International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design and Analysis of PSC Girder ROB with Technical Alteration at Level crossing -50 Bhind Etawa Section

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1. INTRODUCTION

In the realm of transportation infrastructure, Road Overbridges (ROBs) represent a pivotal solution to the challenge of safely navigating vehicular traffic over obstacles such as railway lines, other roads, or water bodies without disrupting the flow. The history of Road Overbridges (ROBs) can be traced back to the Industrial Revolution when the rapid expansion of railways necessitated solutions to safely accommodate increasing road and rail traffic without interruptions. Here's an overview of the historical development of ROBs: -

*Early Railway Crossings

In the early 19th century, as railway networks expanded, crossings between roads and railways were initially at-grade, meaning roads and railways intersected on the same level. This setup often led to accidents, delays, and congestion as both road and rail traffic increased.

* Advancements in Engineering- The development of pre-stressed concrete days back to the mid-20th century. The introduction of high-strength steel and improvements in concrete technology have allowed for the widespread adoption of PSC girders in bridge construction. To provide a comprehensive guide on the design and analysis of PSC girders, ensuring they meet structural and serviceability requirements while optimizing for cost and performance.

*Modern Challenges and Future Directions- Today, the focus is on retrofitting existing infrastructure, incorporating smart technologies for traffic management and maintenance, and addressing environmental concerns related to construction and operation. Future ROB developments are likely to prioritize, sustainability, and inclusivity in urban environments. The implementation of ROBs plays a crucial role in enhancing urban mobility, ensuring smoother traffic flow, and improving overall safety.

Road Over bridges stand out as vital structures designed to facilitate the seamless movement of road traffic over obstacles such as railways, highways, or water bodies. Unlike level crossings, which pose safety risks and disrupt traffic flow, ROBs provide a crucial link by elevating roads above potential hazards, thereby enhancing safety, reducing congestion, and improving overall transportation efficiency. The construction and design of ROBs involve intricate engineering principles, including structural integrity, load-bearing capacities, and adherence to safety standards. These structures not only support the weight of vehicles but also withstand environmental factors such as weather conditions and seismic activity.

to urban planning strategies by integrating seamlessly into the built environment, fostering sustainable development, and promoting accessibility for pedestrians and cyclists. Beyond their engineering aspects, ROBs have broader implications for socio-economic development. They facilitate smoother logistics and transportation networks, supporting industries reliant on efficient movement of goods and services.

The implementation of ROBs requires meticulous engineering considerations, encompassing aspects such as structural integrity, load-bearing capacities, and environmental resilience. Engineers must address various challenges, including the integration of ROBs into existing

urban landscapes, ensuring accessibility for pedestrians and cyclists, and minimizing environmental impacts during construction and operation.

The durability and longevity of ROBs are crucial factors, ensuring they withstand the rigours of daily traffic and external forces.

They facilitate smoother transportation networks, enhancing connectivity between regions and supporting economic activities reliant on efficient logistics. ROBs also play a pivotal role in urban planning by optimizing land use, reducing land acquisition costs, and promoting sustainable development practices.

The evolution of ROBs can be traced back to the Industrial Revolution, a period marked by rapid advancements in transportation technologies and urbanization.

integral to urban planning strategies worldwide, accommodating diverse traffic flows and enhancing connectivity between regions. They not only alleviate congestion but also improve safety by minimizing the risk of collisions between vehicles and trains.

Thus, in view of the importance of PSC Girders in ROBs with our knowledge about different aspects of PSC Girders, present study were carried out with the following objective's: -

1. To study about the key milestone of PSC girders will be reviewed.
2. To study about the multifaceted aspects of ROBs.
3. To study about the various engineering designs, structural, environmental and economic benefits.

2. REVIEW OF LITERATURE

For achieving the goal of objectives taken in proposed in thesis work entitled "Design and analysis of PSC ROB with technical alteration at LC- 50 in Bhind Etawa section", a systematic scientific literature scanning has been initiated on common interest prior to start of analysis through consulting, reading, gathering and procuring from gateway of scientific avenue viz. thesis, scientific journal, monograph, books, internet from library extensive study all collected documents were arranged according to the heading and sub-heading related work and results obtained from materials, methods and results as per the year wise.

Review of literature of present work is categorized in the following headings:

Nilson (1987) provides a comprehensive analysis of the mechanics of PSC girders, emphasizing the role of pre-stressing in improving tensile strength and load distribution. The use of high-strength concrete and steel tendons has been a critical factor in achieving these performance characteristics.

