Journal of Data Acquisition and Processing
ISSN: 1004-9037
https://sjcjycl.cn/
DOI: 10.5281/zenodo.7764424

ANALYSIS OF STRUCTURE AND DESIGN OF STEEL BRIDGE USING STAAD PRO SOFTWARE.

Aashish Nema, Dr. Rajeev Chandak
Department Structural Engineering (Civil), Jabalpur Engineering College
JEC, Gokalpur, Jabalpur - 482011. M.P.-India

Abstract- Nowadays, several historical steel structures present damage and an advanced deterioration state induced by human or natural actions, causing fluctuations in geometrical, physical, and mechanical properties that dramatically affect their mechanical behavior. Due to the economic, cultural, and heritage value, these constructions must be comprehensively assessed to verify their current condition state. This work presents a holistic methodology aimed at the non-destructive experimental characterization and reliability-based structural assessment of historical steel bridges.

Keywords- Aging steel bridge, Non-destructive, Model updating

I. INTRODUCTION

Bridge, structure that spans horizontally between supports, whose function is to carry vertical loads. The prototypical bridge is quite simple two supports holding up a beam yet the engineering problems that must be overcome even in this simple form are inherent in every bridge, the supports must be strong enough to hold the structure up, and the span between supports must be strong enough to carry the loads.

IMPORTANCE OF BRIDGE CONSTRUCTION

All major bridges are built with the public's money. Therefore, bridge design that best serves the public interest has a threefold goal: to be as efficient, as economical, and as elegant as is safely possible. Efficiency is a scientific principle that puts a value on reducing materials while increasing performance. Economy is a social principle that puts value on reducing the costs of construction and maintenance while retaining efficiency. Finally, elegance is a symbolic or visual principle that puts value on the personal expression of the designer without compromising performance or economy. There is little disagreement over what constitutes efficiency and economy, but the definition of elegance has always been controversial.

Steel bridge are usually manufactured using the following types of materials: concrete, steel and timber, however steel steel bridge are preferred in situations where the bridges have long spans and there is the quick availability of structural steel members. A great amount of technical literature is available on these members. These design approaches have different ways of formulating the factor of safety. Thus, when we implement both of these on the same steel structure, they give different results. Different type of loading is usually applied to steel bridges according to the application and location of the bridges. Commonly used loadings are dead load: the self-weight of the bridge steel members, live load: a load which varies with time such as of pedestrians, snow load: load of snow that accumulates on the bridge (only applicable if snow falls in the location of the bridge), wind load: loading on the bridge due to wind blowing, and earthquake load: loading due to seismic activities in the earth where the bridge is installed.

The live pedestrian loading, wind loading, seismic and snow loading are also called un predictive loadings as these events can happen any time. These design approaches have different loading combinations available [1-5].

II. MATERIALS

The four primary materials used for bridges have been wood, stone, iron, and concrete. Of these, iron has had the greatest effect on modern bridges. From iron, steel is made, and steel is used to make reinforced and prestressed concrete. Modern bridges are almost exclusively built with steel, reinforced concrete, and prestressed concrete [6].

Iron and steel

The first iron used during the Industrial Revolution was cast iron, which is strong in compression but weak in tension. Wrought iron, on the other hand, is as strong in compression as cast iron, but it also has much greater tensile strength. Steel is an even further refinement of iron and is yet stronger, superior to any iron in both tension and compression. Steel can be made to varying strengths, some alloys being five times stronger than others. The engineer refers to these as high-strength steels [7].

III. STEEL BRIDGE

Steel bridge are scaffolding structures used for the transportation of pedestrians, cyclists, and riders of different velocity and assistive devices such as wheelchairs. Steel bridge are not designed for any sort of vehicular activity, and they have numerous applications all around the world. In developed countries, they are used to connect two zones separated by either roads, canals or a body of water between them. In underdeveloped countries, where traffic and over congestion are major problems, they may be used to give access to public buildings such as shops and universities [8-10].

