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Inspection and Strengthening Methodology of N- Type Steel Truss Bridge

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***Abstract*— Steel Foot Bridge is a Significant Infrastructure They Helps in Pedestrian Movements in Industrial Operations They are especially Useful in Factories and Plants Steel Bridges Can Be Affected by The Environment This Can be Compromise Their Safety. This Present Research Paper N- type Truss Bridges Having an Overall Span of 360 m having 12 Span, Each Span 30 m, These Span Have Concrete Foundation. This Bridge Exposed to a River and an Aggressive Environment. Perform a Structural Audit for Assess their Current Condition, In This Assessment Visual Inspection and Design and Construction Drawing Reviewed and Non-Destructive Test Includes Ultrasonic Pulse Velocity, Rebound Hammer, Dye Penetration Test Thickness Gauge and PH Scale and Cover Test Were Performed and identified Sectional Loss and Detoriation of Structure. Thus, Investigation Found Differences in Concrete Quality in Pile Caps and Piles with Areas Showing Weaker Material Some Steel Truss Part Had Slight Thinning and Surfaces Rust but The Welded Were Strong, Using This Inspection a Structural Review Was Done to Check Load Carrying Capacity and Epicenter Problem. Depend On This Context Repair Plan Was Proposed Targeting Corrosion Protection Fixing Damage Concrete and Improve Durability with Protective Statement and And Local Strengthening, Our Aim is To Regain the Strength of a Bridge Which Can Increase the Aging of Steel Foot Bridge. This Study Provides a Clear and Practical Methodology for Strengthening a Bridges.**

***Index Terms*— Structural Audit, N type Truss Bridges Corrosion Assessment, NDT techniques.**

I. INTRODUCTION

Figure 1 N-Type Steel Footbridge

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The N- Type Steel Foot Bridge Built Over an Dandi Creek Was Constructed in 1995 To Support Ash Slurry Pipelines And to Provide a Access to Ash Bund Area of a Thermal Power Plant, The Bridge Consists Several Simply Supported Steel Truss Span Which are Supported on Reinforced Concrete Pier And Abutment Resting on Pile Foundation, Since The Bridge is Located in River Environment And it is Continuously Exposure in Environment and Industrial Condition it Has Been Subjected to Severe Environmental Effect. A Bridge Consist 12 Span of 30 m each and Overall Width Of 2.5 m each Panel, having Overall 12 Panel per Span, The Bridge Carries Cast Basalt Pipe line having a dia of 400mm With Flow rate Velocity Of 700 Cubic meter per hour. The Assessment Was Carried Out Through Detailed Visual Inspection and By Using the Techniques Of NDT. This Inspection Disclose That Localized Loss of Steel Section Due to Corrosion, limited agony in Concrete, Component and Failure of Protective Paint System.

Based on this observation and analysis acceptable repair and strengthening were recommended this included Several damaged member and plate strengthening of affected element weld repairs application of coating resisting system, repair of substructure component and adoption of regular maintenance schedule to improve safety and durability of bridge.

There is a recent incident of foot over bridge failure in India Chauras and Kolkata highlight the need of Inherent inspection enforce with relevant codes and Preventive measures of aging of bridge structures this paper review available studies and current practices related to inspection and strengthening of steel foot bridges and proposes a practical methodology.

II. Literature Review

Most Earlier Studies on Steel Foot Bridges focus design and analysis based on standard codes and software. Thes works compare different types of truss arrangements in terms of member forces deflection and material usage. In general foot bridges are report to be more economical than girder type bridges for medium type of spans. However, such studies mainly address new bridges and provide limited information on the condition and performance of bridges that have been in service in many years with time, steel foot Bridge are affected by environmental exposure, leading to problem such as exposure to problem such as corrosion, damage to protective coating, loss of steel thickness, and detioration of concrete substructure. Visual inspection is usually first step in assessment, but it can identify internal defect or hidden damage. Therefore, non-destructive test methods are required to actual condition of material. For Concrete Components like Pier cap Piles and deck Slab Ultrasonic Pulse velocity is used to detect the internal flaws and Concrete quality, while rebound hammer is used to determine the hardness of the components and half-cell is commonly used to evaluate the corrosion in reinforcement, Carbonation depth and Ph test is used to examine the long term durability of Structure in moist and riverine Conditions Some Studies Combine the test results with Analysis this helps figure out how bridge is still strong, restrengthening a bridge is often Cheaper the replacing it But they are not many Studies restrengthening the N type steel foot bridge.

