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Design and Analysis of Steel Bridge by using STAAD.PRO

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ABSTRACT: Steel and steel-concrete composite bridges are commonly used all over the world, owing to the fact that they combine both magnificent aesthetic appearance and efficient structural competence. Their construction in a country not only resembles the vision and inspiration of their architects but also represents the country's existing development and dream of a better future. Compared to traditional reinforced concrete (RC) bridges, steel bridges offer many advantages, comprising high strength-to-self weight ratio, speed of construction, flexibility of construction, flexibility to modify, repair and recycle, durability, and artistic appearance. The high strength-to-self weight ratio of steel bridges minimizes dead loads of the bridges, which is particularly beneficial in poor ground conditions. Also, the high strength-to-self weight ratio of steel bridges makes it easy to transport, handle, and erect the bridge components. Furthermore, high strength-to-self weight ratio of steel bridges permits the erection of large components, and in special circumstances, complete bridges may be installed in quite short periods. The bridge components can be sized to suit access restrictions at the site, and once erected, the steel girders provide a platform for subsequent operations. Flexibility to modify, repair, and recycle steel bridges is a result of the ability to modify the current status of the bridges such as widening the bridges to accommodate more lanes of traffic. Also, steel bridges can be repaired or strengthened by adding steel plates or advanced composite laminates to carry more traffic loads. In addition, if for any reason, such as end of their life of use or change of environment around the area, steel bridges can be recycled. Steel bridges are durable bridges, provided that they are well designed, properly maintained, and carefully protected against corrosion. Finally, steel bridges can fit most of the complex architecture designs, which in some cases are impossible to accommodate using traditional RC bridges.

KEYWORDS:

- Steel-concrete composite bridges;
- Steel bridges;
- Railway and Highway bridges;
- Plate girder bridges;

I. INTRODUCTION

- Steel Bridges - I, that many different types of steel bridges may be designed, depending upon the span length, type of loading and approach road conditions. In this chapter, the design of plate girder and truss girder bridges, which are the most common type, are discussed in detail. An example design of truss Girder Bridge is presented in appendix.
- Design is an open-ended process, wherein different engineers attempting solution to the same problem come up with different designs. In the conceptual design stage, decisions regarding the structural systems to be used, span, spacing and configuration of the main and sub-members of the system are made. The decisions made at this stage have a major impact on the economy, efficiency and aesthetics of the bridge; although very little information is available at this stage. Therefore, experience of the designer is very important at this stage of design. An inexperienced designer may have to try different options and carry out the design of each option to a greater level of detail, before finalizing one design for execution.
- The Indian Standard Code of Practice for Steel Bridges (IS: 1915 - 1961) is based on the Working Stress Method. Since Limit States Method of design is more rational and leads to more efficient, economical design and uniform

reliability, most international standards have adopted it. Indian standards are also in the process of such a change. Hence, the Limit States method has been followed in this chapter. Since Indian Codes on the Limit States Method are just now evolving wherever necessary BS: 5400 - Part 3: 1982 provisions have been followed.

1. PLATE GIRDER BRIDGES

1. Plate girders became popular in the late 1800's, when they were used in construction of railroad bridges. The plates were joined together using angles and rivets to obtain plate girders of desired size. By 1950's welded plate girders replaced riveted and bolted plate girders in developed world due to their better quality, aesthetics and economy. Fig. 1 shows the cross sections of two common types of plate girder bridges. The use of plate girders rather than rolled beam sections for the two main girders gives the designer freedom to select the most economical girder for the structure.
2. If large embankment fills are required in the approaches to the bridge, in order to comply with the minimum head-room clearance required, the half through bridge is more appropriate [Fig. 1(a)]. This arrangement is commonly used in railway bridges where the maximum permissible approach gradient for the track is low. In this case the restraint to lateral buckling of compression flange is achieved by a moment resisting U-frame consisting of floor beam and vertical stiffness which are connected together with a moment resisting joint. If the construction depth is not critical, then a deck-type bridge, as shown in Fig. 1(b) is a better solution, in which case the bracings provide restraint to compression flange against lateral buckling.
3. This thesis proposes a method for evaluating the effects of a terrorist attack on highway bridges. The approach uses probability distributions to characterize the parameters of the vehicle-bound explosives attack scenario: magnitude and location. Applying Monte Carlo simulation, attack scenarios are randomly generated and the equivalent static loads are applied to the bridge's structural model. Next, nonlinear static analysis is conducted using commercially available structural analysis software. Performance criteria, established in performance-based seismic design guidelines, are used to measure the structural damage to the bridge. Finally, the method estimates the costs associated with three consequences: structural damage, casualties, and bridge downtime. Probability distributions account for uncertainty in the consequences. Case studies demonstrate the proposed approach with three functional bridge types of an existing long-span bridge: prestressed concrete beam, continuous teal plate girder, and deck cantilever truss. The case studies analyze attack scenarios to conventional explosives in a vehicle traveling on the bridge.

