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STRUCTURAL HEALTH MONITORING OF AN OLD RC BRIDGE

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Abstract: Bridges are pervasive in all communities and shape the interpersonal, sociological, environmental, financial, ethnographic, and artistic features of these organizations. SHM is required because the properties of both concrete and steel are highly dependent on a variety of factors that are difficult to foretell in practice. The typical criteria selected for monitoring a structure's health may be mechanical, physical, or chemical. Monitoring the condition and functionality of bridges on a regular basis is vital for their appropriate management and functionality. SHM systems have evolved to continually evaluate and assess the functioning state of bridges, hence enhancing maintenance, inspection, and planning. In the previous ten years, researchers have made significant advancements in all facets of SHM, such as highly developed smart sensors, wireless sensors, sensor networks, data acquisition technologies, data communication systems, signal processing systems, data management systems and system integrated techniques, approaches for damage identification, model upgrading, and safety assessment, development and implementation of SHM frameworks for practical civil infrastructure and data interpretation and application. This work aims to compile global case studies on monitoring the structural health of multiple bridges using a variety of approaches, efficiency evaluation, and instantaneous alert systems. The purpose of this study is to review Structural Health Monitoring of a bridge by carrying out non destructive test named rebound hammer along the bridge by concerned authority to obtain the reduced compressive strength parameter of superstructure of bridge and modeling and analyzing it by FEM software specifically STAAD Pro and comparing the results such as bending moments, forces, and deflections and stresses and providing required repair and rehabilitation techniques.

Keywords: Bridges, FEM, Structural Health Monitoring.

I. INTRODUCTION

A structure that is constructed to span a physical barrier without obstructing the passage beneath it is referred to as a bridge. The construction of bridges contributed significantly to the country's social and economic development. Nonetheless, Concrete bridge decks are among the most prone components of transportation infrastructure to damages. This resulted in bridge engineering safety concerns such as material corrosion, catastrophic failure and fracture, low efficiency, operational instability resulting from load, environmental deterioration and natural disasters. If these abnormalities are not detected and responded to in a prompt manner, they lead to structural deterioration and failure, accompanied by significant financial and societal repercussions. Since the early 1980s, there has been an increasing awareness of the deterioration and inefficiency of civil infrastructure assets. To address the safety and economic needs of society and to prolong the lifespan of structures by "quick and efficient" preventive and remedial interventions, sophisticated monitoring systems, such as Structural Health Monitoring (SHM) have been developed.

II. METHODOLOGY

The ability to access the undersides and sides of bridges, where deterioration goes unchecked, is collected by the Bridge Inspection Vehicle (BIV) by concerned authority. This device enables a more accurate evaluation of Bridge's physical and functional state. With the use of BIV, inspections have been carried out to derive structural specifications of bridge and conducting NDT test specifically Rebound Hammer test to derive compressive strengths of each span either completely or almost entirely without impairing traffic flow over the bridge.

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Fig 1. Image of bridge

Fig 2. BIV

Modeling of superstructure of bridge is done by Grillage method in STAAD Pro. As each span of bridge is same throughout the overall length of bridge, a single span is modeled and analyzed for the whole bridge by applying dead load and live load in the form of vehicular or moving load in FEM software specifically STAAD Pro. The results of deflections and stresses are obtained and compared after analysis with that of the deteriorated members after inducing damages specifically reduced compressive strengths.

- Firstly as the bridge was constructed in the year 1956 the grade of concrete used in that period is assumed to be M20 and that of steel is assumed to be 250 N/mm2.
- The longitudinal girders and deck slab are considered as a single unit and are hence modelled as a tee beam having grade of concrete as M20.
- Cross girders are provided as general T sections by calculating there area and moment of inertia.
- Hinged supports are provided even when the girders are directly resting on the piers as the piers and girders are not monolithically cast.

