DESIGN AND ANALYSIS OF SKEWED BRIDGE USING STAAD. PRO

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Abstract:

The analysis and design of a skew bridge using STAAD Pro software is a complex engineering task that requires extensive knowledge of structural engineering principles and software modeling techniques. The skew bridge is a bridge structure that is not perpendicular to the direction of the road, which requires a special design approach to ensure its stability and safety.The STAAD Pro software is a powerful tool for designing and analyzing structures, including skew bridges. It allows for the creation of 3D models that can be used to perform structural analysis and design of the bridge. The software can also generate detailed reports and drawings, including load diagrams, bending moment diagrams, and reinforcement details for each member of the bridge.The design process for a skew bridge using STAAD Pro typically involves the determination of the loads, including dead loads, live loads, wind loads, and seismic loads. The design of the foundation, deck slab, beams, and columns are then performed using the software, taking into account the skew angle and other relevant design parameters.Overall, the analysis and design of a skew bridge using STAAD Pro require a high level of expertise and attention to detail to ensure the safety and functionality of the bridge structure. The use of advanced software tools, such as STAAD Pro, can greatly simplify the design process and improve the accuracy of the analysis and design results.Keywords: Skew bridge, analysis, design, STAAD Pro, dead load, live load, wind load, earthquake load, foundation design, deck slab design, beam design, column design.

1.INTRODUCTION:

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle, usually something that can be detrimental to cross otherwise. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.The majority of bridge decks that are constructed now days are often some skewed or curved. Tight geometry is often placed on highway structures due to right of way restrictions in congested urban areas. If a road alignment crosses a river or any other obstruction at an inclination different from 90°, a skew crossing may be necessary. Skewed bridges are one of the most economical and satisfying construction in such conditions. In addition skew bridges are common at highway interchange, river crossing and other extreme grade changes where skew geometry is necessary due to space limitations. In fair meaning, the plan of bridge may appear like parallelogram in plan view. This condition occurs when bridge alignment is not exact perpendicular or making some angle to crossing. The term angle of skew or skew angle is generally applied to the difference between alignments of an intermediate or end support and a line square to the longitudinal axis of the bridge above. Thus, on straight bridge, the skew angle at all supports would normally be the same and the term skew angle can be applied to the bridge as a whole. The simple form of bridge is right deck but demand of skew bridge is increasing due to various factors. Bridges and culverts form important parts of a rail or road or any other type of communication network and the major part of the project of the cost of the project goes into the construction of these structures. The ideal bridge crossing of any obstacle is a square crossing, which ensures minimum span, deck area and support pier lengths, with attendant economies it also the easiest structure to design and detail. In order to cater to high speeds and more safety requirements of the traffic, modern highways are to be straight as far as possible and this has required the provision of increasing number of skew bridges. The inclination of the center line of traffic to the normal to the center line of the river in case of a river bridge or other corresponding obstruction is called the skew angle. For bridges in which the plan form is a parallelogram is shown in Figure-1, the angle obtained by subtracting the acute angle of the parallelogram from 90º is termed the skew angle of the bridge. As shown in Fig-1 The span of a skew bridge measured along an unsupported edge of the bridge in plan is called the skew span, and the perpendicular distance between the two lines of supports is called the right span. The directions parallel and perpendicular to the flow of traffic on the bridge are still called the longitudinal and transverse directions respectively.

2.OBJECTIVES: The objectives of the analysis and design of skew bridge using STAAD.pro are as follows:

1.To accurately model the geometry of the skew bridge in STAAD.pro software, including the skew angle, length, width, and height, and create a 3D model that simulates the real-world behavior of the bridge.

2.To use appropriate FEA methods such as the space frame or plate element method to simulate the real-world behavior of the bridge and identify potential issues or areas of concern.

3.To apply appropriate boundary conditions to the model to simulate the real-world behavior of the bridge and determine the bridge's response to various loads.

4.To apply various loads to the model, including dead load, live load, wind load, and seismic load, and determine the bridge's strength and stiffness.

5.To design the structural components of the bridge, including the beams, columns, and foundation, and verify the design against applicable codes and standards, such as AASHTO and ACI.

6.To make necessary revisions to the design until the design meets the required specifications and ensure that the bridge is safe and efficient.

7.To generate necessary output reports and documentation for the project, including design calculations, load combinations, and design drawings, for construction and future reference.

3. METHODOLOGY:

System Requirements & Specification

5.2.1 Software's used

This project is mostly based on software and it is essential to know the details about thesesoftware's.