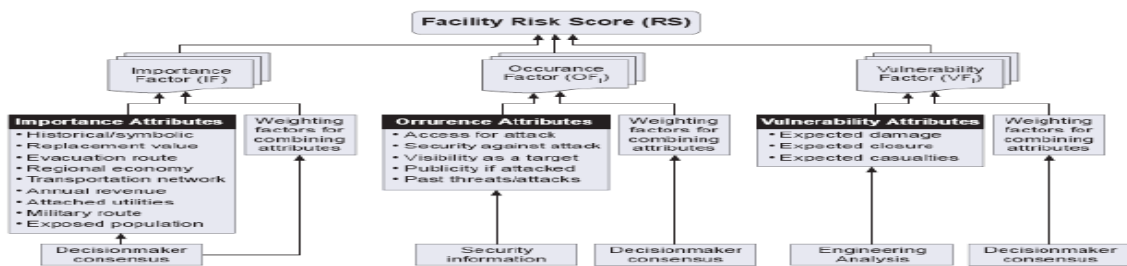


Figure 2-1: Components in Risk Assessment for an Individual Facility [2]

II. DESCRIPTION OF MODEL

This study seeks to estimate the expected consequence costs of a terrorist attack, using three functional bridge types of an existing long-span bridge as case studies. The proposed method is illustrated in a flowchart in Figure 3-1. The procedure can be adapted and modified as needed to fit the user's purpose and scope. Following Figure 3-1 is a general description of each step, where three case studies demonstrate the procedure.

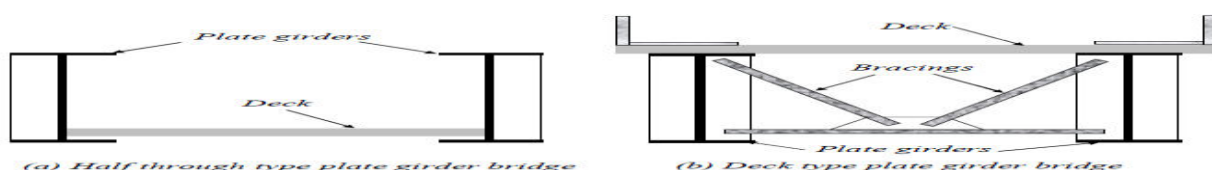


Fig. 1 Common types of plate Girder Bridge

The load effects (such as bending moment and shear force) are to be found using individual and un-factored load cases. Based on these, the summations of load effects due to different load combinations for various load factors are obtained. Since bridges are subjected to cyclic loading and hence are vulnerable to fatigue, redistribution of forces due to plastic mechanism formation is not permitted under BS 5400: Part - 3. The design is made based on Limit State of collapse for the material used considering the following:

- Shape limitation based on local buckling
- Lateral torsional buckling
- Web buckling
- Interaction of bending and shear
- Fatigue effect

Shape limitation based on local buckling

Depending on the type of cross section (compact or non-compact) the variation of stress over the depth at failure varies. A compact section can develop full plastic moment i.e. rectangular stress block as shown in Fig. 2(a). Before the development of this full plastic moment, local buckling of individual component plates should not occur. Thus the compact section should possess minimum thickness of elements on the compression zone such that they do not buckle locally before the entire compression zone yields in compression. The minimum thickness of elements for a typical compact section is shown in Fig. 3, where f_{yis} to be substituted in SI units (MPa).

The section that does not fulfill the minimum thickness criterion of compact section is defined as non-compact section. A non-compact section may buckle locally before full section plastic capacity is reached. Therefore the design of such section is based on triangular stress block wherein yielding at the extreme fibre, as shown in Fig. 2(b), limit the design moment.