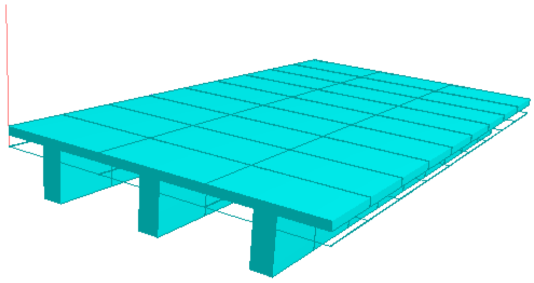

Fig 3. 3D view of span

The bridge span was modeled for M20 grade of concrete as a standard structure by assigning vehicular load of IRC class 70R loading and Class AA loading by referring IRC 6. Dead load consisted of self weight of structural members, weight of transverse and cross girders, dead load of wearing coat, kerb and railing post. The maximum bending moments and shear forces obtained after analysis between these load cases is considered for design as reinforcement details were not available the reinforcement was cross checked against authorized drawings which proved to be satisfactory.

The maximum bending moments and shear forces are considered at supports, 0.9D,L/8,L/4,3L/8,L/2 distances from both sides of all three longitudinal girders and tranverse girders. The deflections were checked after analysis for M20 grade of concrete which is assumed to be standard grade of concrete at the time of construction, the maximum deflection obtained with impact factor is 8.724 mm.

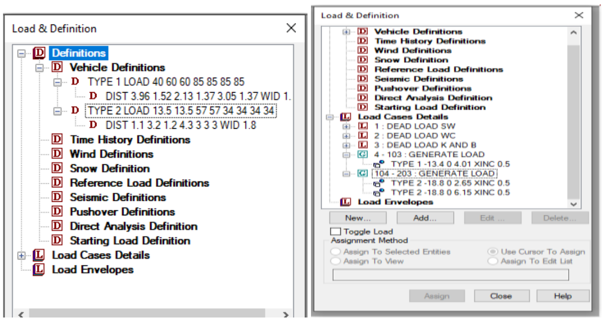

Fig 4. Load case details

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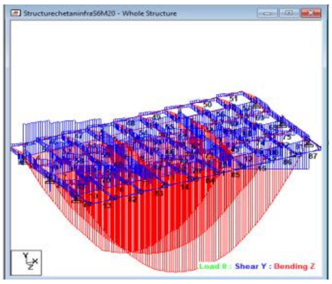

Fig 5. SFD and BMD for critical load case

Inducing damage refers to modeling and analyzing the bridge superstructure by using the compressive strength values obtained by carrying out Rebound Hammer Test by concerned authority and keeping the rest of the structure properties same as the original structure, that is:

SPAN NO	REBOUND VALUE	COMPRESSIVE STRENGTH
1	42.50 N/mm^2	25 N/mm^2
2	45.50 N/mm^2	30 N/mm^2
3	46.70 N/mm^2	32 N/mm^2
5	25.80 N/mm^2	10 N/mm^2
6	32.5 N/mm^2	20 N/mm^2

Fig 6. Compressive strength values

The deflections and the stresses in concrete and steel obtained after analysis from all spans are compared with those of standard one.

III. RESULTS AND DISCUSSION

DEFLECTIONS: According to IRC 112-2011, The following deflection parameters must be taken into consideration, taking into consideration the type of the superstructure, bridge deck furnishings, and technical specifications of the bridge;

- Vehicular : Span/800 = 13600/800 = 17mm
- Vehicular and pedestrian or pedestrian alone : span/1000 = 13600/1000 = 13.6 mm

The deflections obtained by analysis from inducing damages to the structure are as follows:

