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DESIGN, ANALYSIS AND ESTIMATION OF FOOT BRIDGE ON NH-27 TIWARIGANJ

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Abstract : This paper focuses on the design of a foot bridge, considering various structural analysis methods, suitable materials, and construction considerations. The research aims to develop a safe, efficient, and aesthetically pleasing foot bridge that can accommodate pedestrian traffic. Through comprehensive analysis, material selection, and construction planning, this project aims to provide a practical and reliable design solution for a foot bridge. This study evaluated two different approaches for designing a footbridge: manual design and STAAD PRO analysis. Both methods predicted the dynamic response of the footbridge to human-induced loads. In today's construction industry, technology is advancing rapidly, requiring a thorough understanding of footbridge construction and design, including the structural components of footbridges, loadings, columns, beams, etc. It is essential to estimate accurately when designing and analyzing footbridges to optimize the design and save resources and money. While angle sections were used in truss construction for footbridges in the past, tubular sections are now more preferred due to their economic advantages. Wind loads on footbridges are generally low due to their open structure, but high-intensity winds and earthquakes can cause tower failure. Thus, wind loads and seismic loads require a high factor of safety.

IndexTerms **- Design, Foot Bridge, Materials, Construction, Pedestrian Traffic, Loadings, Columns, Beams**

INTRODUCTION

A footbridge is a type of structure designed for pedestrians and sometimes cyclists to cross over areas where there is no vehicle traffic, such as water or railways. Footbridges can enhance the aesthetic of an area by connecting two distinct zones or signaling a transition. In rural areas with limited access to medical facilities, schools, and markets, footbridges may serve as the only means of crossing rivers when water levels are too high. Suspension bridges are a simple design commonly used to span across roads, enabling pedestrians to cross safely without disrupting traffic flow. This type of pedestrian overpass is frequently located near schools to prevent children from running into oncoming vehicles.

Klinth disparate sections of the terrain are united by an innovative and difficult footbridge thanks to the promise of extensive beam generation. Creating footbridges that meet the aesthetic standards of being elongated, lightweight, and slim can be challenging. This endeavor entails developing and analyzing a pedestrian steel footbridge. The design process entails estimating load capacity while accounting for a variety of practical circumstances using a safety factor. The Limits State Method was implemented in this project, which relied on standards such as IS 456-2000, IS 800-2007, and sp-16.

AIM AND OBJECTIVE

The research aims is to develop a safe, efficient, and aesthetically pleasing foot bridge that can accommodate pedestrian traffic.

LITERATURE REVIEW

This part discusses The current knowledge and techniques concerning the performance of pedestrian bridges are obtained from diverse sources, including published papers, textbooks, and conferences. The literature review provides insights into the behavior of foot over bridges.

Chandrikka and colleagues (2019) conducted a study to evaluate the effectiveness of analyzing and the objective of this project is to design foot over bridges using cold-formed steel at Kondalampaaty bye-pass in Salem.. The primary objective of their research was to create a foot over bridge that is safe, cost-effective, and easy to assemble for pedestrians. The study utilized STAAD Pro software to analyze cold-formed steel box sections with a thickness of 2-3mm and a yield strength of 280 $N/mm2$. Due to its low cost and simplicity, the construction of the foot over bridge utilized cold-formed steel box section. The design process for the box-section columns and beams was carried out through manual methods using EUROCODES EN 1993. The study results indicated that using cold-formed box sections reduced the structure's dead weight while also improving its strength and durability.

M. Limje et al. (2019) conducted a thorough assessment and development of a foot over bridge to facilitate high-volume traffic between the Surat railway station and Surat bus station. The primary objective was to design a pedestrian and cyclist-friendly foot over bridge with the capacity to handle significant hourly traffic. STAAD Pro was utilized to analyze and design the bridge. The dimensions of the foot over bridge are 171m long, 12m high, and 4m wide. IS 800:2007 was employed to achieve cost-effective sections. In addition, the study considered potential future modifications and loading conditions when designing the foot over bridge.