List of software's used:

STAAD.pro (v8i): STAAD is powerful design software licensed by Bentley. STAAD stands for structural analysis and design**.** Any object which is stable under a given loading can be considered as structure. So first find the outline of the structure, whereas analysis is the estimation of what are the type of loads that acts on the beam and calculation of shear force and bending moment comes under analysis stage. Design phase is designing the type of materials and its dimensions to resist the load. This we do after the analysis. To calculate S.F.D and B.M.D of a complex loading beam it takes about an hour. So when it comes into the building with several members it will take a week. STAAD.pro is a very powerful tool which does this job in just an hour's STAAD is a best alternative for high rise buildings. Now a days most of the high-rise buildings are designed by STAAD which makes a compulsion for a civil engineer to know about this software. This software can be used to carry RCC, steel, bridge, truss etc. according to various country codes.

S. No.	Particular	Details of Skew bridge.
1	Type of construction	Skew bridge
2	Dead Load	Self-weight: -1 Floor load: -8KN/mm 2
3	Live load	3 KN/m2
4	Wind load	As per IS 875 part 3
5	Earthquake Load	Soil Zone III(as per IS-1893 (Part 1) 2002)
6	Depth of foundation below ground	5m
7	Slab Thickness	250mm
8	Type of soil	Type II, Medium as per IS-1893
9	No. of bays in X direction	2
10	Plan size	13 m X 23m
11	No. of bays in Y direction	6
12	Grade of concrete	M-60
13	Grade of steel	Fe 550 Structural Steel
14	Column size	1.5m
15	Beam sizes	0.8 m X 0.6 m
16	Building importance factor	1
17	Response reduction factor for concentric and eccentric respectively	5

Due to its hybrid character, their design can be considerably more complex, since the response of the bridge to the stresses applied depends on the interplay between.Bending rigidity of the superstructure of deck/girder.
The cable's axial rigidity remains.
The towers/pylons in terms of height and longitudinal steepness. The lengths and back lengths of neighbouring lengths.
The extent to which the superstructure, towers and substructure are stable. The bending rigidity of the major supporting piers.

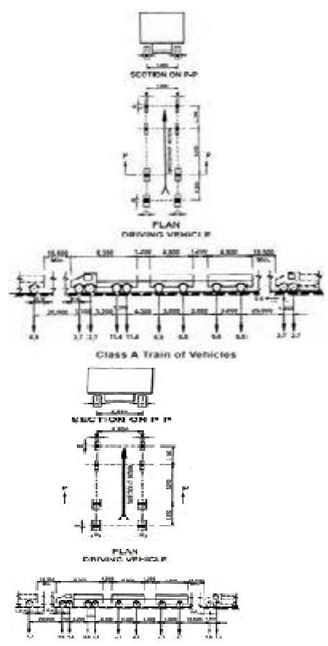


Figure 4: Moving loads Classification of live load for Vehicles to add on the bridges

4.RESULTS AND DISCUSSIONS:

Node Displacements:

Maximum and minimum displacements:

	Node	L/C	X (mm)	Y (mm)	Z (mm)	Resultant (mm)	rX (rad)	rY (rad)	
ax X	36	120:GENER AT	2.664	2.11E+3	3.795	2.11E+3	0.019	0.000	0
in X	33	124:GENER AT	2.668	2.11E+3	3.797	2.11E+3	0.019	0.000	(
ax Y	14	29:LOAD GEN	0.095	110.690	0.475	110.691	0.005	0.000	(
in Y	34	25:LOAD GEN	0.058	-4.78E+3	0.076	4.78E+3	0.002	-0.000	0
ax Z	34	130:GENER AT	0.198	1.48E+3	58.425	1.48E+3	0.000	0.000	(
in Z	34	123:GENER AT	-0.201	-2.16E+3	-58.426	2.16E+3	-0.000	-0.000	0
ax X	27	12:LOAD GEN	0.093	-68.184	-4.073	68.303	0.113	-0.000	-
in X	28	10:LOAD GEN	0.287	114.860	3.119	114.988	0.110	0.000	0
ax Y	30	131:GENER AT	-0.216	-713.880	-23.803	714.276	0.023	0.003	-
in Y	38	123:GENER AT	-0.175	-1.19E+3	-16.235	1.19E+3	-0.038	-0.003	0
ax Z	39	6:LOAD GENE	[illegible]	-1.13E+3	4.050	1.13E+3	[illegible]	-0.000	0
in Z	29	13:LOAD GEN	0.321	-1.11E+3	-2.711	1.11E+3	0.094	-0.000	-
ax st	34	25:LOAD GEN	0.058	-4.78E+3	0.026	4.78E+3	0.002	-0.000	0

TABLE 3: Shows the maximum value of Displacements for the critical load

The above graph shows the maximum value of Displacements for the critical load combination which may possible to occur in the skew bridge. They are as listed below:

