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Analysis of performance of various skew angles of deck slab bridges in MIDAS Software

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Abstract - *In this modern age, many highway bridges are curved and need to facilitate their behavior and corresponding analysis in order to fully achieve their design goals. This project deals with the behavior of skew deck slab bridges with different tilt angles of 0°,20°,40°,60° and 65°. In this project, MIDAS structural analysis software was used to conduct a detailed analysis in wood armer moment with different skew angles, and the analysis complies with the provisions of Indian Codes IRC 6: 2014.*

Key Words: Skew angle, Wood Armer Moments, Skew Bridges; Bridge decks; Span length, MIDAS Software, IRC loading.

1. INTRODUCTION

A street community machine is possibly one of the maximum essential requirements for the monetary improvement of any country, in particular growing international locations. Many of growing international locations, therefore, make investments massive quantity on street creation, at the same time as many growing international locations admire the need for massive funding in capital improvement of roads. Most of the bridges in elder days had been immediately and skew bridges had been stopping as a way as feasible. Lack of data approximately the structural conduct and creation problem had been apparent motives contributing to the designer's preference to assist in a immediately-line bridge in place of skew bridges. But withinside the latest occasions there may be a growing fashion of imparting skew bridges in place of curved or immediately bridges with lengthy method street at indirect intersections. It could be very hard for them to barter on curve roads even at low speeds. The advent of curves additionally will increase the gap travelled with the aid of using the car which in flip impacts the economy. In hilly areas additionally because of topographic conditions, it's far very hard to offer curved methods and commonly skew bridge stays the best option. The railway and roadway intersection also are frequently indirect and calls for method street if skew bridge is to be avoided. Also, vintage and overcrowded metropolis because of be quick of space, bridges should be skew in nature if the intersection isn't orthogonal. Hence there may be want to examine the conduct of skew bridges so one can facilitate short estimation of layout BM, shear pressure and assist reactions and accordingly obviating the want of a rigorous analysis.

1.1 Skew Bridge

The simplest and most common form of bridge is a straight bridge. The centerline of the bridge and the centerline of the obstacles below it intersect at a 90 ° angle. However, in some cases, due to space constraints, straight bridges may not be the preferred solution. In such cases, the bridge is designed to cross the obstacle below at an angle other than 90 °. This is known as a skew bridge.

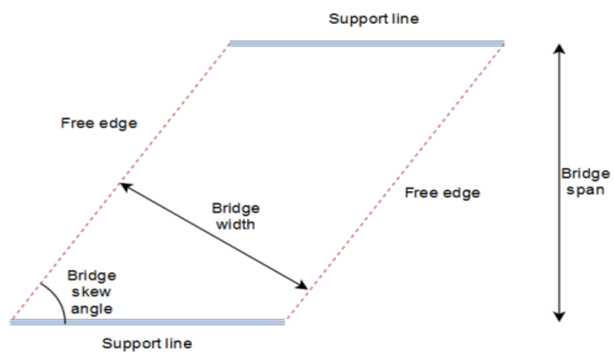

Fig -1: Skew Bridge

1.2 Wood Armer Moments

The design moment along the rebar of the ramp is (a) a combination of normal bending moment and torsional components. These are called wood-armer moments. The Wood-Armer equation was derived for the design of skew and curved reinforced concrete slabs.

2. LITERATURE REVIEW

Many researchers have studied the behavior and performance of skew deck slab bridge. The present theories published by various researchers related to the behavior of of skew deck slab bridge are presented in the following section.

Arindam Dharet al. (2013), This white paper presents the behavioral aspects of a sloping bridge and uses the 3D bridge model of ABAQUS, a finite element analysis software, to compare it with the behavioral aspects of a straight bridge. A single-supported RC bridge was introduced to clearly understand the trends. The results of the ABAQUS bridge model show that the larger the spiral angle, the higher the supporting shear moment and midspan moment of the blunt vertical girder, and the smaller these parameters for the corresponding pointed vertical girder. Most importantly, the twisting moment of the obtuse beam increases rapidly as the spiral angle increases. Such moment changes are usually not taken into account when designing straight bridges. At higher tilt angles, the plate showed asymmetric bending, with more obtuse deflection and less acute deflection. Behavior evaluation of suspension bridges with vertical girders and plate configurations. Since the load transfer mechanism of a sloping bridge is different from that of a straight bridge, the former can concentrate the reaction force at blunt angles and cause negative deflection (raising) at sharp angles. These responses depend on the angle of the bank.

