International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 6 Issue 6, June-2017, Impact Factor: 4.059

A Research Paper on Concrete Bridge Repairs & Rehabilitation

Ayush[1], Mrs. Monika[2], Dr. V. K. Ahuja[3]

[1]M.Tech Student, Dept. of Civil Engg., SatPriya Group of Institutions, Rohtak, Haryana
[2]Asst. Professor, Dept. of Civil Engg., SatPriya Group of Institutions, Rohtak, Haryana
[3]Professor & HOD, Dept. of Civil Engg., Shree Baba MastNath University, Rohtak, Haryana

ABSTRACT

The usual practice in INDIA to maintain concrete structures is simply plastering and masking the defects (ugly looking) without considering the structural aspect of the structure. But such activities should not be called maintenance unless the overall condition of the concrete structure is regained through the task accomplished. When the defects or a failure of the concrete structure is a bit exaggerated, demolishing and reconstruction was the best option and was practiced so far. Unlike the practice we used to do before, concrete bridge rehabilitation techniques, materials and procedures are burning and crucial issue now a day, being many of the bridges are reaching about their design life and need rehabilitation before failure. Considering the urgency of the issue, the universities in particular and the country in general with the respective parties have to think of the problem and participate on provision of possible solutions. Although not satisfactory or to the requirement of the country, Indian Road Congress (IRC) in collaboration with Japan International Cooperation Agency (JICA) has maintained some bridges within the last five to eight years. Concrete bridge maintenance is not an easy task, because regaining the overall condition especially the structural strength of concrete bridge by simple plastering is difficult. So the use of different admixtures (modifying agents), additives (fine mineral powers) and epoxies is mandatory following the procedures and specifications given by the suppliers. At this time there are many suppliers for the construction company involved in maintenance or construction. Considering the importance of concrete bridge rehabilitation on a national base currently, this study has done to address the basic defects, causes of defects, materials for maintenance and possible techniques and procedures of rehabilitation. It has also given some idea about rehabilitation, so that the respective sectors and researchers can have an assignment on the issue for further investigation and work.

I. INTRODUCTION

This study addresses the increasing needs of skill upgrading trainings on bridge maintenance which is not available in universities or higher technical institutions learning in the country. Conducting this research study is found necessary in order to make simple application of the methods considering the local condition by incorporating international maintenance methods and materials that can be available in the country. In addition, it is intended to make it friendly applicable and usable for contractors, consultants, and other interested users.

This research outlines simple guide and procedure (including identification and selection of materials available) for practicing engineers involving in the repair and maintenance of concrete bridges, and could be useful reference document for researchers and students interested in the subject.

The study shall focus on maintenance of concrete bridges which is dominant defect type occurring in constructed concrete works.

In 60 years of Indian Roads Authority history, never before as today the need for bridge asset management and maintenance has acquired attention. This calls for careful assessments of the long stayed problems and provision of an urgent action to establishing bridge database, updating, and inspection, prioritization for rehabilitation or maintenance.

Many bridges in India have attained about design period, as most are constructed 40-70 years ago. Others have suffered abuse by unscrupulous (ignorant) transporters who overload or move over-height containers. As a result, the structures exhibit cracks and deterioration leaving the steel rebar in most cases exposed to aggressive climatic conditions.

Exposed rebar consequently rust and this could easily result in premature failure of the structure. Even in cases where failure does not occur, the safe use of the structure cannot be guaranteed. Often under these circumstances, the first and the simplest option is to demolish and reconstruct the structure. However demolition and replacing is very expensive. Besides, there is great inconvenience to road users due to closure of the road while undertaking new construction.

Thus, maintaining and rehabilitation of existing bridges is a better option provided the relevant strength requirements are satisfied. In this aspect tackling the problems, a number of construction chemicals suppliers advertise wide variety of concrete repair products to meet the needs of all kinds of repair situations, indicating availability for use.

A concrete structure is expected to retain the required levels of its functions during the intended service life. Thus, concrete structure shall retain structural performance over the required levels with adequate reliability during the design service life. Consequently, in order to keep the performance always above and to its required level, the adequate maintenance should be indispensable or necessary for most concrete structures.

