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Rehabilitation of Bridges carried out in India under NHDP Programme

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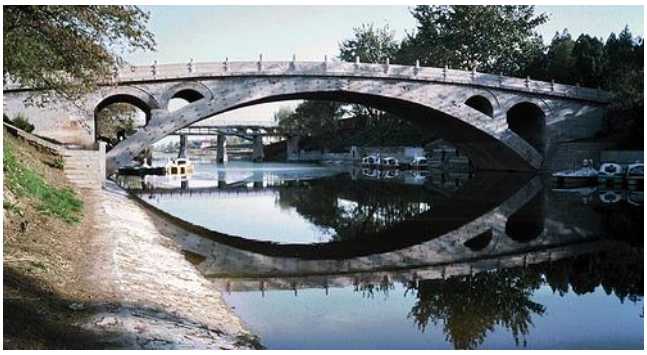
Abstract— This paper deals with the measures which are required for rehabilitation of bridge structure. The cause of deterioration, detection of the damages, severity of the damages and their remedial solution by conducting several NDT/PDT Tests are elaborated in brief.

Keywords— Rehabilitation, Deterioration, NDT & PDT Tests, Cost effective measures.

I. INTRODUCTION

The Government of India after Independence has undertaken 5 year target oriented development programme for the overall development in various sectors till 1980. The irrigation sector was on the topmost precedence. This was because the 85% of the population was engaged in agriculture and less preference was given to the road sector. In the decade of 1980-90, the roads were developed and classified as NH, SH, MDR, ODR & Village Roads. The structure configuration was mostly rubble masonry for substructure & RCC slabs having short spans for superstructure, thereby increasing the cost of construction.

Chinese built big bridges of wooden construction, and later stone bridges, and the oldest surviving stone bridge in China is the Zhao Zhou Bridge built around 605 AD during the Sui Dynasty. This bridge is also historically significant as it is the world's oldest open- stone segmental arch bridge.



In the last decade, little improvement was observed and with the invention & improvement in the binding materials, substructure of plain cement concrete (PCC) were adopted. Slender substructure are being proposed which resulted in cost effective and time saving in construction period in the overall construction industry.

The Government of India has undertaken the massive road development programme under various ministries namely NHAI, MSRDC, MMRDA etc. the National Highways across India are being upgraded to 4/6 lane highways/expressways under this programme. The 4/6 Laning of highway depends on the volume of traffic plying on highway stretches. To make the project economically viable, it was proposed by the apex body NHAI/MORTH to maintain the existing bridge structures in compliance to the present traffic conditions and by carrying out certain rehabilitation measures.

II. DIFFERENT LOADING STANDARDS

In early decades, the loading standards in some countries were first formulated to regulate heavy military vehicles. In UK this type of loading formed the basic of present HA type loading. In USA, a loading standard consisting of truck trains and equivalent loads was introduced by American Association of State Highway Officials (AASHO) in 1935.

2.1. American Association of State Highway and Transport Officials (AASHTO)

The American Association of State Highway and Transport Officials (AASHTO) has recommended the heaviest loading designated as HS 20-44.This loading criteria comprised of a heavy tractor truck with semi-trailer of total load of 320.3 KN or corresponding lane loading [9].

2.2. IRC Loading

The committee has issued guidelines for the loading to be adopted for the design of bridges in the year January 1956. The final draft was approved by council in the meeting AIZWAL on 17-04-1997. Since then the loadings mentioned in IRC-6 are being used for the design of bridges on highways. To cope-up with the present day loadings, to judge the capacity of the existing bridge structure and to make is compatible for the smooth plying of traffic by carrying out certain rehabilitation/restoration/reconstruction measures is the need of the day [1].

III. NEED FOR BRIDGE REHABILITATION

The Various Factors that are taken into account for a bridge to be rehabilitated are [3]:

- Existing condition of the bridge components.
- The year of construction of bridge or the age of the structure
- Type of Foundation and soil conditions.
- Traffic Volume passing over the Bridge.
- Environment Condition.
- Bridge Loading Capacity.
- Economic analysis Considering Emergency Repairs, Rehabilitation, Replacement and Life Cycle costs.