Fig.1. Steel bridge.

Steel bridge are usually manufactured using the following types of materials: concrete, steel and timber, however steel steel bridge are preferred in situations where the bridges have long spans and there is the quick availability of structural steel members. A great amount of technical literature is available on these members.

These design approaches have different ways of formulating the factor of safety. Thus, when we implement both of these on the same steel structure, they give different results. Different type of loading is usually applied to steel bridges according to the application and location of the bridges. Commonly used loadings are dead load: the self-weight of the bridge steel members, live load: a load which varies with time such as of pedestrians, snow load: load of

snow that accumulates on the bridge (only applicable if snow falls in the location of the bridge), wind load: loading on the bridge due to wind blowing, and earthquake load: loading due to seismic activities in the earth where the bridge is installed. The live pedestrian loading, wind loading, seismic and snow loading are also called un predictive loadings as these events can happen any time. These design approaches have different loading combinations available.

STEEL TYPE- MICRO ALLOYED STEEL

The Micro alloyed steel is designed to meet the excellent mechanical properties and good corrosion resistance than conventional carbon steel .This steel is not designed as the normal type alloy steel. The chemical composition of specific HSLA steel may vary for different product thicknesses to meet mechanical property requirements. The HSLA steels are also produced in sheet or plate form with low carbon content up to 0.25% C and having adequate formability and weld ability.

ADVANTAGES OF THE MICRO ALLOYED STEEL

MAS exhibit excellent mechanical properties such as good strength to weight ratio. It did not require heat treatment cycle. It replaces the forged and hot rolled conventional carbon steels. It plays an important role in saving energy (Reduction of heat treatment process) and 25% of weight reduction and cost in automobile industries.

• It acts as bridge for performance and cost between carbon steel and low alloy steel. Good strength to weight ratio than or equal to heat treated carbon steels. Cold worked MA steel does not require cold working to attain the strength of other carbon steels. It also has greater ductility. Since the work material is medium carbon micro alloyed and normalized steel, the cold worked micro alloyed steel resulted in good ductility and strength. The normalizing process of MA steel enhances the hardness and strength.

• Since it has uniform hardness and ferrite-pearlite micro structure, it has good machinability than quenched and tempered steel.

• There is no formation of quenching crack and it does not need stress relieving process.

DISADVANTAGES OF MICRO ALLOYED STEEL

The micro alloyed steel has some disadvantages, which are discussed as follows:

• It does not have good toughness and ductility while compared to quenched and tempered steels.

• It requires more heat during the process in solution like the other alloys. After forming, it needs quick cooling.

• Even the MAS is hard and it does not have softer and tougher core like quenched and tempered steels.

The natural vibration of the bridge is found under constant load, and we know that the vibration characteristics of the suspension bridge are very complex due to the effect of cable arrangement. In bridge selection and initial design stages, the estimated fundamental frequency of the structure is desirable to clarify the effect of the change of bridge parameters on the dynamic characteristics.

IV. FEM

The finite element method (FEM) is a widely used method for numerically solving differential equations arising in engineering and mathematical modeling. Typical problem areas of interest include the traditional fields of structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential.

The FEM is a general numerical method for solving partial differential equations in two or three space variables (i.e., some boundary value problems). To solve a problem, the FEM subdivides a large system into smaller, simpler parts that are called finite elements. This is achieved by a particular space discretization in the space dimensions, which is implemented by the construction of a mesh of the object: the numerical domain for the solution, which has a finite number of points. The finite element method formulation of a boundary value problem finally results in a system of algebraic equations. The method approximates the unknown function over the domain. [1] The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. The FEM then approximates a solution by minimizing an associated error function via the calculus of variations.