Burdette and Goodpasture (1975) conducted experimental investigations on PSC girders, demonstrating their enhanced durability and fatigue resistance compared to traditional reinforced concrete girders. These studies underscore the importance of material properties in the design and performance of PSC girders.

Nawy (2009) discusses the fundamental principles of PSC girder design, including the use of limit state design and serviceability criteria. The author highlights the importance of considering both ultimate and serviceability limit states to ensure the safety and functionality of the structure.

Lin and Burns (1981) introduced the concept of iterative design procedures, where the pre-stressing force is optimized through a series of iterations to achieve the desired performance. This approach has been widely adopted in modern design practices, allowing for more efficient and precise design of PSC girders.

Technical alterations in the design and construction of PSC girders have been a key area research, focusing on improving performance and reducing costs.

Wollmann et al. (1999) explored the use of partially prestressed concrete, where only a portion of the steel tendons is pre-stressed. This approach aims to balance cost and performance, providing adequate strength while minimizing material usage.

Tan and Ng (1997) investigated the application of externally bonded reinforcement (EBR) using fiber-reinforced polymers (FRP) to enhance the load-carrying capacity of existing PSC girders. Their research demonstrated significant improvements in flexural strength and ductility, highlighting the potential of FRP as a retrofit solution.

Mutsuyoshi et al. (1998) examined the use of high-performance concrete (HPC) and ultra-high-performance concrete (UHPC) in PSC girders. These advanced materials offer superior mechanical properties, such as increased compressive strength and reduced permeability, which enhance the durability and longevity of PSC girders.

Numerous case studies have documented the successful application of PSC girders in bridge construction, providing valuable insights into design practices and challenges. **Leonhardt and Walther (1966)** presented a seminal case study on the construction of the Köln-Mülheim Bridge in Germany, showcasing the advantages of PSC girders in long-span bridge applications.

Balaguru and Shah (1992) detailed the design and construction of the Sunshine Skyway Bridge in Florida, emphasizing the use of continuous PSC girders to achieve large spans and improve structural continuity. These case studies highlight the versatility and effectiveness of PSC girders in various bridge configurations.

The literature indicates a growing interest in the development of sustainable and resilient PSC girder designs. **Marsh (2010)** discusses the potential of using recycled materials and environmentally friendly practices in the production of PSC girders. The author also explores the integration of smart technologies, such as embedded sensors, to monitor the structural health of PSC girders in real time.

3. DESIGN DATA

BRIDGE LEVEL DETAILS

Finished Road Level (FRL) = 102.819 m

Bed Level at Abutment A1 Location = 98.960 m

Bed Level at Abutment A2 Location = 98.960 m

Foundation Level for Abutment A1 = 95.960 m

Foundation Level for Abutment A2 = 95.960 m

Foundation Level for Design = 95.960 m

BEARING CAPACITY OF SOIL

Allowable Bearing Pressure of Soil = **20.000** t/m^2

(as per Geotechnical Report)

Allowable Bearing Pressure for seismic Condition = 25 t/m^2

Cl. 706.1.2, IRC: 78-2014

SUPERSTRUCTURE DETAILS

Span (C/C of Expansion Joint) = 24 m

Distance b/w center of bearing to center of expansion = 0.04 m

Type of Superstructure = CC Precast Girder

Overall Width of Deck = 8.4 m

Carriageway Width = 7.5 m

Thickness of Deck Slab = 0.22 m

Main Girder

Depth of main girder including deck slab = 1.695 m

No. of main girders = 3 Nos.

Spacing between girders = 2.650 m

Length of cantilever slab = 1.550 m

Length of flaring section in main girder = 1.500 m

Length of widened section in main girder upto center of bearing =

Length of widened section in main girder from center of bearing to edge Web2.250 m m
thickness of main girder at mid section

=

0.375

=

0.275 m

Web thickness of main girder at support section = 0.650 m

Size of top bulb width = 0.900 m

depth = 0.150 m

Size of top haunch width = 0.313 m

depth = 0.100 m

Size of bottom haunch width = 0.188 m

depth = 0.150 m

Size of bottom bulb width = 0.650 m

depth = 0.250 m

Cross Girder

(DISTRIBUTION COEFFICIENT CONTD.) (a) **DISTRIBUTION COEFF. FOR CLASS ' Ax2' :-**

G1 = 0.638 (AT - 3b/4) **G2** = 0.879 (AT - b/4)
G3 = 1.117 (AT + b/4)

