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Rehabilitation of structures & Bridges

Chirag Hooda[1], Sandeep Singh[2]
[1] M.Tech Civil Engineering Student, MRIEM, Rohtak, Haryana, India
[2] Assistant Professor, Civil Engineering Department, MRIEM, Rohtak Haryana, India

Abstract
The high strength and light weight of fibre reinforced polymer (FRP) and the fact that they are now available in the form of very thin sheets, provide an attractive and economical solution for strengthening existing concrete bridges and structures to increase their ductility, flexure and shear capacity in response to the increasing demand to use heavier truck loads. This paper reviews some of the Canadian projects which have been completed using these materials. The paper presents a new technology for remote monitoring of bridges to minimize the need for frequent site inspections, as well as new material being developed for the rehabilitation of wood bridges. Monitoring is based on using a new generation of fibre optic sensors which have already been implemented in the construction of new bridges in Canada, as well as in the strengthening of existing ones. Repairs and rehabilitation engineering being a specialized field calls for skills and abilities far beyond the construction engineering and has to be a balance amid advanced technology and trends, management, feasibility and economy. Experimental studies from past few earthquakes states, Most of the long-standing buildings that collapsed were found deficient to meet-up the requirements of present day seismic design standards. Frequent earthquakes continue shaking the land every now and then. Due to faulty construction practices, disinclination to seismic design compliance and the construction that has taken place in the past without seismic standards or awareness calls for the Rehabilitation of the existing structures showing signs of descent. This has to be done to save the lives and the economy.
The purpose of this paper is to present the process of rehabilitation, retrofitting characteristics and technical aspects of the major intervention methods.

Keywords: retrofitting, rehabilitation, seismic, audit, deterioration, functional condition, reinforced cement concrete, resources

Introduction
Concrete construction is generally expected to give trouble free service throughout its intended design life. However, these expectations are not realized in many constructions because of structural deficiency, material deterioration, unanticipated over loadings or physical damage. Premature material deterioration can arise from a number of causes, the most common being when the construction specifications are violated or when the facility is exposed to harsher service environment than those expected during the planning and design stages. Physical damage can also arise from fire, explosion_as well as from restraints, both internal and external, against structural movement. Except in extreme cases, most of the structures require restoration to meet its functional requirements by appropriate repair techniques.
The existing buildings nearing its serviceability life and showing sign of breakdown does calls for technical intervention for enhancing their life and to avoid any accidental failure due to seismic event or other structural reason. The deterioration of the structures takes place due to Weathering action, Fire, Natural calamities like earthquake, Flood, Tsunami, cyclones, Soil and structure interaction (Settlement of soil or soil failure), defects in construction and many more. Post the technical evaluationof such structures, the decision to repair or replace a structure or its component has to be taken. This has to be in compliance with economy, construction feasibility and as per latest trends and techniques. The approach towards rehabilitation of any building can be categorized in following steps and actions. • Performing a Structural Audit of the building, • Evaluating various retrofitting options, materials, feasibility and economy • Performing structural calculations and capacity demand ratio for structural members, • Suggesting retrofitting/construction system and getting the rehabilitation of the building done, • Post retrofitting tests on the building.

Fig 1

Objectives

- To cover the methods of assessing the current and future performance of the structure, the diagnosis stages of the structure, survey of structure conditions, remedy: repairing materials, strategies and techniques to upgrade the structure performance.
- To study the static behaviour of reinforced concrete beams as perfect beams, undamaged laminated beams and predamaged rehabilitated beams experimentally by plate bonding technique.
- To study the comparative performance and behaviour of laminated beams by plate bonding technique and cast insitu bonding technique.
- To study the crack propagation, and maximum crack spacing on beams perfect, undamaged laminated beams and predamaged rehabilitated beam.

Literature Review

The Practice in India

- In collaboration with Japan International Cooperation Agency [JICA], IRC has accomplished maintenance of different bridge defects. The materials used for maintenance are basically categorized in to four. These are:
- Materials used for large defects or cracks (pure cement or polymer modified cement type materials),
- Materials used for small defects or cracks (Resin type repairing materials or crack injection materials),
- Crack sealing materials so that small cracks will be ready for injection, and
- Materials for bonding
- All of these are supplied by different companies in the country.

Materials for Repairing of Large Defects or Cracks (polymer and fiber reinforced repair mortar)

These are materials used to repair large defects, especially those falling in rank "A" and "B". We have different materials to restore seriously damaged or injured members, some of them are:

1) (EMACO S88C T)

EMACO S88C T is a cementitious pre-bagged ready-to-use structural repair mortar in powder form. When mixed with the correct amount of water, it produces a thixotropic, high strength repair mortar, reinforced with acrylic polymer fibers. It possesses excellent bond characteristics to steel reinforcement and to concrete.