Objective of the Study

- To identify the basic and most common defects of concrete structures, in general and our country in particular.
- To identify to cause of their defects
- To propose methods of selecting suitable material and recommendations of maintenance procedure.

Scope of the Paper

The paper encompasses concrete bridges from failure to maintenance. But the special attention of the paper is towards the materials and procedures for maintenance.

In this paper you will find

- Different parts of concrete bridges
- Defects of different parts and causes of defects
- Maintenance techniques or procedures of defect maintenance.
- Materials involved for maintenance

So, this paper attempts to address procedures of concrete bridge maintenance with materials involved on national bases.

MATERIAL AND METHODS

Concrete is an essential material. With a worldwide estimated consumption of between 21 and 31 billion tones of concrete in 2006, concrete is the second most consumed substance on Earth after water! A world without concrete is almost inconceivable The principles of producing concrete and understanding the laws of concrete behavior are well enough established through long experience and extensive research to make it possible to design and erect structures that meet the recognized requirements of engineering use and safety. There is still a need for continued research, however. New questions are constantly arising, and new methods and machines for construction operations are being developed. If concrete is to meet increasingly higher expectations with regard to durability and structural efficiency, and continue in the forefront as a building material, the new requirements need to be met by ever-increasing knowledge obtained from research and experience.

Concrete sets, hardens, gains strength, and exhibits reduced permeability with the passage of time, but it is not the passage of time alone that causes these things to happen. If the concrete is kept very cold, none of this will happen. If all moisture is removed, none of this will happen. Many or even most concretes are confronted with potential deteriorative service conditions. If the concrete has not been provided with immunity against these influences, it may well slowly deteriorate as time passes, but not simply because time passes. Concrete need not deteriorate.

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:

(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.

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.

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.

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]**

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.

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 thixotropic compound

-Used for sealing of surface cracks in preparation for injection -
Has strong adhesion to concrete substrate
-1 Lit of nitomortar covers $5m^2$ with 0.2mm thickness but it's heavily dependent on the surface condition
(or with 2 mm thickness – $0.5m^2$)
- Mix proportion (1 can base + 1 can hardener)

CURRENT DEFECT REPAIR PRACTICE IN INDIA

This study addresses the increasing needs of skill upgrading trainings on bridge maintenance which is not available in universities or higher technical institutions in the country. Conducting this research study is found necessary in order to make simple application of the methods considering the local condition by incorporating international maintenance

methods and materials that can be available in the country. In addition, it is intended to make it friendly applicable and usable for contractors, consultants, and other interested users.

Many bridges in India have attained about design period, as most are constructed 40-70 years ago. Others have suffered abuse by unscrupulous (ignorant) transporters who overload or move over-height containers. As a result, the structures exhibit cracks and deterioration leaving the steel rebar in most cases exposed to aggressive climatic conditions.

Thus, maintaining and rehabilitation of existing bridges is a better option provided the relevant strength requirements are satisfied. In this aspect to tackle the problems, a number of construction chemicals suppliers advertise wide variety of concrete repair products to meet the needs of all kinds of repair situations, indicating availability for use.

Collection of inventory data and inspection (regular, major or emergency) of defects is the primary activity conducted during rehabilitation. Different defects like, cracking, peel off, rebar exposure, honeycomb, void, water leakage, deformation, corrosion, wearing, bolt missing on different structural parts (superstructure,

substructure or miscellaneous structural elements) has to be rater based on the rating system specified. That is whether the defect is in rank "A", rank "B" or rank "C" shall be categorized.

Defects that appear on the surface of concrete during construction or within a relatively short time after completion, are usually caused by poor quality materials, improper mix design, lack of proper placing and curing procedures, or poor workmanship. The repair of surface defect is both difficult and costly. The best repair work will not be as good as an original properly finished surface. Every effort should be made both prior to and during construction to avoid the use of materials or construction practices that can cause surface defects.

