International Journal on Recent and Innovation Trends in Computing and Communication
Volume: 4 Issue: 4
ISSN: 2321-8169
755 - 759

Bridge Structure Optimization by FEA

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Abstract—As of late, there has been a developing pattern towards the development of lightweight footbridges. Because of its diminished mass of such structures, the dynamic powers can bring about bigger amplitudes of the vibration. The expansion of vibration issues in present day footbridges demonstrates that footbridges ought to never again be intended for static loads as it were. Vibrations of footbridges may prompt serviceability issues, as consequences for the solace and enthusiastic responses of people on foot may happen. So this work concentrates on streamlining of steel structure for weight lessening with taking thought of characteristic frequencies utilizing FEA.

Keywords—*Bridge structure, Structural Steel, pedestrian–bridge.*

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I. INTRODUCTION

History of Bridge Development

The history of development of bridge construction is closed linked with the history of human civilization. Nature fashioned the first bridge. Likewise the creepers hanging from tree to tree gave birth to suspension bridges.

Importance of Bridge

Bridges enhance the vitality of the cities and the cultural, social and economic improvement of the areas around them. Great battles have been fought for cities and their bridges. This idea probably passed through a design process (procedure):

1) Analysis of the problem (needs)
2) Conceptual design
3) Embodiment design
4) Detailed design.

Five-step' approach for conceptual design

Themethodology is illustrated in Figure below which presents an overview of the wholeprocess of conceptual design – from need definition to proposal of the best solution.

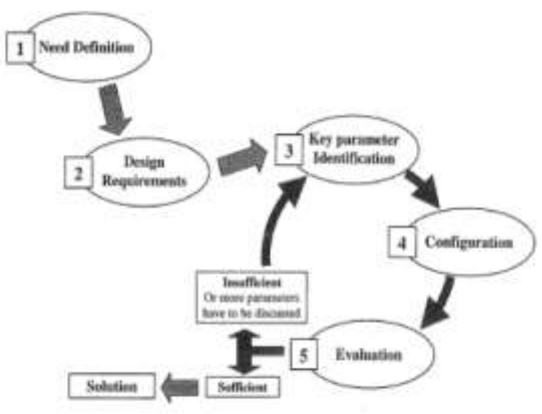

Fig: Five-step methodologies

Types of bridge structures:

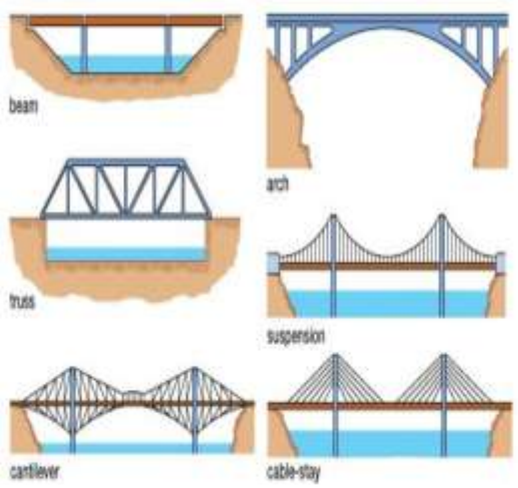

Fig: Bridge structure designs Classification of Bridges

Bridges may be classified in many ways, as follows-

i. According to material of construction of superstructure as timber masonry, steel, reinforced concrete and pre-stress concrete.
ii. According to form or type of superstructure as slab, beam, truss, arch or suspension bridge.
iii. According to inter span relation as simple, continuous or cantilever bridge.
iv. According to position of bridge floor relative to superstructure as a deck, through, half-through or suspension bridge.
v. According to method of connection of different parts of superstructure particularly for steel structure as pin connected, riveted or welded bridge.
vi. According to span length as culvert (less than 8m), minor bridge (8-30m) or long span bridge (more than 30m).