The study conducted by **R. Wakte et al. (2019)** aimed to compare the seismic analysis of steel footbridges for human resource safetyDue to its strength, durability, and high ductility, steel is a commonly used material for constructing footbridges worldwide. This paper conducted an analysis that considered various load cases including Dead Load, Live Load, and Earthquake Load. The study utilized Load Case-I and Load Cases II and III to analyze Dead Load and Live Load, respectively, and included Earthquake Load. The footbridge was located in Zone IV, and IS 1893-2002 and IS 800-2007 were used as references. The analysis employed the seismic coefficient method and response spectrum method to comprehensively compare the results of static and dynamic analysis. The study findings suggest that the dynamic method is both stable and economical, while the static method is safer but not as cost-effective.

The focus of **S. Rajesh's (2017)** study was on creating a steel foot over bridge for the Chennai railway station. The foot over bridge, which is 28m long and 3m wide for the gangway, spans over three tracks in accordance with the Indian railway code. The study utilized STAAD Pro structural software to analyze the various elements of the foot over bridge, including the main truss, columns, and footings. The investigation evaluated the economy of steel material compared to reinforced concrete structures. The design of the foot over bridge adhered to IS 800:2007 for components such as columns, bracing, top cord, and bottom cord members, while IS 456:2000 was employed for footing design. The primary objective of the study was to design a lightweight, safe, and cost-effective foot over bridge with maximum strength. The authors concluded that the foot over bridge components were engineered for optimal safety using economic sections.

Kulkarni et al. (2015) conducted a study on enhancing the strength and durability of foot over bridges through the use of high-quality materials. Over the past thirty years, various types of such materials have been introduced to the market, and research has shown that they can greatly improve the strength of bridges. The objective of this research is to create a bridge structure that is economical and made from top-notch materials that do not compromise the structural properties of the bridge. The study focused on steel foot over bridges and cable foot over bridges for the case study. The STADD pro software was employed to analyze both types of bridges, and design loads were based on the IS 800:2007 code. The findings showed that both bridges can safely support all loads conditions. However, after comparing the designs and drawings, it was observed that the cable foot over bridge is more cost-effective and resilient than the steel foot over bridge.

In **2016, V. A. Saluja et al.** conducted a study on foot over bridges and their seismic analysis under various soil conditions. The research focused on modeling and analyzing spans of 20m and 30m using STAAD Pro structural software. The main objective of the study was to investigate the effects of seismic activity on foot over bridges under different soil conditions and earthquake zones. The analysis used the response spectrum method to determine the stress, deformations, and forces of various load effects. According to the study, the moment and reactions at nodes increased with varying soil conditions in different earthquake zones.

Renan Constantino, Chris Ripke, James Welch (2014): The high traffic volume of Coliseum Boulevard.The high traffic volume of 50,000 vehicles per day on a major roadway near the IPFW campus creates an obstacle for pedestrians in the south, posing a risk to their safety. To resolve this issue, a team of civil engineering seniors has suggested constructing a pedestrian bridge over Coliseum Boulevard, enabling safe and convenient movement for pedestrians. The proposed bridge model adopts the inventive approaches of the Willis Family Bridge and the Venderly Family Bridge.

S.V.V.Prasad (2015): India had access the reinforced concrete technology from Europe. The utilization of this technology has been employed in constructing bridges. Specifically, this study delves into the design and analysis of a concrete girder bridge using standard design details outlined in IRC standards for the superstructure components including the cantilever slab, interior panel, and longitudinal girder. The design is tailored to support two-lane traffic loading with IRC class-AA and class-A requirements. All the design parameters adhere to IRC standards. Soil and hydrological parameters are considered during the study. The research involves the manual and software-assisted design of a 90m RCC concrete I Girder Bridge. Ultimately, the cost estimates for the entire bridge structure, from the foundation to the superstructure, were computed.