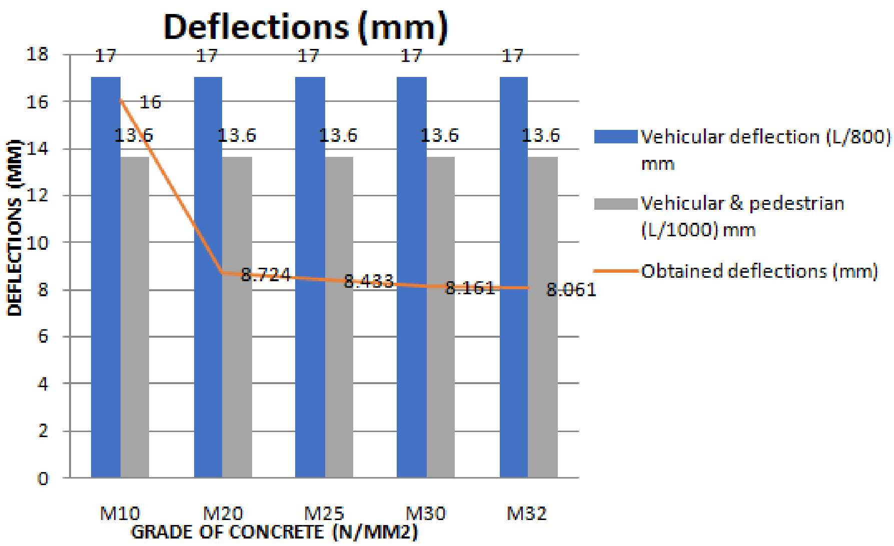

Fig.7 Deflections obtained by analysis

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STRESSES: The Stresses in concrete and steel are compared individually with the permissible limits and it is seen that the stresses in concrete and steel in all spans are within permissible limits.

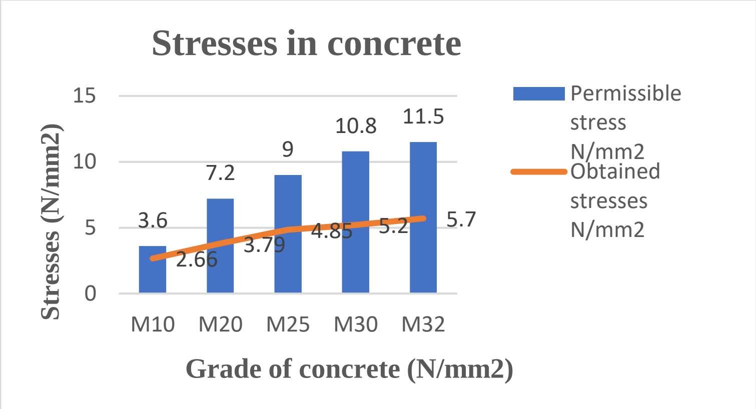

Fig.8 Stresses in Concrete

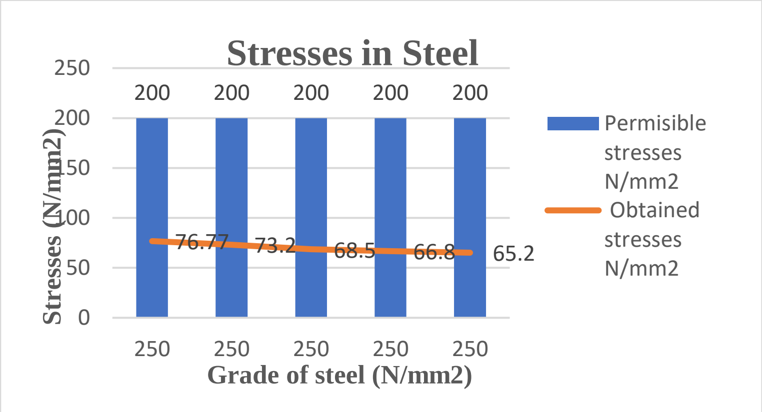

Fig.9 Stresses in Steel

IV. CONCLUSION

The deflections in span 5 under vehicular load are within permissible limits but under the combination of pedestrian and vehicular load it is exceeding the limits due reduced compressive Strength. Stresses in concrete and steel are within permissible limits for all spans, however it is noticed that stresses in concrete for span 5 are very near to permissible limits. As the state of bridge is fine & acceptable with small section losses, cracks the overall risk score of bridge is between 5-6, referring to IOP Conf. Series: Earth and Environmental Science.

Remedial measures: For cracks epoxy treatment is suggested, for delaminated girders and slabs strengthening slab by increasing depth from bottom, applying polymer fiber laminates or by adding additional reinforcement without or without increasing cross-sectional area of girder are suggested.

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