MATHEMATICAL MODELLING

In the first step above, the element equations are simple equations that locally approximate the original complex equations to be studied, where the original equations are often partial differential equations (PDE). To explain the approximation in this process, the finite element method is commonly introduced as a special case of Galerkin method. The process, in mathematical language, is to construct an integral of the inner product of the residual and the weight functions and set the integral to zero. In simple terms, it is a procedure that minimizes the error of approximation by fitting trial functions into the PDE. The residual is the error caused by the trial functions, and the weight functions are polynomial approximation functions that project the residual.

V. SOFTWARE USED STAAD.PRO V8I

STAAD. Pro V8i is a comprehensive and integrated finite element analysis and design offering, including a state of the-art user interface, visualization tools, and design codes. It is capable of analyzing any structure exposed to static loading, a dynamic response, wind, earthquake, and moving loads. STAAD. Pro V8i provides FEM analysis and design for any type of project including towers, culverts, plants, bridges, stadiums and marine structures.

STAAD. Pro is a structural analysis and design computer program originally developed by Research Engineers International at Yorba Linda, CA in year 1997. In late 2005, Research Engineers International was bought by Bentley Systems. STAAD. Pro is one of the most widely used structural analysis and design software. It supports several steel, concrete and timber design codes. It can make use of various forms of analysis from the traditional 1st order static analysis, 2nd order p-delta analysis, geometric non linear analysis or a buckling analysis. It can also make use of various forms of dynamic analysis from modal extraction to time history and response spectrum analysis [4].

The availability of computers and specialized analysis and design programs, towers were often designed by graphical methods. It was considered prudent to test new designs that would be used repeatedly on a transmission line, thereby confirming the design assumptions with a full-scale test. Today's analysis tools allow engineers to refine designs to an unprecedented degree, and as a result, many utilities feel testing is not warranted. However, while great strides have been made in the analysis and design of latticed steel transmission towers, differences between analysis results and full-scale tests still occur.

IRC CLASS LOADING

A bridge is a structure having a total length above 6m for carrying moving loads or pedestrian load and across the obstacle, a bridge is a structure which is built over an obstacle and hence providing a passage without obstructing the object. The passage may be for a railway, a road, a pipeline, a valley, or a canal. The development of the country based on the infrastructure available in the country. Highway which allows the flow of human beings and vehicles is a major part of infrastructure. the construction of bridge is necessary where there is a heavy traffic congestion which results in delay for the passengers. Construction of bridge will reduce the delay and allow the vehicles to travel without interruption. And It is also important to select the suitable type deck slab for different spans keeping good appearance and economy in consideration and construction. The planning of these structures has two important parts first is Traffic Assessment and second is layout and Structural design. As per IRC 92-1985, the bridge design is preferred when the [Passenger Car Unit] value at the intersection exceeds 10,000. IRC codes are developed and used from time to time based on the research work carried out all over the world. There are many different type of bridge designs that each have it's particular reason for design, the designs of bridges depending on the function of the bridge, the nature of the terrain where the bridge is constructed, and the material used to make it, and the funds provided to build it. Deck slab is that part of the bridge which transmitted the load passing the same to the substructure. T-beam are so called because the longitudinal girders and deck are cast monolithically i.e at the same time to form a T shaped bridge structure. A T-beam or beam and slab is constructed when the span is between 10-20 meter. The bridge deck essentially consists of a concrete slab monolithically cast over longitudinal girders so that T-beam formed. The number of longitudinal girders depend on the width of road. Three girders are normally provided for two lane road bridge. These loads may vary depending on duration, direction of action, type of deformation and nature of structural action such as (shear, bending, torsion etc.). In bridge there are mainly two type of loading first is dead load which is self-weight of bridge acting as a UDL and second is live load which is consider as vehicle load which act as a point load on the bridge and the other type of loading like wind load and impact load etc. which are taken in to the account according to the situation. In order to form a consistent basis design, the IRC has developed a set of standard loading condition, which are taken into account and use while designing while designing a bridge. IRC has developed four type of live load condition they are,

(1) IRC Class 70R Loading:

IRC Class 70R Loading is applied for permanent bridges and culverts. Bridges designed for class 70R loading is checked for Class A loading.