METHODOLOGY

The objective of this project is to create a Foot over Bridge for an access road situated on NH-28 near Tiwariganj at Latitude 26.891306º and Longitude 81.064626º. Following thorough research, it was determined that the bridge will be designed using steel structure. The design process will adhere to all necessary Indian Standard codes such as IS:456-2000, IRC:006-2014, and IRC SP-102. The design calculations will be conducted in compliance with IS:456-2000, applying loads on the foundation along with load combinations for Limit state and Serviceability, and suitable load factors. The load combinations used for the design will comply with the applicable IS standards.

Fig. 1: Suggested Position of Pedestrian Bridge

Fig. 2 Traffic in the Proposed Location of the Footbridge

Design Components of Steel Footbridge

The foot over bridge consists of following units:

Built-up Members E350BR (Fe 490) (f_y=350 MPa) as per IS: 2062.

"Hot Rolled Secondary Members IS: 2062 Gr. A (f_y = 250 MPa)"

Pipe & Square/Rectangular Hollow Sections (f_y = 310 MPa) as per IS: 492

Cold Formed Secondary Members IS:1079 (only purlins and side runners with minimum yield strength of 345 MPa). Cross-Bracing Members/ Rod Bracing w/Turnbuckle IS: 2062 Gr A (f_y = 250 MPa).

"High Strength Bolts for Primary Connections IS: 1367, Grade 8.8"

Machine Bolts for Secondary Connections IS": 1364 Class 4.6. (Part 1 to 3)

Anchor bolts of grade 4.6 and 8.8 will be used.

The STAAD Pro software has been utilized to perform the analysis and design of the steel structure.

DESIGN DATA OF FOOT OVER BRIDGE

Clear span = 21m

Width of carriageway = 25m

Cross girder spaced at centers = 2.1m

Type of truss configuration = N type

Assumptions:

Dead load and live load loads IS 875 part I &II

Wind loading IS 875 part III

Pedestrian loading = 4000 $\frac{N}{m^2}$

Flooring to be made timber planks

Design of planking:

Maximum deflection seen δ $= \frac{5}{384} \times \frac{WL^4}{EI}$

$= \frac{5}{384} \times \frac{4500 \times 2.1^4 \times 10.0}{18 \times 10^6 \times 1 \times 10^6}$

$= 6.33$

Allowable/permissible deflection $= \frac{span}{325}$

$= \frac{2100}{325}$

$= 6.46$mm

Design of cross beams

Clear width of footway = 2.5m

Dead load transmitted from cross beam

$= 696.42 \frac{N}{m}$ or say $700 \frac{N}{m}$

Weight of one truss assumed = 400 $\frac{N}{m}$

Total dead load = 700 + 400

$= 1100 \frac{N}{m}$

Live load on one truss $= \frac{4000 \times 2.5}{2}$

$= 5000\frac{N}{m}$

Maximum tension in the member L_3L_4

diagram × load intensity

= (1/2)×21×2.80×6100

= (1/2)×21×2.5×6100

= 179340/150 = 1195 m^2

= 161406/150 = 1076 m^2

Allowing a stress of 150 N/m, Net area required for this member

$= \frac{162750}{150}$

$= 1085\ m^2$

Weight of two truss including bracing = 1085 × 0.785

$= 851\ \frac{N}{m}$

Weight of one truss including bracing $= \frac{851}{2}$

$= 425.5\ \frac{N}{m}$

Hence, safe.