IV. DAMAGES

The most common damages to bridge are as follow [3]

- Cracking
- Scaling
- Efflorescence
- Spalling
- Delamination

Damages to the structures are also caused due to:

- Accidents
- Vehicular movement.
- Characteristics of road user
- Weathering effect caused due to environment

V. TESTS AND INSTRUMENTS FOR DETECTION OF DAMAGES

SR NO	NDT TEST	PURPOSE
i.	Ultrasonic Pulse Velocity Test	Shall be conducted as per the provisions of IS 13311(Part I):1992
i.	Rebound Hammer Test - Schimds hammer test	Shall be conducted as per the provisions of IS 13311(Part II):1992
i.	Half-cell Electrical Potential	To detect corrosion of reinforcing bars.

	method	
v.	Carbonation depth measurement test	To determine whether the moisture has reached the depth of reinforcement
v.	Permeability test	Used for measuring the flow of water through concrete.
i.	Penetration resistance test	Used to measure the strength of surface, surface hardness & near surface layers of concrete.
i.	Covermeter Test	Used to measure the distance of reinforcement bars from the exposed concrete surface.
i.	Radiographic test	Used to detect voids in concrete.

Table1. Test and Instruments for NDT

VI. WORKING PROCESS

6.1. Ultrasonic Pulse Velocity Test

The Principle of Ultrasonic Pulse velocity Test is that the velocity of ultrasonic pulse through any medium depends on the density, modulus of elasticity and poisons ratio.

Pulse velocity measurements can be utilized to detect the homogeneity of concrete, presence of cracks, void etc.; quality of concrete relative to standard requirements, quality of one element of concrete in relation to another and value of concrete elastic modulus [7].

Sr. No	Pulse Velocity in Km/Sec	Condition of concrete
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	Below 3.0	Poor

Table2. Relation between pulse velocity and condition of concrete

6.2. Rebound Hammer

The basis of this test depends on the principle of rebound of elastic mass corresponding to the surface hardness. The rebound value is read along a graduated scale and is designated as the 'rebound number' or 'rebound index'. This rebound number is related to the compressive strength of the concrete as follow [8]

Average Rebound Number	Quality of Concrete
>40	Very Good Hard Layer
30 to 40	Good Layer
20 to 30	Fair
<20	Poor Concrete
0	Delaminated

Table3. Relation between rebound number and condition of concrete

6.3. Half-cell Electrical Potential method

In 'Half-cell Potential Test', electrical connection to reinforcing bar is necessary to obtain potential measurements. The open circuit potential measuring technique is the most important of the electrochemical techniques that can be adopted for site use. The equipment consists of a half-cell, voltmeter and electrical lead wires. Normally copper – copper sulphate halfcell is used but other half-cells like silver – silver nitrate can also be used [10].

6.4. Carbonation Depth Measurement

The carbonation process is also referred as depassivation. Carbonation of concrete occurs when the carbon dioxide in the atmosphere in the presence of moisture reacts with hydrated cement minerals to produce carbonates, e.g. calcium carbonate. Carbonation penetrates below the exposed surface of concrete extremely slowly. The time required for carbonation can be estimated knowing the concrete grade and by using the following equation:

$$T = [d/k]^2$$

where, t is the time for carbonation,
d is the concrete cover,
k is the permeability

The phenomena of carbonation cannot be avoided as the usual protection of the reinforcing steel generally present in concrete due to the alkaline conditions caused by hydrated cement paste is neutralized by carbonation. Thus, if the entire concrete cover over the reinforcing steel is carbonated, it may result in corrosion of the steel due to exposure of steel to moisture and oxygen [10].

6.5. PDT Tests

The Partial Destructive Test provides more realistic results of grade of concrete, strength of concrete and the probable life span of the bridge, which would survive after carrying out suitable and cost effective rehabilitation measures.

VII. CONCLUSION

7.1. The agencies which carried out the above tests and rehabilitation measures shall be NABL (National Accreditation Board for Testing and Calibration Laboratories) as per the circular of MORTH & NHAI. The adoption of any particular rehabilitation measures depends on:

- The significance of the structures
- Probable life span of structure
- The severity of the damages

7.2. The cost of rehabilitation work shall be bare minimum against the cost of construction of new bridge. If it appears that the cost involved in rehabilitation work is comparatively on higher side, then with the consent of the Authority certain restoration work (cost involved is more) or reconstruction work may be opted.

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