Seismic Retrofitting of Long Span Bridges

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Abstract – *Long span bridges are essential pieces of infrastructure for transportation because they allow people and products to travel across great distances. However, the public's safety and the stability of the economy are seriously threatened by their susceptibility to seismic shocks. One of the most important ways to reduce this risk is through seismic retrofitting, which is the process of making existing structures more earthquake resistant. An overview of seismic retrofitting methods designed especially for long span bridges is given in this abstract.*
Long span bridge seismic retrofitting entails a thorough evaluation of structural weaknesses and the application of suitable measures to improve seismic resistance. Numerous retrofitting methods are used, such as installing seismic isolation systems, dampening devices, and reinforcing structural parts.
The main factors in the seismic retrofitting process—such as structural analysis, material choice, and building techniques—are highlighted in this abstract. It also goes over how crucial it is to use cutting-edge modeling and simulation methods in order to precisely forecast how retrofitted buildings would respond to seismic loads

***Key Words*: *Seismic retrofitting, Long span bridges, Structural resilience, Seismic vulnerability, Retrofitting techniques*.**

1.INTRODUCTION

Long span bridges are essential parts of the transportation network because they cross valleys, rivers, and other barriers to provide key connections. But in areas where earthquakes are common, these technical wonders face a serious obstacle. Long span bridges' safety and operation are seriously threatened by earthquakes, hence proactive steps to increase their seismic resistance are required.

One of the most important approaches to addressing the susceptibility of long span bridges to seismic occurrences is seismic retrofitting. Retrofitting is the process of altering already-existing structures to make them more resilient to seismic pressures, which lowers the possibility of collapse or significant damage during an earthquake. Although seismic concerns may be incorporated into the design of new bridges, retrofitting provides an affordable way to improve the functionality of aged infrastructure and lessen the possible effects of seismic hazards.

Long span bridge seismic retrofitting offers special opportunities and problems. Bridges are susceptible to complicated dynamic pressures because of their raised and elongated shape, unlike typical constructions. Because of this, retrofitting methods need to be carefully designed to meet the unique vulnerabilities of long span bridge constructions, taking into consideration elements including ambient conditions, material qualities, and structural layout.

This study seeks to give a thorough review of long span bridge seismic retrofitting techniques in this setting. The article will examine the many approaches and strategies used to improve the seismic resilience of these vital infrastructure assets through a review of the research that has already been published, case studies, and real-world examples. The significance of cutting-edge modeling and simulation methods in the retrofitting process will also be covered in this presentation, along with the use of cutting-edge materials and technologies to maximize performance and save construction time and expense.

Engineers can reduce the hazards associated with seismic occurrences, protecting communities' well-being and transportation networks' safety, by improving the seismic resilience of long span bridges through retrofitting methods. Additionally, retrofitting initiatives help infrastructure systems become more resilient and sustainable overall, making it possible for them to face the difficulties presented by natural catastrophes and other outside threats. We shall examine the effectiveness, advantages, and practical concerns of the seismic retrofitting methods designed especially for long span bridges in the sections that follow.

Fig 1:- FRP jacketing of Bridge deck from bottom

Types of Seismic Retrofitting:-

When seismically retrofitting large span bridges, a variety of retrofitting approaches are frequently used. By using these methods, bridges' structural resilience will be increased and their susceptibility to seismic forces will be decreased. The following are some of the main categories of retrofitting for long span bridges:

- **Strengthening of Structural Elements:** To increase the bridge's ability to handle seismic loads, important structural elements such columns, beams, and foundations must be strengthened. Concrete jacketing, the insertion of steel or carbon fiber reinforced polymer (FRP) wrapping, or the installation of additional structural components are examples of strengthening techniques.
- **Seismic Isolation Systems:** Using isolation bearings or base isolators, seismic isolation entails severing the superstructure of the bridge from its substructure. By allowing the bridge to move apart from its supporting piers during an earthquake, these devices lessen the amount of seismic stress that is transferred to the structure, minimizing damage.
- **Damping Devices:** Within the bridge construction, damping devices are incorporated to disperse energy and lower the amplitude of vibrations caused by seismic waves. Viscosity dampers, tuned mass dampers, and friction dampers are examples of common damping devices that absorb and distribute seismic energy to minimize damage and structural reaction.
- **Base Strengthening and Foundation Retrofitting:** The seismic performance of a bridge is significantly influenced by its foundation. In order to increase soil-structure interaction and stability during seismic events, retrofitting solutions for foundations may involve deepening or enlarging foundation components, adding more piles or footings, or grouting existing foundations.
- **Expansion Joint Retrofitting:** Bridge constructions' expansion joints are weak spots where large amounts of damage can occur after an earthquake. Retrofitting expansion joints might entail adding more damping or energy dissipation devices to already-existing joints to enhance their performance under seismic stress, or it can entail replacing antiquated joints with more recent, seismic-resistant designs.
- **Structural Redundancy** Enhancement: To guarantee that alternative load channels are available in the event that key structural parts are damaged, retrofitting to increase structural redundancy entails adding redundant load paths or reinforcing connections within the bridge structure. This can enhance the overall structural strength and stop increasing collapse.
- **Advanced Modeling and Analysis:** It is crucial to apply sophisticated modeling and analytical methods, such as performance-based seismic design and finite element analysis (FEA), in order to precisely evaluate the seismic performance of long span bridges and create efficient retrofitting plans. With the use of these tools, engineers may improve retrofitting designs in accordance with performance goals and restrictions by simulating different seismic situations.