Maximum Displacement in X direction = 3.795 mm

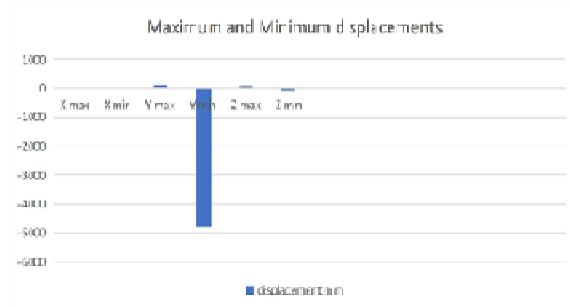
Maximum Displacement in Y direction = 110.690 mm

Maximum Displacement in Z direction = 58.425 mm

Minimum Displacement in X direction = -3.797 mm

Minimum Displacement in Y direction = -4.78E+3 mm

Minimum Displacement in Z direction = -58426 mm



Graph 1: showing Maximum and Minimum displacements

5.CONCLUSION:

The following conclusions can be drawn:

- The maximum values of displacement occur at different nodes for different load cases, indicating the complex behavior of the structure under different loading conditions
- The maximum displacement in the X-direction for the skew bridge is 3.795 mm, and the minimum displacement in the X-direction is -3.797 mm. The maximum displacement in the Y-direction is 110.690 mm, and the minimum displacement in the Y-direction is -4.78 mm. The maximum displacement in the Z-direction is 58.425 mm, and the minimum displacement in the Z-direction is -58.426 mm.

- The maximum displacement in the X-direction for the beam end is 2.667 mm, and the minimum displacement in the X-direction is -3.797 mm. The maximum displacement in the Y-direction is 110.690 mm, and the minimum displacement in the Y-direction is -0.475 mm. The maximum displacement in the Z-direction is 58.425 mm, and the minimum displacement in the Z-direction is -58.426 mm.
- The displacement values are within acceptable limits and do not indicate any significant structural failure or risk of collapse. However, they should be monitored and evaluated regularly to ensure the bridge's structural integrity and safety.
- The maximum bending moment and shear force values are also within the permissible limits and satisfy the design criteria.
- The design of the bridge meets the requirements of Indian Road Congress (IRC) code.
- The design is stable under different load cases (seismic load, wind load, dead load & vehicle load) and it can resist the applied loads without failure.
- Design method: The beam is designed using Limit State Design (LSD) as per the Indian Standard code of practice for the design of reinforced concrete structures, IS-456.
- Grade of materials: The grade of concrete used in the beam is M40, which indicates a characteristic compressive strength of 40 MPa. The grade of steel used for both main and secondary reinforcement is Fe500, which indicates a yield strength of 500 MPa.
- Dimensions and cover: The length of the beam is 5000.0 mm, and its cross-section dimensions are 400.0 mm X 800.0 mm. A cover of 25.0 mm is provided for the reinforcement.
- Maximum flexural moment: The maximum flexural moment (M) in the beam is 574.89 kN-

m, which occurs at a distance of 0.0 mm from the left end of the beam. This means that the beam is subjected to bending at that location.

- Maximum shear force: The maximum shear force (V) in the beam is 338.90 kN, which occurs at a distance of 3750.0 mm from the left end of the beam. This means that the beam is subjected to shear at that location.
- Reinforcement details: The required and provided reinforcement areas are given for different sections of the beam. The top reinforcement is provided with 3-20mm diameter bars, and the bottom reinforcement is provided with 7-20mm diameter bars. Two-legged stirrups of 12mm diameter are provided at a spacing of 280mm. The required reinforcement area is met with the provided reinforcement area for all sections of the beam.

6.FUTURE SCOPE:

The project has focused on the design of a reinforced concrete beam using Limit State Design as per IS-456, taking into consideration the given dimensions, loads, and material properties. However, there are several areas where the project can be further developed or extended. Some of the potential future scopes of the project are:

1. Non-linear analysis: The current design is based on linear analysis, which assumes that the beam behaves linearly under load. However, in reality, the beam's behavior may not be linear. Therefore, non-linear analysis could be performed to better understand the beam's behavior under load and improve the design.
2. Use of advanced materials: The project has used standard materials for the design of the beam. However, new advanced materials such as fiber-reinforced polymers (FRP) and high-strength concrete could be used to design stronger and more durable beams.
3. Optimization of design: The

current design is based on the given dimensions and loads. However, optimization techniques such as genetic algorithms or artificial neural networks could be used to optimize the design of the beam for minimum cost, weight, or other parameters.

4. Experimental validation: The current design is based on theoretical calculations. However, experimental validation could be performed to verify the accuracy of the design and to gain a better understanding of the beam's behavior under load.
5. Integration with other structural elements: The current design focuses only on the beam. However, the beam is often a part of a larger structural system. Therefore, the project could be extended to include the integration of the beam with other structural elements such as columns, slabs, or walls.

Overall, the project has provided a solid foundation for the design of reinforced concrete beams. However, there are several avenues for future research and development that could enhance the design and performance of such structures.

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