(2) IRC Class AA Loading:

IRC Class AA Loading is adopted within municipal limits for existing and industrial areas.

(3) IRC Class A Loading:

IRC Class A loading is adopted for all roads on which permanent bridges and culverts are to be constructed.

(4) IRC Class B Loading:

IRC Class B loading is adopted for timber bridges.

LOAD CATEGORIES

- **Dead Load**

The dead load is nothing but a self-weight of the bridge elements. The different elements of bridge are deck slab, wearing coat, railings, parapet, stiffeners and other utilities.

- **Live Load**

The live load on the bridge, is moving load on the bridge throughout its length. The moving loads are vehicles, Pedestrians etc. but it is difficult to select one vehicle or a group of vehicles to design a safe bridge. So, IRC recommended some imaginary vehicles as live loads which will give safe results against the any type of vehicle moving on the bridge. The vehicle loadings are categorized in to three types and they are

1. IRC class AA loading
2. IRC class 70R loading
3. IRC class A loading
4. IRC class B loading

VI. METHODOLOGY OF STEEL ANALYSIS

The target of this venture is to outline a Foot over scaffold, alongside association &foundation points of interest, and to dissect it, beneath said fundamental parameters are considered: Broad writing review by alluding books, specialized papers did to comprehend essential idea of subject.

i. Selection of a suitable model of foot over scaffold.

ii. Computation of burdens and choice of preparatory cross-segments of different auxiliary individuals.

iii. Geometrical demonstrating and basic investigation of foot over scaffold for different stacking conditions according to IS Codal arrangements.

iv. Interpretation of results. Following exploration must be completed for meeting the above destinations:

v. Now foot over bridge are demonstrated and investigated as a three dimensional structure utilizing STADD.Pro V8

vi. STAAD pro highlights cutting edge UI, perception devices, capable investigation and plan motors with cutting edge limited component (FEM) and dynamic examination abilities.

From show era, investigation and configuration to representation and result confirmation STAAD genius is the expert first decision. STAAD expert was created by rehearsing engineers

far and wide. It has advanced more than 20 years and meets the necessities of ISO 9001 confirmation.

STAAD or (STAAD.Pro) is an auxiliary investigation and outline PC program initially created by Research Engineers International at Yorba Linda, CA in year 1997. In late 2005, Research Engineers International was purchased a more established adaptation called STAAD-III for windows is utilized by Iowa State University for instructive purposes for common and basic specialists.

At first it was utilized for DOS-Window framework. The business form STAAD Pro is a standout amongst the most generally utilized basic investigation and outline programming. It underpins a few steel, cement and timber configuration code.

VII. RESULT AND DISCUSSION

STAAD. PRO V8I. ANALYSIS

The output data for the IRC Class 70R bogie loadings are considered which include nodal displacement, nodal displacement summary, beam forces, beam end displacements, beam end displacement summary, reactions, reaction summary, axial forces, beam moments, live load effect and many more by STAAD. Pro V8i. As all of them cannot be described in this paper, the data result tables being very large, some of the glimpse of the output results in the tabular forms is provided in this Works.

STEEL BRIDGE DESIGN

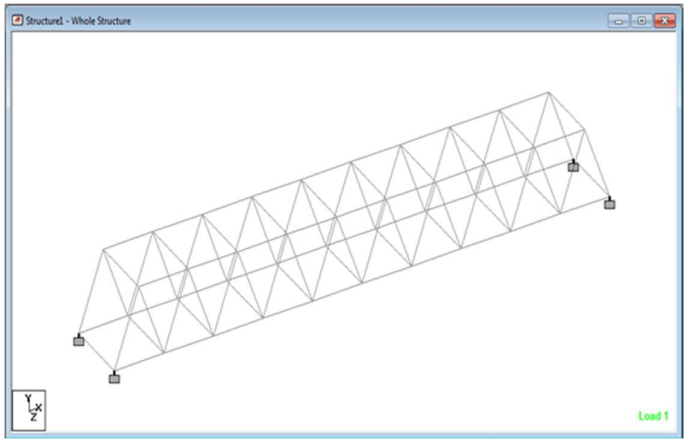

Fig.2 Design domain Implementation of Steel bridge.