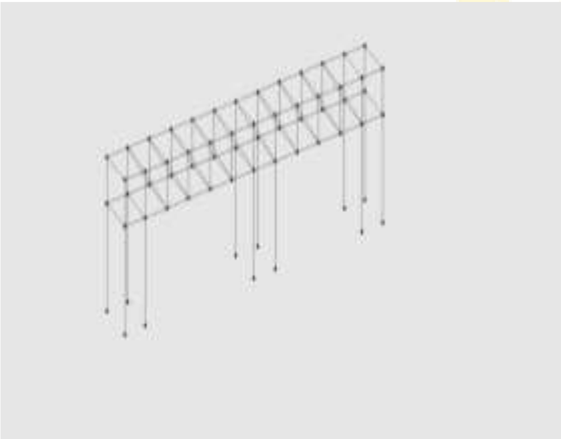

Fig.3: Structure of foot bridge diagram

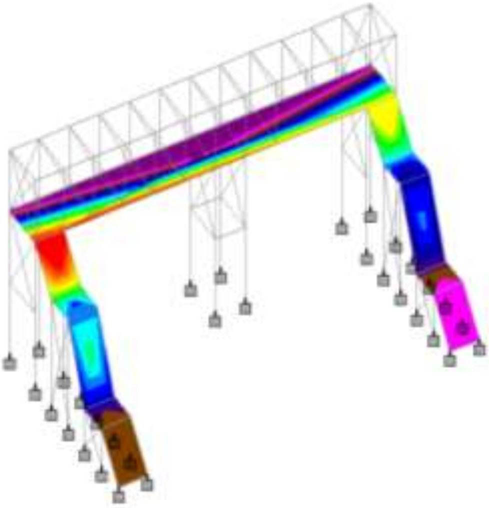

Fig.4: Stress Diagram of the Footbridge

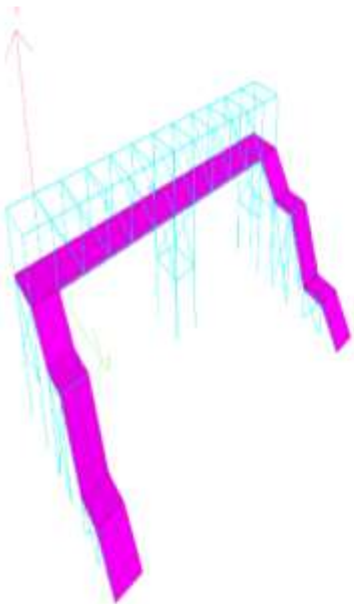

Fig.5: 3D Rendered View of the Footbridge

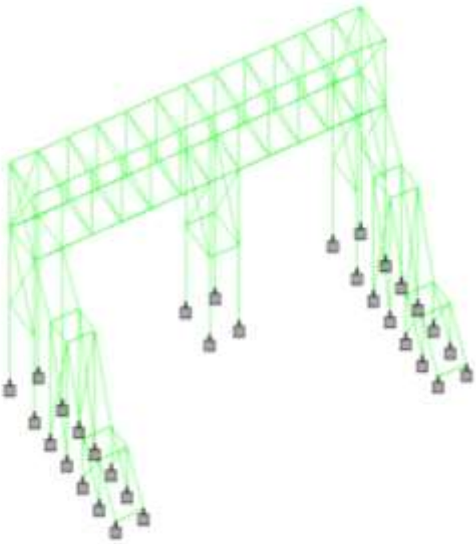

Fig.6: Deflection in the Members of the Footbridge

CONCLUSION

This study evaluated two different approaches for designing a footbridge: manual design and STAAD PRO analysis. Both methods predicted the dynamic response of the footbridge to human-induced loads. In today's construction industry, technology is advancing rapidly, requiring a thorough understanding of footbridge construction and design, including the structural components of footbridges, loadings, columns, beams, etc. It is essential to estimate accurately when designing and analyzing footbridges to optimize the design and save resources and money. While angle sections were used in truss construction for footbridges in the past, tubular sections are now more preferred due to their economic advantages. Wind loads on footbridges are generally low due to their open structure, but high-intensity winds and earthquakes can cause tower failure. Thus, wind loads and seismic loads require a high factor of safety.

FUTURE SCOPE FOR WORK

- Developing advanced models can enable accurate prediction of the dynamic response of footbridges under the load from pedestrians walking on them.
- One approach could be to consider the first vertical bending mode of a simply supported footbridge that is subjected to the load from a uniformly distributed crowd.
- Furthermore, more analysis can be done by including additional modes and studying various types of bridges and crowd distributions.
- To expand the amount of measured data for verification of numerical models, it is necessary to conduct full-scale measurements on operational footbridges and laboratory tests.

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