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BEHAVIORAL STUDY OF INTEGRAL BRIDGES WITH SINGLE PIER SUPPORT AND PORTAL FRAME

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ABSTRACT

The rapid development of modern infrastructure necessitates innovative and efficient engineering solutions. One such solution is the adoption of integral bridges, which are designed without expansion joints or bearings, forming a continuous and monolithic structure. This project report delves into the comparative behavioral study of integral bridges with single pier support versus portal frame support. By analyzing critical parameters such as bending moment, steel percentage, creep and shrinkage, and shear force, this study aims to provide comprehensive insights into the structural performance and advantages of each support system. The findings will contribute to optimizing bridge design and construction practices, ensuring enhanced durability, reduced maintenance, and overall cost-effectiveness in bridge engineering.

Keywords: Bridge, Single Pier Support, Portal Frame Support, MiDAS, Analysis, Sustainable Infrastructure.

INTRODUCTION

The aim of this project is to conduct a comprehensive behavioral study of integral bridges utilizing two different support systems: single pier and portal frame. By analyzing key structural parameters such as bending moment, steel percentage, creep and shrinkage, and shear force, this project seeks to provide a deeper understanding of the performance and advantages of each support type. Through detailed finite element analysis using MiDAS software, the goal is to determine the most effective support configuration for enhancing the strength, durability, and cost-efficiency of integral bridges. Ultimately, the findings from this study will contribute valuable insights for optimizing bridge design and construction practices in modern infrastructure projects.

SIGNIFICANCE

The study on integral bridges with single pier and portal frame supports is significant for multiple reasons. Integral bridges, designed without expansion joints, offer enhanced durability and require less maintenance compared to conventional bridges. This research provides crucial insights into the structural behavior of integral bridges, particularly in the Indian context, where infrastructure must withstand diverse environmental conditions and dynamic loads. By utilizing MiDAS software for detailed finite element analysis, the study evaluates key parameters like bending moment, steel percentage, creep and shrinkage, and shear force. The findings highlight the long-term cost benefits and improved seismic performance of integral bridges, promoting their adoption in future projects. This study also addresses existing research gaps, offering valuable design recommendations that align with both global and Indian standards. Ultimately, the research contributes to the development of more resilient, cost-effective, and sustainable infrastructure, ensuring safety and longevity in bridge construction. This knowledge is essential for engineers, policymakers, and stakeholders involved in the infrastructure industry, guiding them toward more effective bridge design and construction practices.

OBJECTIVE

- **To Conduct Finite Element Analysis:** Use MiDAS software to model and analyze the structural behavior of integral bridges with single pier support and portal frame support.
- **To Evaluate Structural Parameters:** Assess key parameters such as bending moment, steel percentage, creep and shrinkage, and shear force for both support types.
- **To Compare Performance:** Determine the differences in load distribution, stability, and overall structural integrity between the single pier and portal frame supports.

- **To Provide Design Recommendations:** Develop insights and recommendations for optimizing the design of integral bridges based on the comparative analysis of the two support systems.

MODELING

General

This chapter briefly describes the various assumptions and considerations used in this project work. The following are the various considerations used in this work.

1. **Bridge Specifications**:

i. Total Length: 120 meters (4 spans of 30 meters each)

ii. Deck Type: Reinforced concrete deck

iii. Support Systems: Single pier support and portal frame support

iv. Location: Urban area with moderate traffic loads

2. **Design Standards**:

i. IS 456: 2000 for reinforced concrete design

ii. IRC 112: 2011 for concrete road bridges

iii. IS 1893 (Part 1): 2016 for seismic considerations

iv. IS 875 and IRC 6: 2017 for load cases

3. **Key Parameters Analyzed**:

i. Bending Moment

ii. Steel Percentage

iii. Creep and Shrinkage

iv. Shear Force

4. **Methodology**:

i. Modeling and analysis using MiDAS software

ii. Finite Element Analysis (FEA) to simulate load conditions and evaluate structural integrity