EMACO S88C T is shrinkage compensated which reduced risk of crack due to shrinkage and is formulated for sprayed or trowelled applications; in thickness up to 50mm in one layer by hand application. Greater thicknesses can be achieved when spray applied.

2) Renderoc TGXtra + Polypropylene Fiber

Shrinkage controlled polymer modified, vertical and overhead cementitious repair mortar system.

It is suitable for hand application to repairs where light to medium load bearing is required. It is applicable to general concrete and masonry repairs, voids greater than 10mm deep, repairs to honeycombing.

3) Sika Mono Top-612

Sika Mono Top-612 is wet sprayed/hand placed fiber reinforced repair mortar. It is a cementitious, polymer modified, low permeability, high strength mortar containing silica fume and synthetic fiber reinforcement. Excellent workability, adjustable consistency, excellent slump resistance, sprayable by the wet spray method, good mechanical strength, easily sprayed in layer thickness up to 30mm, and good resistance to water and chloride penetration are the characteristics of Sika Mono Top-612

Materials for Repairing of Small Defects or Cracks (crack injection material)

These are materials used to repair small defects especially for cracks having width of crack less than 5mm. It is also applicable for defects or damages which fall in rank "C". We have different materials to restore lightly damaged or injured members, some of them are:

1) Concresive 1315

CONCRESIVE low-viscosity injection resins are two component crack injection fluids for sealing cracks, filling cavities and voids in concrete and stopping water ingress. They can be injected in to cracks of varying sizes (100 microns to 9mm) including cracks too fine to be filled with traditional materials. It is highly penetrative and cures to form a permanent seal. It is applicable to columns, bridge decks, floors, piers, abutments, tunnels, basements, beams, and underpasses.

2) Nitofill EPLV

Low viscosity solvent free epoxy resin system used for injecting cracks in concrete or masonry to form permanent bond or seal. Nitofill EPLV It has two components base and hardener mixed in proportion to form strong permanent bond. The advantages of Nitofill EPLV are:

- Low viscosity allows penetration in to the finest cracks
- Formulated for hot climates
- Suitable for structural cracks or repairs
- Excellent bond to concrete, brick and masonry
- Minimum creep under sustained load
- Resistant to wide range of chemicals
- Non-shrink, adheres with no loss of bond

Mixing Procedures

- Stir each components separately to disperse settlement
- Pour hardener in to base & mix thoroughly
- Pour the mix in to injection gun
- Inject in to the pipes installed starting from lower elevations
- Bend pipe, carefully remove injection gun, tie pipe with wire
- Wash injection gun with thinner
- Curing for 24hrs

3) Sikadur-52 ZA

A two part solvent free, low viscosity injection liquid based on high strength epoxy resins applicable to civil engineering

buildings, industrial buildings, columns, bridges, and foundations. It has advantage of hardness but not brittleness, low viscosity, injectability, suitable for both dry and dump conditions, and high mechanical and adhesive strength.

Crack Sealing Materials for Injection (Epoxy resin mortar)

Materials for sealing of very small cracks (crack width less than 5mm), so that ready for application of crack filling or injection (resin type repairing) materials. Materials involved are: [15]

1) Concresive2200

It is high strength, non-flow, epoxy bedding and repair mortar. It is a two packs, fine aggregate filled, fast curing material, and ideal for a variety of bedding, gap filling and concrete repair applications. CONCRESIVE2200 is a stiff but easily workable compound that can be applied by trowel, spatula or knife. It is impact resistance and mechanical strength is greater than that of concrete. It can be applied as a gap filling adhesive, fixing slip bricks to concrete, dowel bar anchoring, bedding tiles, repairing concrete posts in-situ, securing bolts in to walls, and repairing surface defects or to honeycombing concrete in horizontal, vertical or overhead situations.

2) Nitomortar FC

High strength trowel grades, epoxy resin fairing coat, repair mortar, bedding and adhesive. It is suitable for filling pinholes prior to over coating with nitocoat or nitoflor products, general reprofiling over large areas, up to 3mm depth, Sealing of surface cracks in preparation for crack injection, general purpose bedding mortar and adhesive. Nitomortar FC is a two component thixotropic, solvent free, compound based on epoxy resins, graded fillers and thixotropic agents. It is applied directly to concrete substrates, without primer, and cures to a surface ready for over coating. The base component is light gray coloured and the hardener black to ease identification of uniform mixing.