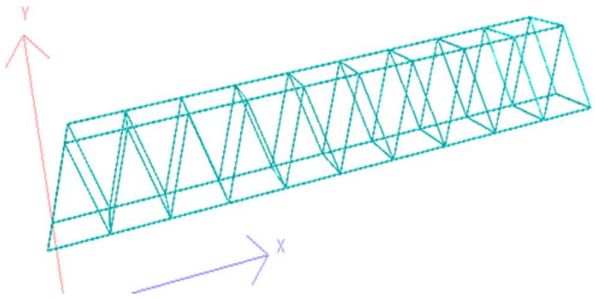

Fig.3 Design domain Implementation of Steel bridge.

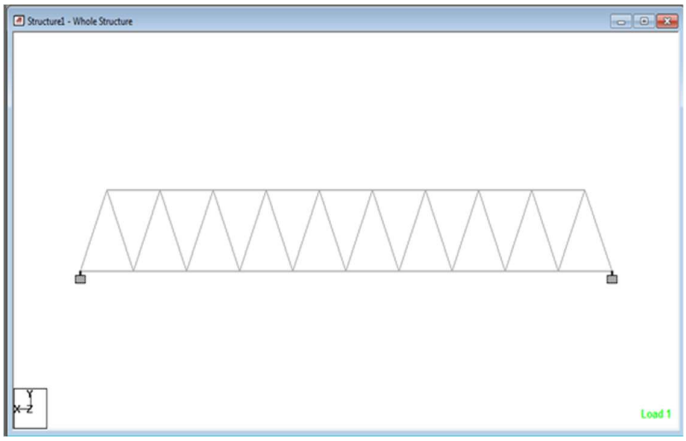

Fig.4 Design domain Implementation of Steel bridge.

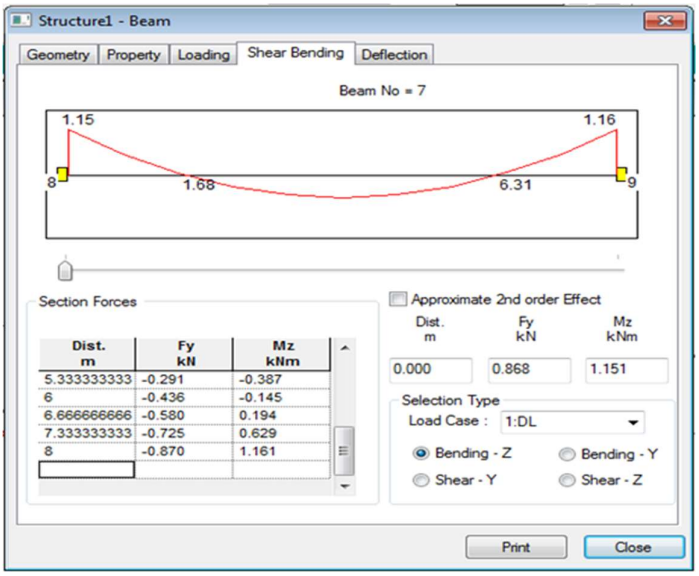

Fig.5 Banding design parameters Steel bridge.