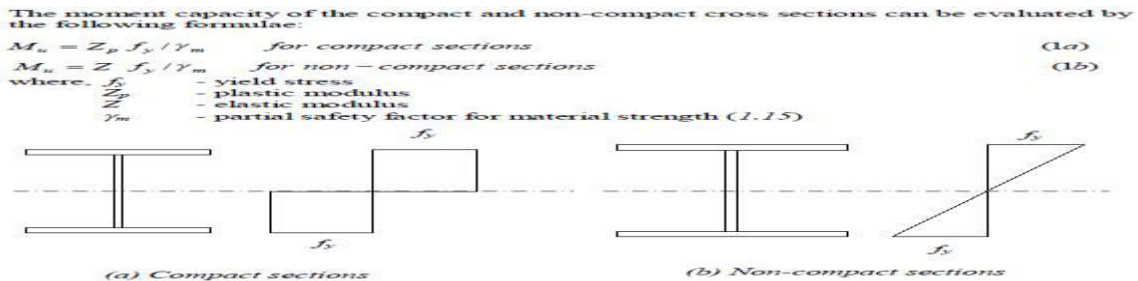
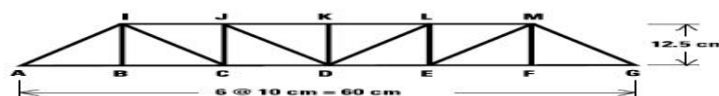
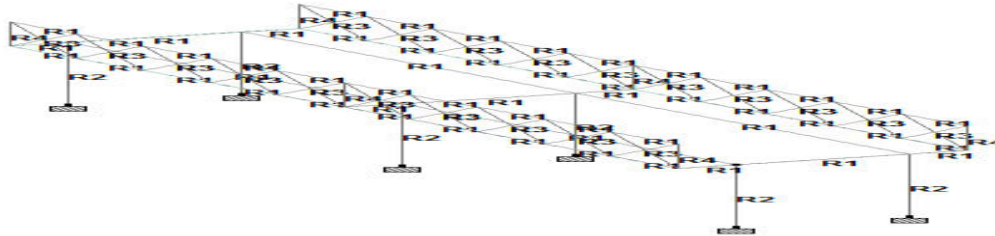


Fig. 2 Design stresses

III. METHODOLOGY

To model the Grant Road Bridge, we must define (1) the geometry of the structure, (2) the loads, and (3) the supports and reactions. We begin by idealizing the three-dimensional bridge structure as a pair of two-dimensional Pratt trusses. Since these two trusses are identical, we only need to analyze one of them. The geometry of the truss is shown below. The dimensions indicate the locations of the center lines of the members. Joints are identified with letters—the same letter designations that were used on the bridge plans provided in Learning Activity #1. To facilitate the analysis, we will assume that the truss members are perfectly straight, the joints are friction less pins, and the loads are applied only at the joints. We will also assume that the weight of the truss itself is zero.





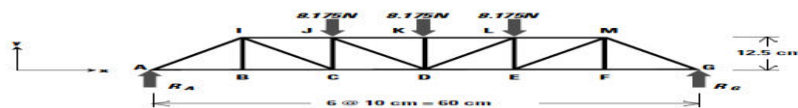
When we load-tested the Grant Road Bridge in Learning Activity #1, we applied the load in two different ways—with a stack of books placed on the top chord and with a bucket of sand suspended from the floor beams. Before we can define the loads for our structural model, we need to decide which of these two loading configurations to use. As a general rule, a structural evaluation should be based on the most severe loading condition—the one that produces the highest member forces. If the analysis shows that the truss is safe for the most severe loading, then the structure will certainly be safe for less severe ones. Unfortunately, in this case, it is not immediately obvious which of the two loading configurations is more severe. The best we can do is to make an assumption and check it later. For now, we will assume that the top-chord loading, shown here, is more severe.

Having decided on the location of the load, we must now determine its magnitude. In Learning Activity #2, we applied the equation $W=mg$ to determine that the weight of a 5-kilogram mass is 49.05 newton’s. When we placed the stack of books onto the top chord of the truss, the weight of the stack was supported on joints J, J’, K, K’, L, and L’. We can reasonably assume that the weight of the books is distributed equally to these six joints. Therefore, the downward force applied to each joint is

$$\text{Load per Joint} = \frac{\text{Total Load}}{\text{Number of Joints}} = \frac{49.05\text{ N}}{6} = 8.175\text{ N}$$

Since there are two main trusses, three 8.175N loads will be applied to each truss. Since all of the loads are downward, and the bridge is supported only at its ends, we will add upward reactions R_A and R_G at joints A and G.