Engineers may successfully improve the seismic resistance of long span bridges and guarantee their continuous operation and safety in seismically active locations by combining various retrofitting approaches. Every retrofitting strategy should be specifically designed to address the unique qualities and weaknesses of the bridge structure, accounting for elements like seismic hazard levels, materials, and geometry.

1. Objectives:-

The ultimate Aim is to enhance the structural integrity and seismic resilience of an existing long span bridge to mitigate the potential risks posed by seismic events. The objectives of the present study includes :

a) To design a Retrofitting across pier and girder is to analyze its application in seismic retrofitting to improve resilience by using fiber reinforced polymer materials.

b) To perform seismic analysis of these two models by Staad software for Zone V.

c) Main parameters for the seismic analysis are base shear (lateral force due to earthquake on the bridge), fundamental period, maximum displacement of the bridge due to lateral load, maximum overturning moment of the bridge.

e) The models will also be analyzed based on the moving load as per IRC 6 Code of the bridge.

f) Conduct an analysis of two bridge models, specifically examining seismic factors in order to enhance comprehension of seismic performance.

3. Methodology:-

- Considering a Three dimensional finite element model of bridge.
- Considering bridge span of 90m (longest failed span of daman-ganga river)
- Bridge model to be considered as beam bridge type of structure.
- After geometric evaluation of structural model will undergo analysis.
- To compute design seismic forces, the code requires taking into account elements like the Response Reduction Factor (R), Importance Factor (I), and Zone Factor (Z).
- Performing comparative Analysis ,comparison of result from both the analysis of structure before and after application of retrofitting on long span will takes place and the conclusion will be drawn .

4. Indian Standard Code For Load:-

In this Project , there are several Indian standard codes used for load case, such as

- The Indian Standard Code 875 part-1 used for the self-weight of the bridge.
- Indian Roads Congress 6:2017 used for the vehicle load and vehicle considered as Tracked Vehicle 70R [9] (Tracked) Vehicle.
- Indian Standard Code used for the seismic load is 1893 part-1:2016.

5. Geometrical Parameters Of Bridge Model

Geometry of Bridge	Dimension
Dimension of the Pier	1000 mm*4500 mm
Dimension of the Main Girder	1000 mm x 9000 mm
Dimension of the Supporting Girder	1000 mm x 5000 mm
Total Lane Width of Bridge	9000 mm
Total Span of the Bridge	90000 mm
Height of the Deck	9000 mm
Height of the Railing from the Deck	2000 mm
Distance between the Supporting Girder	5000 mm
Cross section of the Side Girder	I section ISMB 600
Cross section of the Railing	Tube 75x75x4 mm
Retrofitting jacketed steel column Thickness	1000 x 1000 mm