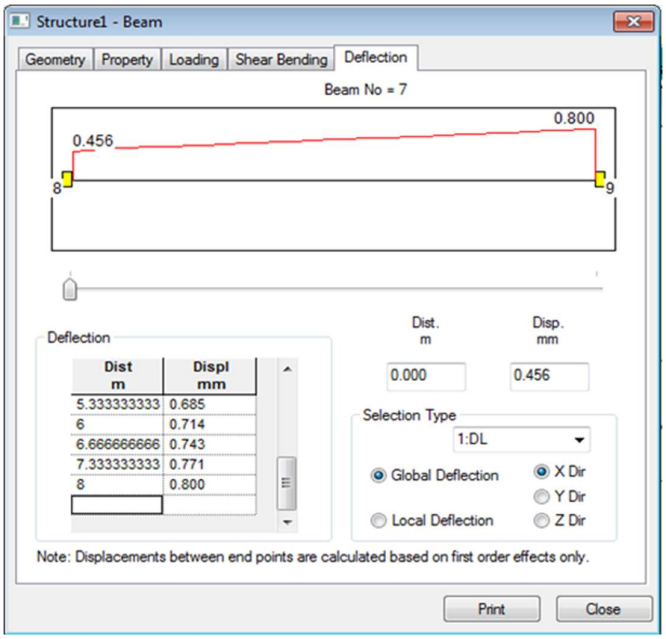

Fig.6 Deflection design parameters Steel bridge.

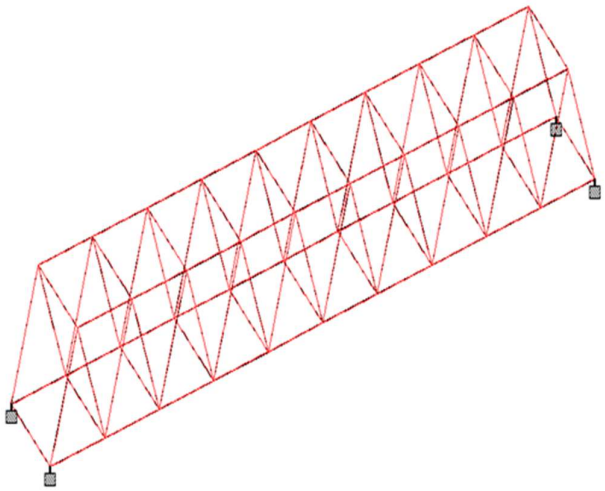

Fig.7 Share ZZ.

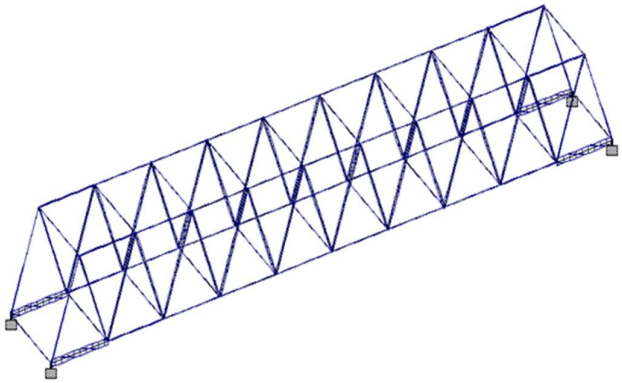

Fig.8 Bending ZZ.

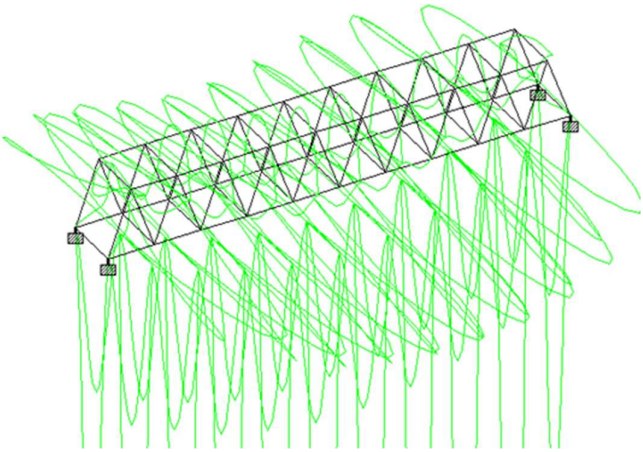

Fig.9 Torsion.