III. Key Finding from Literature Review

Steel foot bridge with a certain frame design are common for medium distances they are strong because they are good enough to save money most are the bridge are old need to often to kept them safe, Only looking at the bridge isn’t enough it require special test to holding them as strength and safety wise, this test result should be used with calculations, to figure out how to strengthen the bridge using various factors as per the finding it is usually said that instead of replacing or Constructing a new bridge choose repair or restrengthen the bridge.

IV. Gap Identified in Literature

Not Many Studies focuses on specific type of bridge how the test result is fix isn’t always clear and how these results can help in redesign or restrengthening is not always clear what happen if the bridge fix long term survived is rarely studied, there is no any clear and concise inspection rules how to actually fix the bridge is still not well documented.

V. Relevance of Present Study

This Work really tackles Some important gaps in research by diving deep into the case study of an N-type steel foot bridges which located in Dahanu, Mumbai, So What we do ? well we mixing a thing up a bit by using visual inspection and NDT techniques and Structural assessment, along with some practical ideas with strengthening which is all about creating able to do again aging of steel bridge, therefore the findings provide a solid advice for engineer and researcher who are in thick of inspecting, assessing and rehabilating these Structure especially when they're up against tough environmental condition, honestly it is making sure that the bridge is safe and usable for everyone.

TABLE I: SUMMARY OF METHODOLOGIES AND KEY FINDINGS

Author (Year)	Method / Key Findings	Limitations/ Research Gap
Jha et al. (2024)	Structural modelling and optimization of steel foot over bridge using STAAD Pro; evaluated multiple configurations based on weight, cost, and stiffness; identified economical truss-based solutions for urban spans	Study mainly based on static analysis; limited investigation of pedestrian-induced vibrations and long-term fatigue behavior
Dongare, Chougale & Radke (2024)	Comparative study of steel truss and steel girder foot bridges; analysis using IS codes showed truss systems to be more economical for medium spans	Dynamic response and serviceability criteria such as vibration comfort were not considered
Kapse, Dubal & Mahajan (2023)	Review of design and analysis of steel foot over bridges using plated fabricated members; highlighted advantages of steel in terms of weight reduction and constructability	Review-oriented study; lacks experimental validation and detailed numerical comparison of different bridge forms
Gokul & Sundari (2023)	Analysis and design of steel foot over bridge using tubular sections and STAAD Pro; demonstrated efficiency of tubular members in reducing self-weight	Limited to a single structural configuration; no assessment of seismic performance or pedestrian comfort
Birajdar, Maiti, and Singh (2016)	Conducted post-failure forensic assessment and structural analysis of Garudchatti Bridge after the Chauras Bridge collapse. Strengthening measures such as member replacement and stiffness enhancement were shown to restore structural safety	Study is reactive in nature; lacks predictive modeling, structural health monitoring (SHM), and preventive maintenance strategies for steel footbridges.
Chandrikka et al. (2022)	Analysis of cold-formed steel foot over bridge systems; highlighted material efficiency and ease of fabrication	Cold-formed steel behavior under dynamic pedestrian loading not addressed
Dongare et al. (2023)	Review on design practices of foot over bridges in Indian conditions; summarized common modelling approaches and software usage	Heavy reliance on secondary literature and student projects; limited critical evaluation of research outcomes
Patil & Deshmukh (2021)	preferable for rapid construction and longer spans	
Kharade et al. (2021)	Finite element analysis of pedestrian bridge structures focusing on stress and deflection control	Pedestrian-induced vibration and resonance effects not included
Mahajan & Kulkarni (2020)	Design-oriented study of steel pedestrian bridges using IS 800 provisions; emphasized practical detailing and fabrication aspects	Lacks advanced numerical modelling and experimental or field validation

VI. INSPECTION AND METHODOLOGY

The Study follows step by step approach to understand the structural condition of N-type steel foot bridge and how it can be strengthened. The works iniatize with collecting and reviewing the data available design, drawing construction details and maintenance record, this data helps to getting a better understand how the bridge was built in 1995, the span arrangement, the type of foundation, the initial review is very important, because it helping in planning inspection and testing works properly.