6. Modelling:-

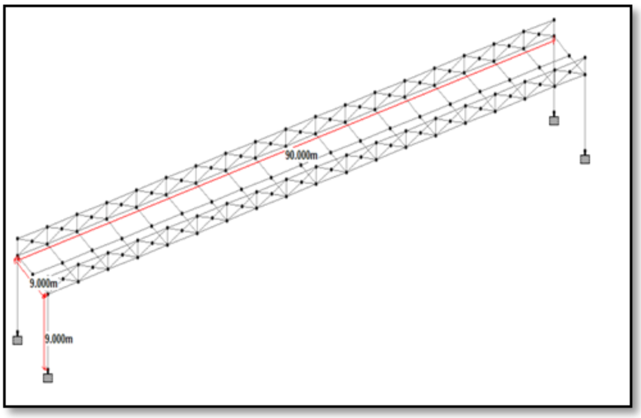

Fig 2: -Geometry of bridge without retrofitting

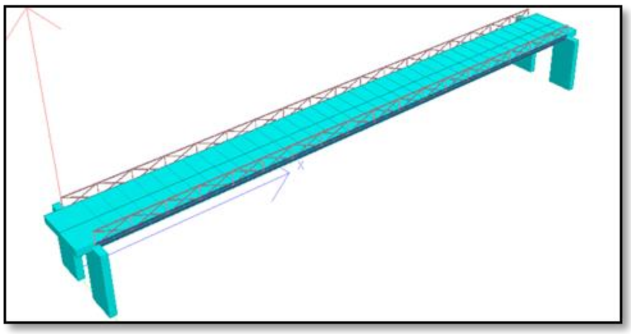

Fig 3: -3D view of bridge without retrofitting

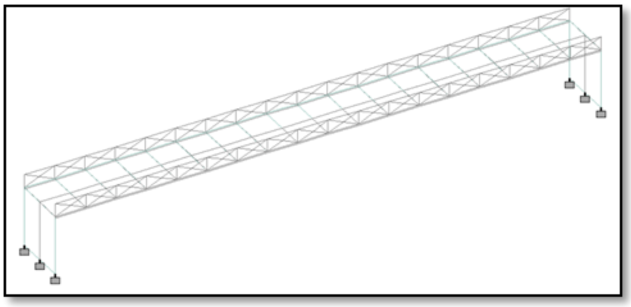

Fig 4:- Geometry of Bridge with Jacketing as a retrofitting

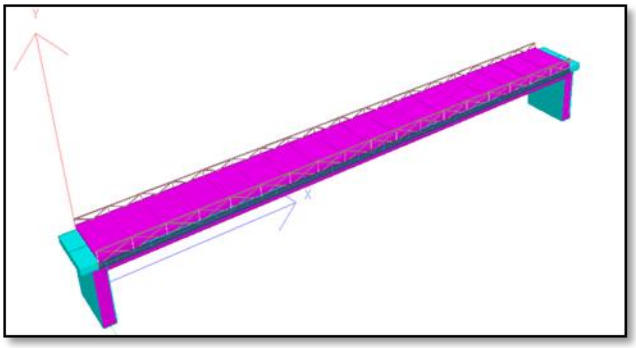

Fig 5:- 3D View of Bridge with Jacketing as a retrofitting

7. Loading Parameters:-

Dead Load:-

- 1. Selfweight
- 2. Floor Finish:- 1kN/m^2

Live Load:-

- The Live load Consist of two types
- Pedestal Loading
- Moving Loading
- 1. Pedestal Loading:- 2kN/m^2

Two Types of Moving loads are applied to structure

- Class 70R loading
- Class A Loading

8. Seismic Loading Parameters

- Zone Factor:- Zone V (0.36)
- Response Reduction Factor : 5 (SMRF)
- Importance Factor:- 1.5 (Important structure Bridge)
- Soil Type :- Hard Soil
- Type of Structure:- 3 (RCC and Steel Structure framing)
- Damping: 5%

9. RESULT:-

1. Lateral Displacement Result:-

Table1:- Maximum Displacement

Type of Structure	**Without Retrofitting**	**With Steel Jacketing**
Maximum Lateral Displacement	398	48

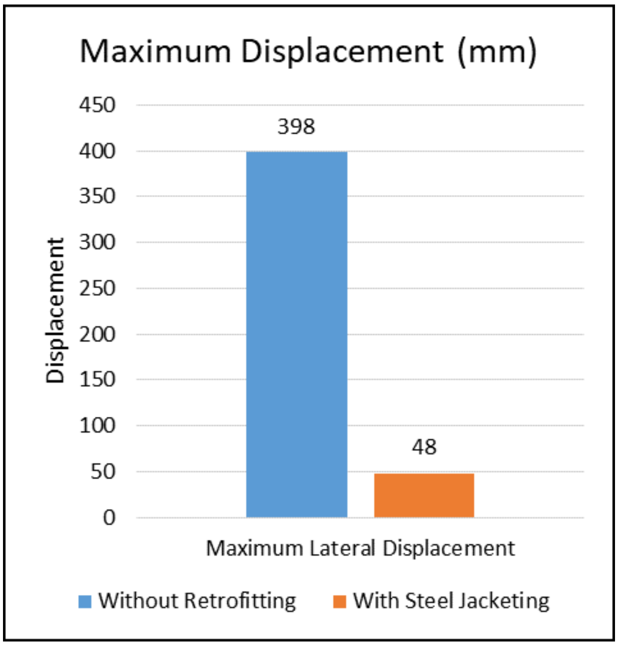

Fig 6:- Comparison of maximum displacement.