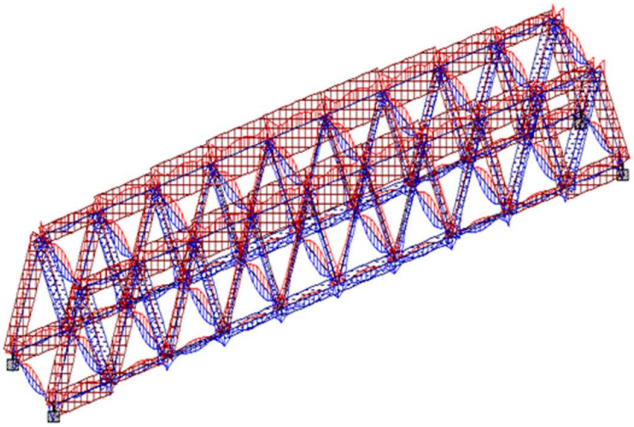

Fig.10 Mzz Bending.

VIII. CONCLUSION AND FUTURE SCOPE

CONCLUSION

After studying the Comparison, steel is most universally useful and versatile material for engineers and construction purpose. As a good engineer to save the natural resources is very

big task. The main ingredients of cement which are very much expensive as well as on verge of extent. So, it is very important to find out alternative material with respect related properties like strength, Cost and time. Also, engineers are reluctant to accept the composite steel and concrete structure because of unfamiliarity in analysis and design.

Following Result are Conclude this research work

• **Decreased Weight—**One of the biggest advantages of steel is weight savings, which means lower erection costs, since the bridge pieces can be handled with lighter equipment. In addition, for the same span and load, a steel girder requires less depth than a concrete girder, which can be helpful when constrained by vertical clearance requirements.

• **Faster Erection—**Steel components are made to closer tolerances, which often translates into faster erection.

• **Lighter Foundations—**If the substructure and superstructure are designed properly, the lighter weight of steel will allow lighter foundations than for concrete.

• **Structural Efficiency—**Generally, it's easier to make spans continuous for both live and dead loads and to develop composite action with steel designs rather than with concrete ones.

FUTURE SCOPE

STEEL is the most environmentally friendly material used in bridge construction.

Recycled Steel—A principal ingredient of the raw material for steel bridges is scrap steel. Rolled shapes and angles are virtually 100% reclaimed steel from scrap. Plates are about 75% recycled steel. New steel bridge construction in the US annually consumes about 350,000 tons of scrap metal. Demand for steel scrap is so high that virtually 100% of it is recycled instead of sent to landfills. Much of the steel collected from the destruction of the World Trade Center, for example, has already been recycled. New steel bridges annually use recycled steel from hundreds of thousands of old cars that would otherwise mar the landscape.

Longer Spans—Steel permits cost-effective longer spans for crossing streams, lakes, wetlands, and environmentally protected areas. The long spans may eliminate or at least minimize environmental impact. In some cases, the long spans possible with a steel bridge can avoid the need for costly environmental impact studies. Longer spans also reduce the number of piers necessary for a crossing, minimizing the number of elements affecting the aesthetics.

Lighter Weight—Construction impact on an environment is lessened because the lighter weight of steel increases a crane's reach. Also for the same span length, the contractor can use smaller cranes and other equipment.

Faster Construction—Steel bridge structures can be erected quickly while habitat creatures are still in hibernation or otherwise dormant.

BRIDGES are usually significant structures that have the power to add or detract from the landscape. Their beauty or lack of it has less to do with material selection and more to do with overall design in terms of geometry, proportion, structural concept, and integration with the site. When the local community gets to consider bridge design, nostalgia sometimes plays a role in the replacement of old steel bridges.