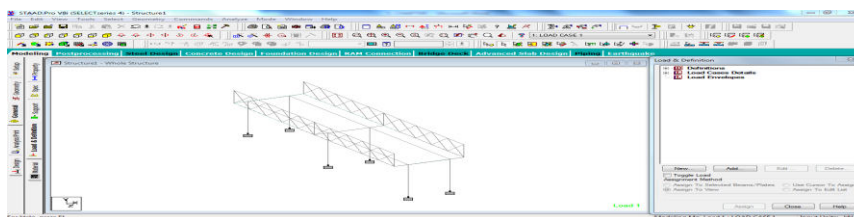
A complete free body diagram of the truss looks like this:



Check Static Determinate and Stability

Before we can use the equations of equilibrium to analyze this truss, we must first verify that it is statically determinate and stable. The mathematical condition for static indeterminacy and stability is $2j = m+3$

Where j is the number of joints and m is the number of members. Our truss from the Grant Road Bridge has 12 joints and 21 members. Substituting these numbers into the equation above, we find that $2j$ and $m+3$ are both equal to 24, so the mathematical condition for static determinacy and stability is satisfied. Furthermore, we note that the truss is composed entirely of interconnected triangles, which confirms our conclusion that the structure is stable.



Calculate Reactions

On the free body diagram above, the forces R_A and R_G are the unknown reactions at Joints A and G. We know that the truss is in equilibrium; therefore, the sum of all forces acting on the structure must be zero. Since all of the forces—loads and reactions—are acting in the y-direction, only one of our two equilibrium equations is relevant to the calculation of reactions:

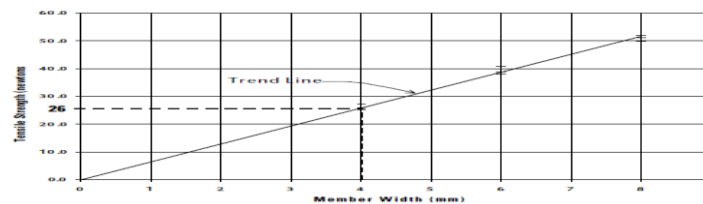
$$\sum F_y = 0$$

$$R_A + R_G - 8.175 - 8.175 - 8.175 = 0$$

Since the structure, the loads, and the reactions are all symmetrical about the center line of the truss, the two reactions R_A and R_G must be equal.

Determine the Strengths of the Members

Now that we have calculated the force in each member, we must determine the corresponding strength of each member. To do this, we will use the graphs we developed in Learning Activity #2. We'll start with the bars—the bottom chords, diagonals, and hip verticals. The table above tells us what we have already observed in our Grant Road Bridge model—that all of the bars are in tension (except the hip verticals, which have zero internal force). Thus we need to determine the tensile strength of the bars. All of the bars used in the Grant Road Bridge are 4mm wide. Using the tensile strength vs. member width graph we developed in Learning Activity #2, we find the tensile strength of a 4mm bar to be 26 newtons, as shown below.



Determining the tensile strength of a 4mm bar

Note, however, that all of the bottom chords, diagonals, and hip verticals are actually doubled 4mm bars. Thus the tensile strength of these members is exactly twice that of a single 4mm bar, or 52 newtons.

Our structural analysis shows that all of the tubes—the top chords, the end posts, and the interior verticals—are in compression. Thus we must determine the compressive strength of these members, using the strength vs. length graph we developed in Learning Activity #2. The top chord members are all 10mm x 10mm tubes, and each has a length of 10 centimeters. The strength of these members is approximately 50 newtons

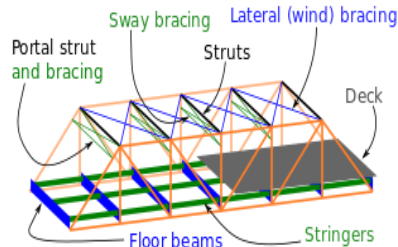
IV. RESULTS AND DISCUSSIONS

The nature of a truss allows the analysis of the structure using a few assumptions and the application of Newton's laws of motion according to the branch of physics known as statics. For purposes of analysis, trusses are assumed to be pin jointed where the straight components meet. This assumption means that members of the truss (chords, verticals and diagonals) will act only in tension or compression. A more complex analysis is required where rigid joints impose significant bending loads upon the elements, as in a Vierendeel truss.