2. Reaction:-

Table2:- Maximum Reaction

Type of Structure	**Without Retrofitting**	**With Steel Jacketing**
Maximum Reaction (kN)	55770	192446

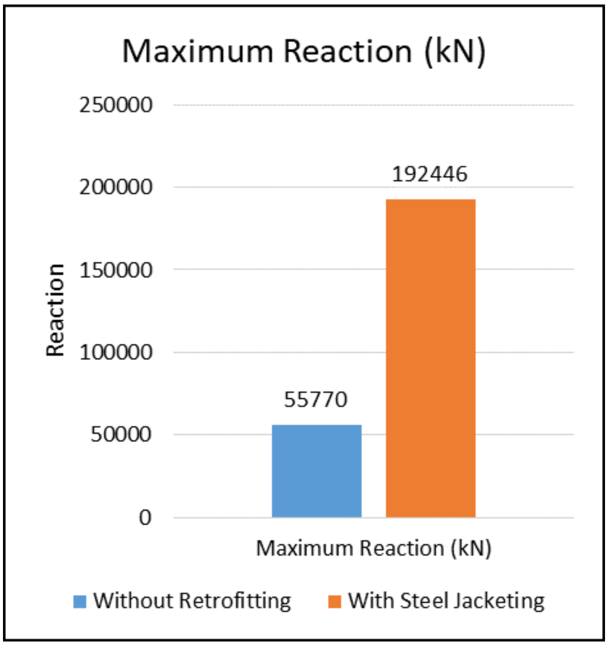

Fig 7:- Comparison of maximum reaction

3. Overturning Moment:-

Table3:- Maximum Overturning Moment

Type of Structure	Without Retrofitting	With Steel Jacketing
Maximum Overturning Moment (kN-m)	99700	24628

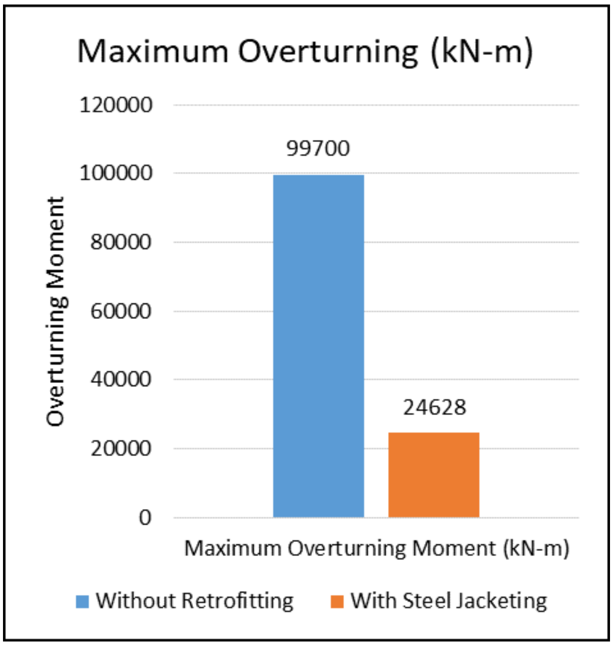

Fig 8:- Comparison of maximum Overturning Moment

4. Shear Force:-

Table 4:- Maximum Shear Force

Type of Structure	Without Retrofitting	With Steel Jacketing
Maximum Shear Force (kN)	62406	27536

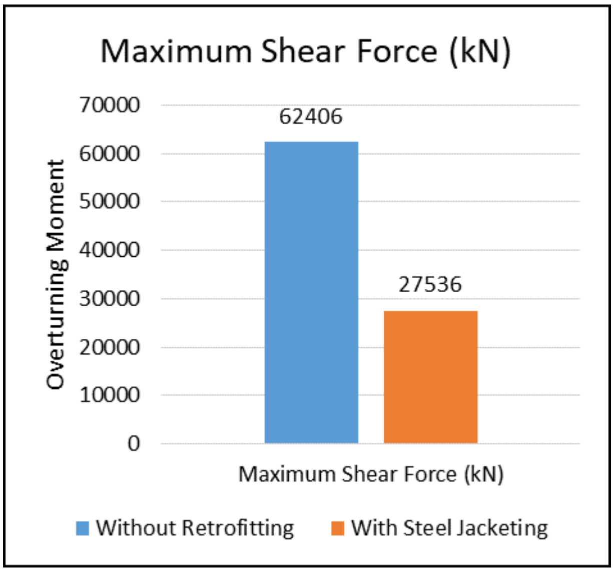

Fig 9:- Comparison of maximum Shear Force

5. Axial Force:-

Table 5:- Maximum Axial Force

Type of Structure	Without Retrofitting	With Steel Jacketing
Maximum Axial force (kN)	68627	38335