REFERENCES

[1] ISCARSAH (International Scientific Committee for Analysis and Restoration of Structures of Architectural Heritage). Recommendations for the analysis, conservation and structural restoration of Architectural Heritage; 2003.

[2] Anigacz W, Beben D, Kwiatkowski J. Hybrid measurement techniques used to a study of historic cast iron suspension bridge. In: IOP conference series: material science and engineering, vol. 419. Institute of Physics Publishing; 2018. doi: 10.1088/1757-899X/419/1/012013.
[3] Riveiro B, Morer P, Arias P, de Arteaga I. Terrestrial laser scanning and limit analysis of masonry arch bridges. Constr Build Mater 2011;25(4):1726–35. https:// doi.org/10.1016/j.conbuildmat.2010.11.094.
[4] Kim D, Kwak Y, Sohn H. Accelerated cable-stayed bridge construction using terrestrial laser scanning. Autom Constr 2020;117:103269. https://doi.org/ 10.1016/j.autcon.2020.103269.
[5] Yan Y, Hajjar JF. Automated extraction of structural elements in steel girder bridges from laser point clouds. Autom Constr 2021;125:103582. https://doi.org/ 10.1016/j.autcon.2021.103582.
[6] Gyetvai N, Truong-Hong L, Laefer DF. Laser scan-based structural assessment of wrought iron bridges: Guinness Bridge, Ireland. Proc Inst Civil Eng - Eng History Heritage 2018;171(2):76–89.
[7] Krautkramer ¨ J, Krautkr¨ amer H. Ultrasonic testing of materials. Springer Berlin Heidelberg; 1990. doi: 10.1007/978-3-662-10680-8.
[8] Costa BJA, Magalh˜aes F, Cunha A, ´ Figueiras J. Rehabilitation assessment of a centenary steel bridge based on modal analysis. Eng Struct 2013;56:260–72. https://doi.org/10.1016/j.engstruct.2013.05.010.
[9] Marques F, Moutinho C, Magalhaes ˜ F, Caetano E, Cunha A. ´ Analysis of dynamic and fatigue effects in an old metallic riveted bridge. J Constr Steel Res 2014;99: 85–101. https://doi.org/10.1016/j.jcsr.2014.04.010.
[10] Altunis¸ik AC, Karahasan OS, Genç AF, Okur FY, Günaydin M, Adanur S. Sensitivitybased model updating of building frames using modal test data. KSCE J Civ Eng 2018;22(10):4038–46. https://doi.org/10.1007/s12205-018-1601-6.
[11] Altunis¸ik AC, Okur FY, Genç AF, Günaydin M, Adanur S. Automated model updating of historical masonry structures based on ambient vibration measurements. J Perform Constr Facil 2018;32(1).
[12] Yang YB, Chen YJ. A new direct method for updating structural models based on measured modal data. Eng Struct 2009;31(1):32–42. https://doi.org/10.1016/j. engstruct.2008.07.011.
[13] Ribeiro D, Calçada R, Delgado R, Brehm M, Zabel V. Finite element model updating of a bowstring-arch railway bridge based on experimental modal parameters. Eng Struct 2012;40:413–35. https://doi.org/10.1016/j.engstruct.2012.03.013.
[14] Malveiro J, Ribeiro D, Sousa C, Calçada R. Model updating of a dynamic model of a composite steel-concrete railway viaduct based on experimental tests. Eng Struct 2018;164:40–52. https://doi.org/10.1016/j.engstruct.2018.02.057.
[15] Bautista-De Castro A, ´ Sanchez-Aparicio ´ LJ, Ramos LF, Sena-Cruz J, Gonzalez- ´ Aguilera D. Integrating geomatic approaches, Operational Modal Analysis, advanced numerical and updating methods to evaluate the current safety conditions of the historical Boco

ˆ Bridge. Constr Build Mater 2018;158:961–84. https://doi.org/10.1016/j.conbuildmat.2017.10.084.