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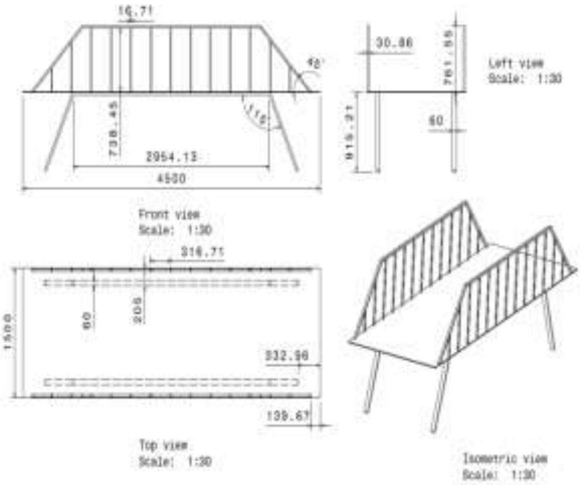
Scope of Work:
Bridge structure (Metal Structure- Foot bridge) used in Company for transport of personals over process line is to be designed and optimized using FEA.

Here new design is desirable which will be of low cost and should satisfy safety criteria's as per the requirement.

The Specifications require are as follows:

Material used is Structural Steel



Objectives (Steps of Work):
Study of Bridge structure and various layouts.
Selection of materials for structure and Design of various Channels that is to be used in Structure.

3D Modelling of the structure using CAD Software.
Analysis and Optimization of the Structure for said loading Conditions.

II. LITERATURE REVIEW

Pedro J.D. et. al. [1] in his work proposed 12m range, made by a deck made by steel fiber fortified self-compacted concrete (SFRSCC) of 40 mm thickness and 2 m wide, and GFRP ""I"" shape profiles. To alter the GFRP profiles to the solid deck, epoxy cement and metallic stays (M10) were utilized.

Rahul et. al. [2] in this work, endeavors has been made to outline and streamline such footbridge. The auxiliary part comprises of a rectangular plate of length 1.5m, 0.5m width and thickness of 3mm altered on the edge of kaleidoscopic bars at the fringe and in the middle. Rectangular empty light emission compound with measurement 60mm × 40mm × 3mm (thickness) was considered for the auxiliary individual from the convenient footbridge after advancement.

Manisha D. Bhise at. al. [3] recorded different sorts of scaffolds and fundamentals, similar to: the extensions are made of timber, stone workmanship, block brick work and strengthened bond concrete, pre-focused on cement and steel. "Code of practice for the outline of substructures and establishments of scaffolds" Indian Railway Standard.

Delong Zuoet. al. [4] presents the attributes of passerby incited vibration of a pre focused on solid bar span watched utilizing full-scale estimation. The impact of the person on foot stacking on the wavering recurrence of the extension, and its suggestion on the system of pedestrian–bridge association, is researched. considerable level of synchronization prompting huge scaffold vibration happens when the extension is stuffed with people on foot.

F.J. Olguin Coca et. al. [5] presents about studies including the weakness and the consumption of extension components. Assessed reports incorporate steel structures and steel-strengthened solid extensions, named exploratory and hypothetical methodologies. Moreover, it was found that a reasonable stacking time-history has not been connected, paying little mind to the methodology chose.

III. BRIDGES AND THEIR TYPES

Highway Bridges
Bridges are an essential part of the transport infrastructure.

General Information:
A bridge is a means by which a road,railway or other service is carried overan obstacle such as a river, valley, and other road or railway line, either with nointermediate support or with only alimited number of support satconvenient locations.

Fig: Docklands Light Rail Bridge, London, England.

Basic features of bridges:
Superstructure
`The superstructure of a scaffold is the part specifically in charge of conveying the street or other administration. Its design is resolved to a great extent by the demeanor of the support of be conveyed. Much of the time, there is a deck structure that conveys the heaps from the individual haggles the heaps to the primary basic components, for example, shafts traversing between the substructure bolsters.

Street spans convey various movement paths, in maybe a couple bearings, and may likewise convey footways. At the edge of the extension, parapets are accommodated the security of vehicles and individuals.

Rail connects regularly convey two tracks, laid on weight, albeit separate superstructures are frequently accommodated every track. They are tight (around 2m wide) and are

ISSN: 2321-8169
755 - 759

generally single traverse structures that infrequently traverse more than 40m.