To examine the internal condition without causing the damage, non-destructive tests are performed. For concrete components, ultrasonic pulse velocity and rebound hammer are used to check the concrete quality. Carbonation, ph. tests, and cover meter tests are carried out to evaluate the durability and reinforcement condition, for steel member dye penetration test are used to examine welded joints and thickness, these measurements are taken to identify corrosion related loss.

This result are helps in identifying critical areas that require instant attention. Based on this finding Structural evaluation is perform to check the load carrying capacity and safety of key bridge components structural check are carried out as per relevant design and standard under present and expected loading condition to identify weak member.

Finally suitable strengthening and rehabilitation are measured are proposed, this including repairing damaged, concrete protecting steel members from corrosion, and strengthening critical area to restore structural capacity and extend the service life of bridge.

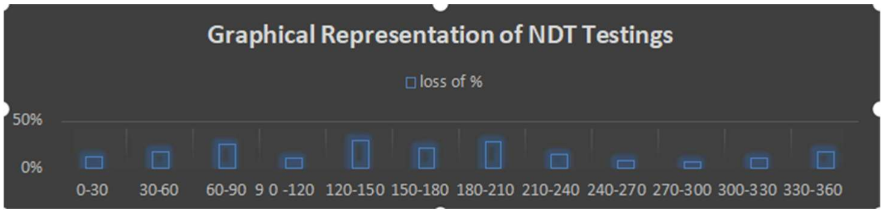

Figure 2 loss of Section in Each Span

VII. COMPARATIVE ANALYSIS

The strengthening strategy is developed by comparing the original assumptions with the present condition of material, the current structural behavior and construction practices used instead of use conventional repair method the focus is applying on targeting strengthening measures, the N-type truss system is found to be Structurally effective in current condition. For an analysis consider a single span having a length of 30m with width and height of 2.5 m, taking an average of loss in section 20-30 %, all load calculation and structural checks are carried out according to IS800.

TABLE II: DATA

Item	Description
Bridge type	N-type steel truss bridge
Span length	30m
Panel length	2.5m
Number of Panels	12
Triss height bridge width	2.5m
Support Condition	Hinged-roller

Fig 3

TABLE: III CALCULATION AND RESULTS

Load Combinations	Support Reactions	Axial Force Results	Section loss Consideration	Section Capacity Calculations	Strength Check
DL+LL = 345kn	Left Hinged = 240 (V) 95 (H)	Top chord = 890KN (C)	Observed Section loss 20-30 %	Original area = 6500mmsq	Axial force Demad = 890kN
DL+LL+ML=480kn	Right Roller= 240(V) 0 (H)	Bottom Chord =820KN (T)	Governing Case = 30% loss	Reduced area = 4550mmsq	Available Capacity = 4550x 250/1.10 = 1034. kN
-----		Vertical member = 340KN (C)	-----	Yield stress 250 Mpa	Utilization ratio = 0.86
-------		Diagonal Member = 480KN (T)	-------	Material factor =1.10	Status = Safe

Loading Calculations

- Dead load
  - Self-weight of steel truss = 2.8 kN/m
  - Deck Slab + Finishes = 3.2 kN/m
  - Hand Rails + Utilities = 0.5 kN/m
  - Total Dead load = 6.5 kN/m Total Dead load= 6.5 x 30 = 195kN
- live load
  - Pedestrian live load = 5.0 kN/m Total Live Load = 5 x 30 = 150kN

- MS Pipe Moving Load
  - Pipe flow Velocity = 700m3/hr.
  - Equivalent load = 4.5 kN/m   Total Moving load = 4.5 x 30 = 135kN

A. Structural Analysis Approaches

We conducted a structural analysis to check how internal forces are distributed, how stable the structure is globally, and if it is serviceable under current loading operation the analytical model, we used accurately how member connected.