5. **Load Cases Considered**:

i. Dead Load: Self-weight of the bridge structure

ii. Live Load: Variable loads such as traffic and pedestrians

iii. Seismic Load: Dynamic loads induced by seismic activities

iv. Other Loads: Wind load, temperature effects, and other relevant load cases

6. **Expected Outcomes**:

i. Detailed comparison of load distribution and stability for both support systems

ii. Evaluation of long-term durability and cost-effectiveness

iii. Recommendations for optimal support configurations in integral bridge design

Bridge Specifications

An integral bridge is a continuous, monolithic structure designed without expansion joints or bearings, spanning a total length of 120 meters divided into four spans of 30 meters each. Constructed with a reinforced concrete deck, this type of bridge is noted for its enhanced durability and reduced maintenance requirements. The support syste ms employed include single pier supports, which provide a straightforward load transfer, and portal frame support s, which offer improved load distribution and stability. Located in an urban area with moderate traffic loads, the in tegral bridge is designed to efficiently handle dynamic forces while ensuring long-term structural integrity and cost-effectiveness.

TEST METHODS / MODELLING

For this study, Midas software will be used for modeling of the bridges and analyzing the behavior of the bridges and response to various loading conditions. The study focusses on the effect of loading on support. The loading for both the cases will be identical and response on the supports will be monitored and compared for analysis.

ANALYSIS

The model was subjected to a range of maximum and various loading combinations and stresses to evaluate its performance under different conditions. These included long-term deformation under Creep Secondary and Shrinkage Secondary, which account for material changes over time. The analysis also included Braking forces, which simulate the dynamic impact of vehicles, and critical moments such as Mvmax: SV (My) and CBCmax: ULS (My), which assess the bridge's capacity to handle bending stresses.

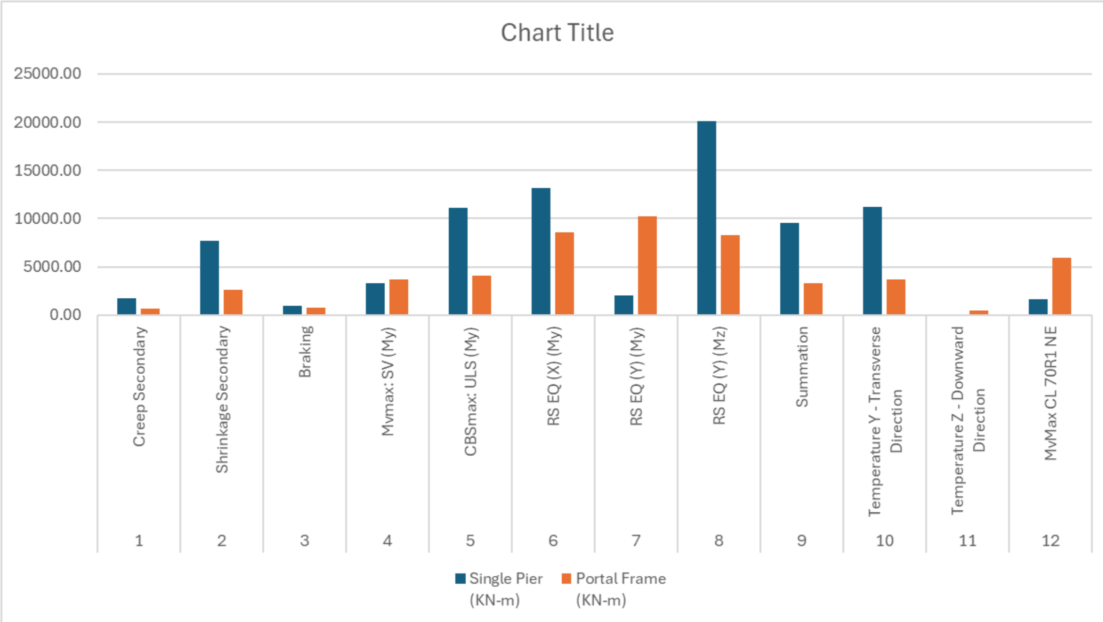
Moreover, the bridge's response to seismic activities was thoroughly analyzed by applying seismic responses such as RS EQ (X) (My), RS EQ (Y) (My), and RS EQ (Y) (Mz), reflecting potential earthquakes in different directions and their associated twisting moments. The Summation stress factor provided an aggregated view of these multiple loading conditions. Thermal effects were also evaluated, with Temperature Y representing transverse thermal expansion and contraction, and Temperature Z addressing vertical temperature gradients. Lastly, the model accounted for maximum vehicular loading scenarios like MvMax CL 70R1 NE, which is crucial for understanding the bridge’s ability to withstand heavy traffic loads.

