary supporting systems shall be provided prior to dismantling to avoid any possible mishap during dismantling work. The sequence of dismantling shall be slab panels followed by beams/columns drops and then columns. The dismantling shall be from top proceedings towards bottom. The regions which are going to be retained shall be discontinued from dismantling regions by disc cutting/slicing of concrete. Then only the dismantling can be done.

The severely affected region of the building to be dismantled is shown in enclosed sketch.(refer sketch Civil-Aid/NDT/RES-01)

2.Encasement of columns

(a)In-filled wall, if any on either side of the columns shall be removed for about 1.0 m width for the entire height from top to bottom to create working space for providing encasement. The column encasement shall start from footing top.

(b)Existing plaster/debonded cover concrete shall be removed completely by gently chipping until hard and sound concrete is exposed.

(c)The exposed concrete surface and re-bars shall be cleaned thoroughly with air and water jet to remove loose particles..

(d)14mm dia, 100mm deep holes shall be drilled for fixing of shear connectors. The drilled holes shall be thoroughly cleaned to remove dust particles using air and water jet.

(e)8mm dia shear connectors shall be fixed in drilled holes using polyester resin anchor grout.

(f)Proposed reinforcement shall fabricated, placed in position and tack welded to shear connectors.

(g)75mm dia holes shall be drilled in rc slab on either side of the beam and at column beam junction to pour free flow normal concrete.

(h)75mm thick, free flow normal concrete encasement shall be provided for columns and beams using 20mm down size aggregates, with slurry tight shuttering as per specification enclosed. The encased concrete shall be cured for a minimum period of 14 days.

Treatment for cracks in rc retaining wall

(a)'V' groove to be made all along the crack and 10mm dia holes, 50mm deep, 250mm c/c shall be drilled along the crack to fix PVC nozzles for grouting.

(b)8mm dia nozzles to be fixed in drilled holes using polyster resin anchor grout

(c)V groove to be filled with epoxy mortar/putty.

(d)Low viscosity epoxy grouting shall be carried through the nozzle until refuisal is reached, as per specification.

(e)The distressed regions of the wall shall be provided with 75mm thick M20 grade concrete lining (over a coat of bonding epoxy) with the nominal reinforcement (10mm dia at 250mm c/c both ways) fixed with 8mm dia shear connectors at 500mm c/c as per specification.

(f)The distressed regions of the wall shall be provided with 75mm thick M25 grade concrete lining (over a coat of bonding epoxy) with the nominal reinforcement (10mm dia at 25mm c/c both ways) fixed with 8mm dia shear connectors at 500mm c/c as per specification.

3.Treatment for cracks in rc beams of administrative block

(a)'V' groove to be made all along the crack and 10mm dia holes, 50mm deep shall be drilled along the crack to fix PVC nozzles for grouting.

(b)8mm dia nozzles to be fixed in drilled holes using polyester resin anchor grout

(c)'V' groove to be filled with epoxy mortar/putty.

(d)Low viscosity epoxy grouting shall be carried through the nozzle until refusal is reached, as per specification. (Refer sketch Civil-Aid/ND/NDT/RES-04)

4. Removal and redoing of in-filled walls in distress

The existing in-filled walls which are in distress shall be removed and redone as per standard practice and as per proposed requirements.

1	2	3	4	5
	GROUND FLOOR			Refer Table-2A for estimated compressive strength range of in situ concrete
14	RC Columns	A4	34	
15		A5	35	
16		B2	35	
17		C2	33	
18		F2	38	
19		G3	22	
20		G5	28	
21		G7	29	
22		F8	34	
23		F6	25	
	FIRST FLOOR			
24		D5	29	
25		E5	32	
26		E2.3,D2.3AND	40	
		E2,D$_2$2		
27		E1,D$_1$1 AND E2,D$_2$2	42	
	First Floor			
28		D4,E4 and D3,E3	38	
29	R.C. Ceiling Slab	Column Drop at D4	38	
	First Floor			
30		D3	40	

V. CONCLUSION

From the outcome of detailed studies of the fire affected building located at the premises of Balaji (complex owner), Bhagya nagar, ANANTAPUR , it is concluded that, the RC members have undergone considerable damage in were house and shop floor region due to fie. Severely distressed region shall be removed and redone as per standard practice. The identified moderately distressed regions of the building shall be restored as detailed above. The proposed modification in the building shall be carried out without causing over loading on the existing column footings. While carrying out recommended restoration measures, all the column footings especially at the corners shall be inspected for distress if any in the footing concrete and shall be brought to the notice concerned authorities.

SCOPE FOR FURTHER STUDIES

- The work can be extended to study the moment curvature relation, ultimate load, displacement recovering under the same parameters.
- The present investigation can be extended with the use of Ferro cement for strengthening.
- The fibres like steel fibre, carbon fibre, glass fibre etc. can be used as secondary reinforcement.
- The work can be extended to study the behaviour under dynamic loading and fatigue.
- The work can be extended to study the investigations about water sheded areas like underground water tanks &ground level reservoirs.
- The work can be further investigations about bridge piers.

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