TABLE IV: STRUCTURE ANALYSIS APPROACHES

Item	Detailed Description
Structure	N type steel bridge
Geometry Consideration	Panel length 2.5m, truss height 2.5m width 2.5m
Modeling approach	3D Space truss Model with pin Connected member
Support Condition	One end hinged and another end is roller
Load Case considered	Dead load, Pedestrian live load, MS pipe flow load 700m3/hr
Load Combination	DL+ LL and DL+LL+Moving load
Serviceability Check	Mid-Span deflection with in permissible limit.

B. Design Adequacy Assessment

When we looked into design adequacy, we compared the force demands from our analysis with the residual strength we got from field inspection and non-destructive testing. We did spot some minor corrosion-related loss in the steel member; nut thankfully remain section is still adequate.

TABLE V: DESIGN ADEQUACY ASSESSMENT

Aspect	Assessment
Basis of assessment	Comparison of analysis force demand with residual analysis
Condition Data Source	Visual inspection and NDT techniques
Observed Section loss	20-30 %
Strength Check	Remaining effective Cross-Section adequate to resist axial forces
Connection Condition	Welded connection found structurally sound
Deck System	RCC deck and Secondary member Satisfied Condition
Overall Adequacy	Structure remains adequate for existing load

C. Durability Considerations

The Original design took into account strength strength and stability, but now long-term exposure to the environment is what really affect to the performance.

TABLE VI: DURABILITY CONSIDERATION

Aspect	Description
Original Design Focus	Strength, Stability and Serviceability
Environmental Exposure	Coating Degradation
Primary Concern	Progressive material deterioration
Impact on Performance	Reduction in effective cs-section over time
Critical Location	Bottom chord, joints and Splash zones
Durability requirement	Arrest corrosion and prevention loss

D. Design-Based Strengthening Philosophy

When it comes to Strengthening our philosophy is all about preserving what's already there with as little interference as possible.

TABLE VII: DESIGN-BASED STRENGTHENING METHODOLOGY

Aspect	Plan of Action
Strengthening Objective	Restore Durability and long-term serviceability
Design Basis	Considering 20-30 % Section loss
Intervention level	Minimal and non-intrusive
Load Capacity	Maintain existing load carrying capacity
Environmental Resistances	Measure to limit moisture ingress and aggressive exposure
Structural Behavior	Existing load path and truss action preserved

E. Outcome

In the end, the N-Type steel foot bridge is still structurally sound for its current service condition the main issue we are facing is durability degradation that's why our strengthening measures.

TABLE VIII: OUT-COME

Aspect	Results
Structural Safety	Bridge Remain Structurally safe and current loading condition.
Strength Adequacy	Sufficient residual Capacity 20-30% section loss
Strengthening Need	Durability related strengthening recommended
Overall Assessment	Bridge suitable for continued service after protective coating

VIII. CONCLUSION

The study really emphasize how crucial is to systematically strengthen aging of bridge especially the N-type steel truss, after digging through a bunch of inspection data, structural evaluation and ndt testing results it is clear that this pedestrian bridge can suffer from material deterioration, it affects various things like corrosion exposure to environment, and the wear and tear from everyday continuous movement. The analysis show that tiny bit of loss of section in critical truss member or some degradation in concrete can make a big difference how the bridge perform what's more this study illustrate that having a condition based systematic approach that combine visual inspection, ndt evaluation and structural analysis is absolutely the key of keeping these steel footbridges is safe, Its functional and long-lasting run-in harsh environment. it's also Clear that monitoring and maintenance are must, Particular in India where the environmental Challenges and industrial exposure exposure can really speed up the deterioration. To wrap it up the research show that when N type steel foot bridge are assessed and strengthened using structural methodology, they can keep provide safe, dependable and efficient access for pedestrian and utilities for a long time. The findings from the study offer a practical framework that could be applied to similar footbridge across India ultimately leading to better structural integrity.

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