The results from this comprehensive analysis revealed that the bridge's portal frame support system is robust and capable of sustaining the specified loads and stresses.

RESULTS AND OBSERVATIONS

The tabular representation is given below:

Sr No	Description of Loading/ stresses/ Moment	Single Pier (KN-m)	Portal Frame (KN-m)
1	Creep Secondary	1721.24	626.70
2	Shrinkage Secondary	7709.46	2584.77
3	Braking	919.20	737.43
4	Mvmax: SV (My)	3350.96	3704.67
5	CBSmax: ULS (My)	11112.36	4051.59
6	RS EQ (X) (My)	13193.79	8576.73
7	RS EQ (Y) (My)	2050.99	10246.32
8	RS EQ (Y) (Mz)	20076.90	8266.65
9	Summation	9524.47	3336.84
10	Temperature Y - Transverse Direction	11200.39	3704.67
11	Temperature Z - Downward Direction	0.00	471.12
12	MvMax CL 70R1 NE	1607.77	5985.51



CONCLUSION

Based on the detailed comparative analysis of the Single Pier and Portal Frame support systems for the major bridge, we can draw several significant conclusions. The Single Pier generally demonstrates higher stress values in numerous categories, such as Shrinkage Secondary, CBSmax: ULS (My), and RS EQ (Y) (Mz). These elevated values indicate that the Single Pier can withstand substantial loads and stresses, making it a robust support system for scenarios that demand high structural integrity and substantial load-bearing capacity. The Single Pier's ability to handle greater creep secondary moments and high ultimate limit state conditions underscores its strength and durability under extreme conditions.

On the other hand, the Portal Frame shows superior performance in specific categories like RS EQ (Y) (My) and MvMax CL 70R1 NE. This suggests that the Portal Frame is more suitable in situations where lateral seismic responses and maximum vehicular loading are critical. The Portal Frame’s lower summation of moments indicates a more efficient load distribution, reducing overall stress and potentially leading to a more sustainable and cost-effective bridge design. Furthermore, the Portal Frame's ability to handle transverse and vertical temperature stresses more effectively enhances its suitability for diverse environmental conditions.

Overall, while the Single Pier support system excels in high-load applications, providing exceptional strength and resilience, the Portal Frame offers a balanced approach. It combines adequate load-bearing capacity with efficient stress distribution, making it a viable option for sustainable and economical bridge construction. This detailed comparison highlights that the choice between Single Pier and Portal Frame supports should be based on specific project requirements, considering factors such as load conditions, environmental impacts, and long-term sustainability.

FUTURE SCOPE OF WORK

Future research and development in bridge engineering can focus on optimizing the use of advanced materials, such as high-performance concrete and composite materials, to enhance the durability and load-bearing capacity of bridge structures. Additionally, integrating smart monitoring systems for real-time assessment of structural health could significantly improve maintenance strategies and extend the lifespan of bridges. Investigating the impact of climate change on bridge performance and developing adaptive design methodologies to mitigate potential risks will also be crucial. Furthermore, exploring innovative construction techniques and design automation tools can lead to more efficient and cost-effective bridge construction practices.

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