Various causes may have contributed to the formation of a particular defect. However every effort should be made to determine the cause to ensure that the correct repair strategy is adopted. Sometimes the cause is clear, for example fire or collision damage. Structures may be overstressed by conditions outside the control of the designer and constructor, such as overloading, change to the flow of a river, failure of adjacent structures and various natural causes. Settlement of a structure, which was not anticipated and allowed for in design, can result in very severe damage to concrete structures. Wide cracks and crushing where members come into unintentional contact may indicate that settlement has occurred.

Following a vehicular collision with a bridge, careful consideration of the structural effects must be carried out by an experienced structural engineer. Damage to primary elements can severely weaken a structure, or even cause collapse. Generally defect in concrete structures result from many factors such as poor design detailing, construction deficiencies, structural failure due to overstress or loss of section resulting from other defects, free/thaw effects, chemical attack, settlement of the foundation, changes to the support or loading conditions caused by scour or silting, failure of bearings or expansion joints, and traffic collision defect.

The defects mentioned above are rehabilitated by different materials, one of the fundamental materials and widely used one is concrete. With a worldwide estimated consumption of between 21 and 31 billion tones of concrete in 2006, concrete is the second most consumed substance on Earth after water! A world without concrete is almost inconceivable!

The principles of producing concrete and understanding the laws of concrete behavior are well enough established through long experience and extensive research to make it possible to design and erect structures that meet the recognized requirements of engineering use and safety. There is still a need for continued research, however new questions are constantly arising, and new methods and machines for construction operations are being developed. If concrete is to meet increasingly higher expectations with regard to durability and structural efficiency, and continue in the forefront as a building material, the new requirements need to be met by ever-increasing knowledge obtained from research and experience.

Concrete sets, hardens, gains strength, and exhibits reduced permeability with the passage of time, but it is not the passage of time alone that causes these things to happen. If the concrete is kept very cold, none of this will happen. If all moisture is removed, none of this will happen. Many or even most concretes are confronted with potential deteriorative service conditions. If the concrete has not been provided with immunity against these influences, it may well slowly deteriorate as time passes, but not simply because time passes. Concrete need not deteriorate.

Concrete is essentially a compressive material. While it has adequate strength for most structural uses, it is best suited for relatively massive members that transmit compressive loads directly to the founding material. Although concrete has low tensile strength, reinforcing it with steel bars produces a material that is suitable for the construction of

flexural members such as deck slabs, bridge girders, etc. Cement is the fundamental component of concrete, so cement alone or in combination with polymers or epoxy can be used for maintenance. Based on the type of the defects the materials used for maintenance can be grouped in to four. These are:

- materials used for large defects or cracks (pure cement or polymer modified cement type materials) Polymer modified cement type : this is cement modified using different polymers and fibers
- 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
- materials for bonding

The repair work will be accomplished after conducting inspection and preparation of the repairing materials. During repairing the procedures has to be properly followed as per the specification or order of the expert. But removal of concrete if necessary, surface cleaning, substrate preparation and repairing material application are the general steps applied during rehabilitation.

Details of Grade Separator

The grade separator was on a curve and has two independent carriageways namely 'Inner carriageway' and 'Outer carriageway'. Each carriageway has 4 spans of single cell box-girder shape (consisting of soffit slab, web and deck slab, each of 35 m length and simply supported over a pair of pot bearings on each support.) Each box girder was to be prestressed with 18 Nos. of prestressing tendons. Fig.1 shows the location plan and Longitudinal section of span P2-P3 is shown in Fig.2.