Generally

It is a two component thyrotrophic compound Used for sealing of surface cracks in preparation for injection -Has strong adhesion to concrete substrate -1 Lit of nit mortar covers 5m2 with 0.2mm thickness but it's heavily dependent on the surface condition (or with 2 mm thickness – 0.5m2) - Mix proportion (1 can base + 1 can hardener)

Mixing Procedures

1. Stir each components separately to disperse settlement
2. Pour hardener in to base & mix thoroughly until uniform colour grey is obtained (it is very viscous compound which makes stirring tedious)
3. As soon as we finish mixing apply it on surface prepared using filling knives
4. Clean all equipments used using solvent Curing

3) Sikadur-31CF Normal

A moisture tolerant, thixotropic, structural two part adhesive and repair mortar, based on a combination of epoxy resins and special fillers, designed for use at temperature between 10 and 30 degree centigrade. It can be used as a structural adhesive and mortar for concrete elements, hard natural stone, ceramics, bricks, masonry steel, iron, and aluminum. Easy to mix and apply, suitability for dry and damp concrete surfaces, very good adhesion to most construction materials, high strength adhesive, thixotropic (non-sag in vertical and overhead applications), hardness without shrinkage, different colour components, high initial and ultimate mechanical strength, good abrasion resistance, and impermeability to liquids and water vapour are some of the advantages of this epoxy.

Materials for Bonding

1) Concresive 1414

Epoxy bonding agent for concrete repairs, bonding concrete to concrete, steel and granolithic toppings. It is a permanent epoxy adhesive for internal or external bonding and has greater tensile strength as compared to that of tensile strength of concrete. CONCRESIVE 1414 may be applied to clean, sound and durable surfaces that is steel, glazed tiles and bricks, ceramics and quarry tiles, terrazzo tiles and floors. high strength, non shrink, moisture tolerant, durability, and resistant to chemical attack are some of the advantages of this epoxy.

2) Nitobond EP

Epoxy resin concrete bonding agent used to bond fresh wet cementitious material to existing cementitious surface. It is used for horizontal and vertical surfaces of roads, bridges, pavements, loading bays and factories both externally and internally. Nitobond EP has two components white base and green hardener mix together and applied on dry or damp substrates. The advantages of Nitobond EP are: exhibits high mechanical strength, positive adhesion-exceeds that of the tensile strength of the host concrete, slow cure allows time to erect steel reinforcement and formwork, and solvent free-can be used in enclosed locations.

Generally

- It is a two component material (base and hardener)
- It is used for bonding existing concrete surface with the new mortar applied
- Exhibit high bonding (tensile) and mechanical strength
- Working life time – 160min (we have to apply it on the surface before this time)
- Max overlay time – 24hr (we have to apply EMACO before this time)
- 1Lit of nitobond covers 3.5 – 4m2
- Mix proportion (1 can base + 1 can hardener)

Mixing Procedures

1. Stir each components separately to disperse settlement
2. Pour hardener in to base & mix thoroughly until uniform colour is obtained
3. As soon as we finish mixing apply it on surface prepared using brush
4. Clean all equipments used using solvent.

3) Sika Latex

Water resistant bonding agent for mortar. It is a high quality,

synthetic polymer emulsion for adding to cement mortars where good adhesion and water resistance are required. It can be applicable for thin layer patching mortars, renders, floor screeds, concrete repair mortars, abrasion resistant lining, and tile fixing mortars. Sikalatex has greater elasticity, small shrinkage, better adhesion strength, excellent water resistance, better chemical resistance, and non-toxic.

4) Sikadur-32 N

Wet to dry epoxy resin bonding agent. It is a two component solvent free, moisture insensitive, medium viscosity, structural epoxy bonding agent used for bonding fresh concrete to an existing concrete or mortar substrate. It is suitable for vertical anchor bolt grouting. Sikadur-32 N has different advantages, some of them are: easy to mix and apply, solvent-free, excellent adhesion to concrete and a wide variety of other substrates, tensile strength far greater than concrete, and can be applied to damp substrates.

Conclusion

Rehabilitation of structures embroils contribution of high end technology, advanced skills and calculations. This is a very responsible job to be done to save hazardous failure of structures due to deterioration. The success of this subject totally depends on gaining expertise in the field and day to day advancements. Rehabilitation is highly recommended for age-old buildings showing signs of decent and save human lives from failures.

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