Substructure:

The substructure of an extension is in charge of supporting the superstructure and bringing the heaps to the ground through establishments. To bolster the superstructure, single traverse extensions require two 'projections', one at every end of the scaffold. Where the bearing quality of the dirt is great, these projections can be entirely little, for instance a strip establishment on a dike.

Different traverse spans require moderate backings, regularly called 'wharfs', to give extra backing to the superstructure. Middle of the road backings are by and large developed of fortified cement.

Forms of steel:

Bridge Construction

Structural steelwork is used in thesuperstructures of bridges from thesmallest to the greatest.

There is a wide variety of structuralforms available to the designer but eachessentially falls into one of four groups:

• Beam bridges
• Arch bridges
• Suspension bridges
• Stayed girder bridges

The fourth group is, in many ways, ahybrid between a suspension bridge anda beam bridge but it does have featuresthat merit separate classification.

The following sections describe therange of forms of steel and composite(steel/concrete) bridge that is in currentuse, explaining the concept, layout andkey design issues for each type.

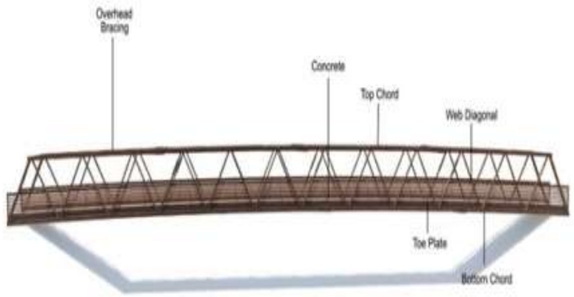


Fig: Sample bridge nomenclature

Beam bridges:

Beam and slab bridges:

A bar and section scaffold is one where a fortified solid deck chunk sits on top of steel I-bars, and acts compositely with them in bowing. There are two central types of this shaft and chunk development – multi-brace development and step deck development.

Multi-girder decks:

In multi-girder construction a number ofsimilarly sized longitudinal plate girdersare arranged at uniform spacing acrossthe width of the bridge, as shown in thetypical cross section in Figure 1 below.The girders and slab effectively form aseries of composite T-beams side-by-side.

Ladder decks:

An alternative arrangement with onlytwo main girders is often used. Thenthe slab is supported on crossbeams atabout 3.5m spacing; the slab spanslongitudinally between crossbeams andthe crossbeams span transverselybetween the two main girders.

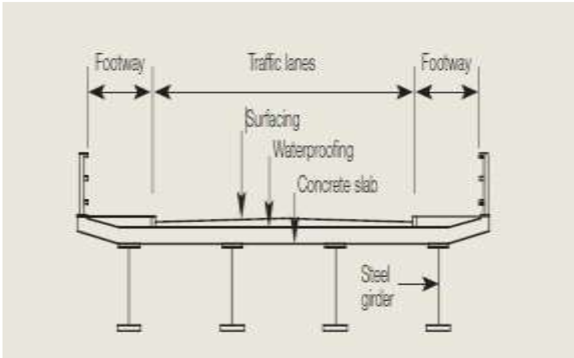


Fig: Cross-section of a typical multi-girder deck bridge

Wider decks can be carriedon a pair of ladder decks.For both deck types, the use of plategirders gives scope to vary the flangeand web sizes to suit the loads carriedat different positions along the bridge.

Half-through plate girder bridges:

In a couple of circumstances, extraordinarily for railroad interfaces, the significance between the trafficked surface (and rails) and the underside of the framework is greatly constrained and there is little significance open for the structure. In these circumstances, 'half through' advancement is used. In this structure there are two rule supports, one either side of the roadway or railroad and the lump is reinforced on crossbeams connected with the internal countenances at the base of the systems. Down the center through advancement using I-shafts, the top spine, which is in weight, must be given sidelong soundness by a few strategies.