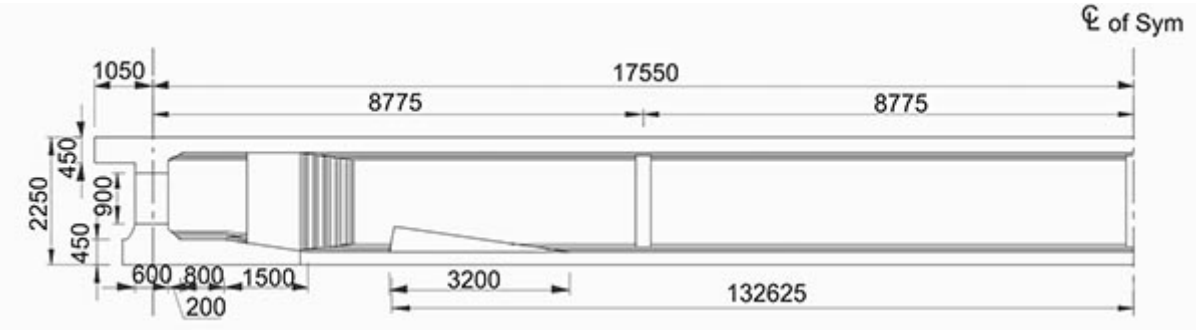

Figure 1: Typical Longitudinal Section of Box-Girder Span

Materials Used for Repair

Figure 2: NitoBond (hardener & base)

Figure 3: Nito Bond (hardener & base)

CONCLUSION

In concrete bridge failures, reconstruction of the structure instead of rehabilitation for every defect or failure is very difficult in terms of money and construction. That is the amount of money involved for reconstruction of bridge is much and very expensive. In addition closing of the road may interrupt traffic flow, which has significant impact on the economy of the country especially when the bridge is on the federal road. So rehabilitation or maintenance of concrete bridges become very crucial and mandatory to stop failure of bridges before reaching their design period and to avoid unnecessary expense to construct a new bridge instead of maintaining and lengthen the service life of the bridge.

Proper design and construction does not mean that the bridge will serve about its design life. Because lack of inspection and controlling with minor rehabilitation may make the bridge to fail before serving to its maximum capacity. So monitoring, inspection, and maintenance of every concrete bridge have to be done starting from construction day before failure, which leads to erection or construction of a very expensive new bridge.

Unlike the practice we used to do before, concrete bridge rehabilitation techniques, materials and procedures are burning and crucial issue now a day, being many of the bridges are reaching about their design life and need rehabilitation before failure. Considering the urgency of the issue, the universities in particular and the country in general with the respective parties have to think of the problem and participate on provision of possible solutions. Although not satisfactory or to the requirement of the country, Indian Road Congress (IRC) in collaboration with Japan International Cooperation Agency (JICA) has maintained some bridges within the last five to eight years.

REFERENCES

[1]. Branko Glisic and Daniele Inaudi, " Fibre optic met hods for structural health monitoring",
[2]. John Wiley & Sons, Chichester, 2007.
[3]. Guidelines for Structural Health Monitoring, ISIS Canada.
[4]. International Society of Structural health Monitoring and Intelligent Infrastructure, www.ishmii.org
[5]. "Report on Dam Safety Procedures", Government of India, Ministry of Water Resources.
[6]. Jacob Egede Anderson, "Structural Health Monitoring Systems", Cowi A/S and Futurtec OY,
[7]. "Report card for America's Infrastructure", American Society of Structural Engineers, 2005.
[8]. http://memory.loc.gov/ammem/collections/habs_h aer/
[9]. Radomski W., Bridge Rehabilitation, Imperial College Press
[10]. ACI Committee 440. State-of-the-Art Report on FRP for Concrete Structures. ACI 440R-96
[11]. Manual of Concrete Practice, ACI, Farmington Hills, MI, 1996, 68 pp.
[12]. G.L. Rai, "Different Strengthening Techniques for RC Columns", R&M International.
[13]. B.N. Pandya, M. M. Murudi, A. A. Bage, "Seismic retrofitting of reinforced concrete buildings", Proceedings WSRR 09.
[14]. Gopal Rai, Kulvinder Singh, Yogesh Singh, "External Pre-Stressing Using Carbon Fiber Laminates", Proceedings WSRR09, IIT Bombay.
[15]. Bambole A. N., Jangid R. S., Rai G. L., "Rehabilitation and Testing of the Karal Rail Over Bridge for 18. JNPT, Navi Mumbai", Proceedings WSRR09, IIT Bombay.