In the bridge illustrated in the info box at the top, vertical members are in tension, lower horizontal members in tension, shear, and bending, outer diagonal and top members are in compression, while the inner diagonals are in tension. The central vertical member stabilizes the upper compression member, preventing it from buckling. If the top member is sufficiently stiff then this vertical element may be eliminated. If the lower chord (a horizontal member of a truss) is sufficiently resistant to bending and shear, the outer vertical elements may be eliminated, but with additional strength added to other members in compensation. The ability to distribute the forces in various ways has led to a large variety of truss bridge types. Some types may be more advantageous when wood is employed for compression elements while other types may be easier to erect in particular site conditions, or when the balance between labor, machinery and material costs have certain favorable proportions.

The inclusion of the elements shown is largely an engineering decision based upon economics, being a balance between the costs of raw materials, off-site fabrication, component transportation, on-site erection, the availability of machinery and the cost of labor. In other cases the appearance of the structure may take on greater importance and so influence the design decisions beyond mere matters of economics. Modern materials such as prestressed concrete and fabrication

methods, such as automated welding, and the changing price of steel relative to that of labor have significantly influenced the design of modern bridges.



STAAD SPACE

START JOB INFORMATION

JOINT COORDINATES

1 3 0 0; 2 3 5 0; 4 6 5 0; 6 6 0 0; 7 7 5 0; 8 7 7 0; 9 2 5 0; 10 2 7 0;
11 3 0 10; 12 3 5 10; 13 6 5 10; 14 6 0 10; 15 7 5 10; 16 7 7 10;
17 2 5 10; 18 2 7 10; 19 3 0 20; 20 3 5 20; 21 6 5 20; 22 6 0 20;
23 7 5 20; 24 7 7 20; 25 2 5 20; 26 2 7 20; 27 7 5 12; 28 7 5 14;
29 7 5 16; 30 7 5 18; 31 7 7 12; 32 7 7 14; 33 7 7 16; 34 7 7 18;
35 7 7 2; 36 7 7 4; 37 7 7 6; 38 7 7 8; 39 7 5 2; 40 7 5 4; 41 7 5 6;
42 7 5 8; 43 2 5 16; 44 2 7 18; 45 2 7 14; 46 2 5 12; 47 2 7 12;
48 2 5 14; 49 2 7 16; 50 2 5 18; 51 2 7 8; 52 2 5 6; 53 2 7 4; 54 2 5 2;
55 2 7 2; 56 2 5 4; 57 2 7 6; 58 2 5 8;

MEMBER INCIDENCES

1 1 2; 3 2 4; 5 4 6; 6 4 7; 7 7 8; 8 2 9; 9 9 10; 10 2 12; 11 4 13;
12 7 39; 13 8 35; 14 9 54; 15 10 55; 16 11 12; 17 12 13; 18 13 14;
19 13 15; 20 15 16; 21 12 17; 22 17 18; 23 12 20; 24 13 21; 25 15 27;
26 16 31; 27 17 46; 28 18 47; 29 19 20; 30 20 21; 31 21 22; 32 21 23;
33 23 24; 34 20 25; 35 25 26; 36 27 28; 37 28 29; 38 29 30; 39 30 23;
40 31 32; 41 32 33; 42 33 34; 43 34 24; 44 35 36; 45 36 37; 46 37 38;
47 38 16; 48 39 40; 49 40 41; 50 41 42; 51 42 15; 53 29 34; 54 29 32;
55 32 27; 56 27 16; 58 31 28; 59 28 33; 60 33 30; 61 24 30; 63 38 41;
64 41 36; 65 36 39; 66 39 8; 68 35 40; 69 40 37; 70 37 42; 71 16 42;
72 35 7; 73 34 23; 74 15 31; 75 15 38; 76 43 50; 77 44 26; 78 43 44;
79 45 49; 80 43 45; 81 46 48; 82 45 46; 83 46 18; 84 47 45; 85 48 43;
86 47 48; 87 49 44; 88 48 49; 89 50 25; 90 49 50; 91 26 50; 92 51 18;
93 52 58; 94 51 52; 95 53 57; 96 52 53; 97 54 56; 98 53 54; 99 54 10;
100 55 53; 101 56 52; 102 55 56; 103 57 51; 104 56 57; 105 58 17;
106 57 58; 107 18 58; 108 55 9; 109 44 25; 110 17 47; 111 17 51;