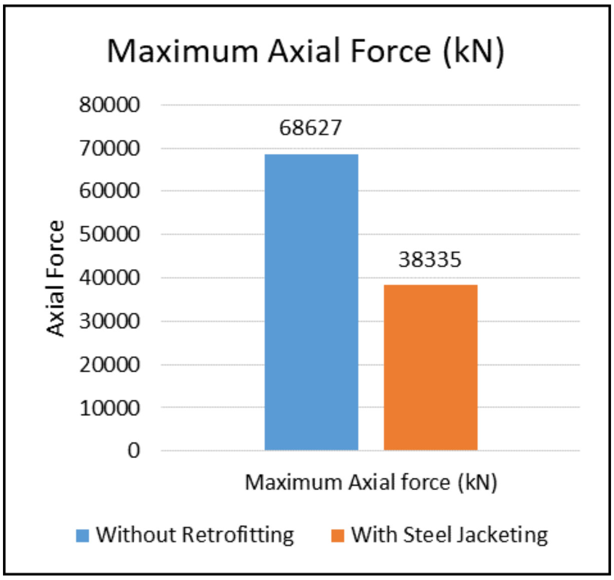

Fig 10:- Comparison of Maximum Axial Force

6. Seismic Force:-

Table 5:- Maximum Seismic Force

Type of Structure	**Without Retrofitting**	**With Steel Jacketing**
Maximum Seismic Force	5747.76	6005

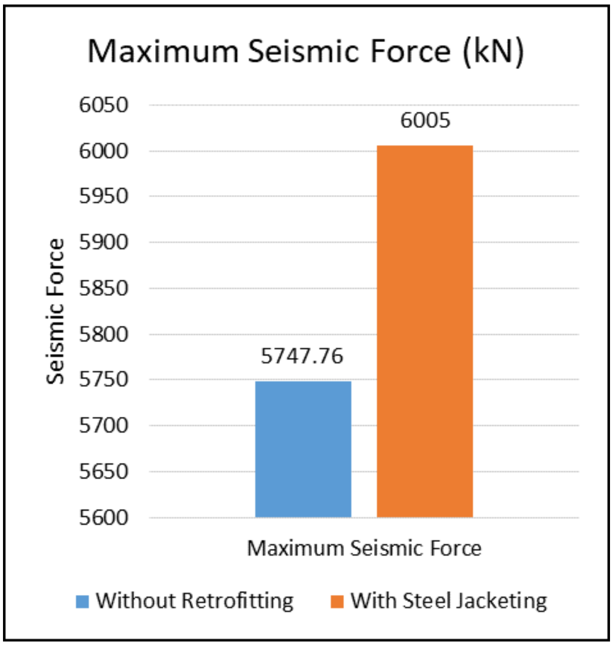

Fig 11:- Comparison of Maximum Seismic Force

CONCLUSION

From the Analysis of the Bridge for Seismic loading following conclusion will has been made.

1. The Maximum displacement for the non-retrofitted bridge was much greater and above permissible range while for the retrofitted bridge has the displacement which is under the permissible limit of 250mm. More than 85% reduction in retrofitting

2. The Base reaction of retrofitted bridge is comparatively more than the non-retrofitted bridge because of the addition of applied steel jackets which increase the self weight of the structure. 10% increase in retrofitting weight

3. The Maximum overturning moment gets decreases when we applied the retrofitting which gives proper strength to the base of the bridge. 50% reduction in retrofitted bridge

4. Shear force and bending moment are directly proportional to steel reinforcement required in the members.

5. The maximum time period for the both the structure are same but differ in x and z direction because of the change in length and width of the bridge.

6. The seismic force is DL+0.5LL + Ah (seismic load formula).

7. Overall the provided retrofitting gave a proper strength and reduction in the forces to bring under permissible parameters which increased the strength by over 75% as compared to non retrofitted structure.

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