Box girder bridges:

Confine braces are impact a specific type of plate support, where two networks are joined top and base by a typical rib. Enclose supports perform essentially twisting, additionally offer great torsional firmness and quality. Box supports are regularly utilized for vast and extensive ranges, once in a while as a link stayed span. In shaft and section spans, box supports are an other option to plate braces when ranges surpass 40-50m. Two structures are utilized:

• Multiple closed steel boxes, with thedeck slab over the top
• An open top trapezoidal box, closedby the deck slab, which is connectedto small flanges on top of each webSpans of 100 to 200m typically useeither a single box or a pair of boxeswith crossbeams.

Truss bridges:

A trussis sometimes referred to as an ‘openweb girder’, because its overallstructural action is still as a memberresisting bending but the open nature ofthe framework results in its elements(‘chords’ in place of flanges and 'posts'and diagonals' in place of webs) beingprimarily in tension or compression.

Fig: Brinnington Rail Bridge, Manchester, England

Arch bridges

Fig: Arch Bridges

In an arch bridge, the principal structuralelements ('ribs') are curved membersthat carry loads principally incompression. Arches are sometimes skew to the lineof the deck and sometimes the archplanes are inclined (inclined arch planeshave been used in many recentfootbridges, for dramatic visual effect).

Suspension bridges:

A suspension scaffold is on a very basic level basic in real life: two links (or ropes or chains) are suspended between two backings ('towers' or 'arches'), hanging in a shallow bend, and a deck is upheld from the two links by a progression of holders along their length. The links and holders are in basic strain and the deck traverses transversely and longitudinally between the holders.

IV. BRIDGE DESIGN AND MATERIALS

Material properties and specifications:

Steel derives its mechanical properties from acombination of chemical composition, mechanicalworking and heat treatment.

For structural use in bridges, steelproducts (plates, hot rolled sections andtubes) are cut to size and welded. In thestructure, the material is subject totensile and compressive forces. Thesteel generally responds in a linearelastic manner, up to a 'yield point', andthereafter has a significant capacity forplastic straining before failure.Mechanicalworking is effectively rolling the steel; themore steel is rolled, the stronger itbecomes, but this is at the expense ofductility. All new structural steel for bridges is'hot-rolled' to one of the followingEuropean standards.

• BS EN 10025-2Non-alloy steels
• BS EN 10025-3 & 4
Fine grain steels
• BS EN 10025-5
Weather resistant steels
• BS EN 10025-6
Quenched and tempered steels
• BS EN 10210
Structural hollow sections:

In these material standards, thedesignation system uses the prefix "S"to denote structural steels, followed by athree digit reference that corresponds tothe specified minimum yield strength (inN/mm2). The most commonlyspecified steel for bridges is gradeS355J2+N to BS EN 10025-2; the "J2"indicates a certain level of toughnessand "+N" indicates the process route(i.e. which combination of heattreatment and rolling are used).

The principal properties of interest to thedesigner are:

• Yield strength
• Ductility
• Toughness
• Weldability

Advantages of steel bridges
- High strength to weight ratio
- High quality prefabrication
- Speed of erection
- Versatility
-Durability
- Modification, demolition and repair

Concluding remarks

Steel is a perfect material for extensions, and is broadly utilized for all types of scaffold development around the globe. Steel is a perfect material for extensions. The numerous favorable circumstances of steel have prompted it being broadly utilized for all types of extension development around the globe, from straightforward pillar spans up to the longest suspension spans. It joins top notch, plant made items (the steel braces) with a cast in-situ strengthened solid deck section, using every component where it is generally monetary. It is fitting for the considerable greater part of ranges, from 13m up to 100m or more.

V. SUMMARY AND FUTURE WORK

SUMMARY

In this part of work following things/basics are studied for further work doing:

Basics of the Transportation bridges along with types and applications.Various Bridge structures/layout.

- Material used for bridges and its properties.
- Various ways of bridge design and problems faced

FUTURE WORK

- Design of bridges - various layouts of structures
- CAD modelling of structure
- FEA modelling and Optimization of Chassis structure based on steel channels based on Static and Modal analysis (Frequency analysis).
- Selection of final structure and propose the final model.

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