ELEMENT INCIDENCES SHELL

112 9 7 23 25;

DEFINE MATERIAL START

ISOTROPIC STEEL

E 2.05e+008

POISSON 0.3

DENSITY 76.8195

ALPHA 1.2e-005

DAMP 0.03

TYPE STEEL

STRENGTH FY 253200 FU 407800 RY 1.5 RT 1.2

END DEFINE MATERIAL
MEMBER PROPERTY INDIAN
3 6 8 10 TO 15 17 19 21 23 TO 28 30 32 34 36 TO 51 76 77 79 81 84 85 -
87 89 92 93 95 97 100 101 103 105 TABLE ST ISMB350
1 5 16 18 29 31 TABLE ST ISMB450
53 TO 56 58 TO 61 63 TO 66 68 TO 75 78 80 82 83 86 88 90 91 94 96 98 -
99 102 104 106 TO 111 TABLE ST ISA40x40x5
7 9 20 22 33 35 TABLE ST ISMB125

SUPPORTS
1 6 11 14 19 22 FIXED
LOAD 1 LOADTYPE Dead TITLE LOAD CASE 1
SELFWEIGHT Y -1 LIST ALL
PERFORM ANALYSIS
PRINT ANALYSIS RESULTS
FINISH

V. CONCLUSIONS

The following summary statements regarding structural characteristics for metal truss bridges, key periods of significance for metal truss bridges in Maryland, and the earliest known documented examples of metal truss bridges in the state are based solely on documentary research. Metal truss bridges (see Figures 8 through 12 and Plates 5 through 7) comprise two parallel trusses and a floor system supported on a concrete or masonry substructure. Each metal truss consists of individual components connected in a series of triangles. The particular type of metal truss bridge is defined by the arrangement of individual members, and the way in which those members are stressed (compression or tension); a wide variety of configurations is possible, many of which were proprietary, or patented variants, such as the commonly known Pratt and Warren types. Individual members form the horizontal portions of the truss, called top and bottom chords, and the vertical and diagonal web members. The verticals and diagonals are connected to the top and bottom chords at joints (pin connections or rivet connections are possible). Minor web components may include sub-struts or sub-ties. Members may be in tension or compression, depending on the variety of truss (see Figures 9 through 12). Other basic components include the portal, stringers, floor beams, and deck. Portal bracing provides lateral bracing for the two parallel trusses at the top of the end posts. Stringers are longitudinal members which transmit loads to the floor beams, which in turn transmit loads to the trusses at each panel point (joint connection) where the floor beams, the chord, and the verticals and diagonals are connected.

REFERENCES

1. "Steel Design" by William T. Segui
Covers fundamentals of steel design, including design for bridges under the AISC Steel Construction Manual.
 2. "Design of Steel Structures" by Edwin H. Gaylord, Charles N. Gaylord, and James E. Stallmeyer
Comprehensive book with examples on bridge design and structural analysis.
 3. "Bridge Engineering" by Weiwei Lin and Teruhiko Yoda
Focuses on bridge design principles, including material behavior, structural types, and steel bridges.
 4. "Design of Highway Bridges: An LRFD Approach" by Richard M. Barker and Jay A. Puckett
Includes Load and Resistance Factor Design (LRFD) methodology used in steel bridge design.
 5. "Steel Bridges: Conceptual and Structural Design of Steel and Steel-Concrete Composite Bridges" by Manfred Hirt and Jean-Paul Lebet
- Standards and Codes**
6. AASHTO LRFD :Bridge Design Specifications Primary guide for highway bridge design in the United States, covering analysis and design of steel bridges
 7. Euro code 3 (EN 1993):Provides guidelines for designing steel structures, including bridges, in Europe.
 8. IS 800:2007 (Indian Standard Code of Practice for General Construction in Steel):Indian code for steel structures,including bridge-related provisions.
 9. IRC Codes (Indian Roads Congress):For Indian-specific bridge design, including composite steel bridges.
 10. BS 5400 (British Standard for Steel, Concrete, and Composite Bridges):Relevant for bridge designs in the UK.



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