(b) **DISTRIBUTIO N COEFF. FOR CLASS ' AA ' :-**

G1 = 0.239 (AT - 3b/4) **G2** = 0.744 (AT - b/4)
G3 = 1.246 (AT + b/4)

(c) **DISTRIBUTIO N COEFF. FOR CLASS ' 70R ' :-**

G1 = 0.326 (AT - 3b/4) **G2** = 0.775 (AT - b/4)
G3 = 1.218 (AT + b/4)

APPLYING 10% INCREASE IN THE COEFFICIENTS

			OUTER	**INNER**	**Ratio**
DESIGN DIST. COEFF.	**FOR CLASS ' A'**	=	**1.490**	**1.229**	1.21
DESIGN DIST. COEFF.	**FOR CLASS ' AA'**	=	**1.933**	**1.371**	1.41
DESIGN DIST. COEFF.	**FOR CLASS ' 70R'**	=	**1.835**	**1.340**	1.37

4. RESULTS & DISCUSSIONS

The results of the present Design analysis “PSC girders ROB at LC-50” have been presented in this Chapter 4 under the appropriate heads and subheads. It constitutes that the size of PSC girders has been reduced i.e. 1.4m and it was usually used by 2 to 2.5m in this type of soil strata and secondly it can observed that there is no variation in vehicle loading.

LOAD CALCULATIONS

1.0 The intermediate diaphragm is supported on the PSC Girders

1.1

Self Weight

Thickness Of Int Diaphragm = 350 mm
Depth Of Intermediate Diaphragm = 1370 mm
UDL on the Diaphragm = 0.35 x 1.37 x 2.5 = 1.2 t/m

1.2

Deck Slab

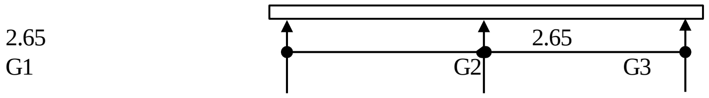
Thickness Of slab = 220 mm
c/c of girder = 2650 mm
Effective Width Of Load from Deck slab On Diaphragm = 2650.0 mm
= 0.22 x 2.65 x 2.5 = 1.5 t/m

Wearing Coat

Thickness Of Wearing Coat = 75 mm
Effective Width Of Load from Deck slab On Diaphragm = 3000.0 mm
= 0.075 x 3 x 2.5 = 0.6 t/m

1.3 Live Load Ref. LL Staad Grillage Analysis

Class 70R Wheeled Class A x 1 Wheeled Class A x 2 Wheeled Class 70R Tracked



Bending Moment & Shear Force

Particulars		Bending Moment (t-m)		Shear Force (t)
		At Support	Mid Span	
Total Self Weight & SIDL		40.91	**0**	12.53
Vehicular LL				
Case I	CLASS 70-R 1-LANE	**8.75**	**1.2**	7.52
Case II	CLASS A x 2	**12.03**	**0**	10.6
Max Design LL Moment		**12.03**	**1.20**	**14.08**
Impact Factor		1.1552	1.1552	1.16
Max Design (LL With Impact)		**13.90**	**1.39**	16.26
Total		**54.81**	**1.39**	**33.86**

6. CONCLUSION

The conclusion of this thesis on the basis of above calculation's encapsulates the comprehensive investigation into the design and analysis of Pre-stressed Concrete (PSC) girders for Road Over Bridges (ROBs), highlighting key findings and recommendations for future applications.

he study reaffirms the viability of PSC girders as a robust and efficient solution for road over bridges. The combination of high structural performance, durability, and cost-effectiveness makes PSC girders an attractive option for modern infrastructure projects. By adopting the recommendations outlined in this thesis, engineers and designers can further enhance the implementation of PSC girder technology, contributing to safer and more sustainable bridge construction. In conclusion, PSC girders offer a promising approach to addressing the growing demands of urban transportation infrastructure. Their application in ROB projects not only improves traffic flow and safety but also provides long-term economic and environmental benefits. This thesis serves as a valuable resource for practitioners and researchers alike, paving the way for future advancements in the field of bridge engineering.

Engineers and designers should focus on optimizing the design parameters of PSC girders to achieve the best balance between performance and cost. This involves using advanced computational tools and simulation techniques to refine the designs based on specific project requirements. Consideration of site-specific conditions, such as soil characteristics and environmental factors, is crucial for optimizing the design and ensuring the long-term performance of the bridge.

Strict quality control measures should be implemented during the manufacturing and construction phases. This includes ensuring proper curing of concrete, accurate placement of pre-stressing tendons, and adherence to design specifications. Adopting best practices in construction and using high-quality.