Mauricio Diaz Arancibia et al. (2020), This treatise shows the effect of tilt on bridges through finite element analysis, bridge inspection, and statistical analysis. We inspected five deck girder bridges with and without slopes. We analyzed a database of over 1,400 deck girder bridges and found a relationship between slopes and National Bridge Inventory (NBI) ratings. On some steep bridges, sharp cracks in the corners of the deck and bridge movements are recorded. Field inspections and database analysis have shown that not all high skew bridges have performance issues and that NBI assessments are generally not skew sensitive. This can be due to many factors that affect performance and certain details that mitigate the effects of distortion.

Ibrahim S. I. Harba (2011), In this article, we conducted an analytical study using the 3D finite element method to investigate the effect of slip angles on the behavior of simply supported reinforced concrete T-beam bridge decks. The parameters examined in this analytical study were span and tilt angle. We compared the results of a finite element analysis (FEA) of a curved bridge with a straight reference bridge (not curved). The geometric dimensions of the T-beam bridge deck and the loads used comply with AASHTO standards. The FEA results and the comparison of sloping and straight bridges show the maximum. Tilt bridge T-beams reduce live load bending moments and deflections, but at all spans considered (12, 16, 20, and 24 m), are maximal for some ramp bridge T-beams. Increases shear, torsion, and support reaction forces. This study is inconsistent with the AASHTO standard and LRFD by recommending that bridges with a pitch angle of 20 ° or less be designed as straight (non-inclined) bridges. It was also suggested that engineers should perform 3D finite element analysis on the deck of a sloping T-beam bridge.

C. Menassa, et. al. (2007), In this paper, the effect of skew angle on a single-span reinforced concrete bridge is shown using the finite element method. The parameters examined in this analytical study were span, plate width, and tilt angle. The results of the finite element analysis (FEA) of the curved bridge were compared with the straight reference bridge and the American Association of State Highway Traffic Authority (AASHTO) standards and LRFD procedures. A total of 96 case study bridges were analyzed and exposed to AASHTO HS-20 design trucks located near the ends of each bridge, resulting in maximum deflection of the slab. The decrease in longitudinal torque ratio is offset by a maximum lateral torque ratio increase of up to 75% as the slip angle increases from 0 to 50 °. The ratio of maximum FEM live load deflection between tilted and straight bridges decreases in a pattern that matches the pattern of longitudinal moments.

Junyi Meng et al. (2004), This paper describes an experimental study of a ramp model conducted at the Turner Fairbank Highway Research Center of the Federal Highway Authority. The objectives of the experiment are (1) to carry out pilot surveys on the design, construction, measurement, testing, and data processing of ramp bridge models, and (2) to provide experimental data to verify ramps with 3D finite elements. That is. (3) Confirm the applicability of the simplified bridge model (2-beam rod model) developed for dynamic analysis of inclined bridges. Learn more about model bridge design, construction, instrumentation, testing, and data processing. The results of static displacement, natural frequency, mode shape, and damping of the model bridge are displayed. Comparing the results from these tests numerically from the finite element analysis and analytically from the dual stick bridge model shows a good correlation.

Punit Patel et. al. (2016), This paper presented an analysis of ramps with various tilt angles consisting of 0 °, 15 °, 30 °, 45 ° and 60 ° for single-span T-beam reinforced concrete girders under the load of the Indian Road Council (IRC). .. Dead roads, vehicle payloads, and payload combinations are considered for research. A slab girder with a span of 20 m and a two-lane road width of 7.5 m is considered. The analysis is performed using Staad Pro software. Determining the effect of skewness on the general behavior of a bridge. The analysis results show maximum bending moments, torsional moments, and shear forces compared to different tilt angles.

Bikram Kesharee Patra et. al.(2013), This paper aims to employ efficient analytical techniques for analyzing different tilted decks. First, various methods were studied to determine the exact and approximate solution for the tilted deck. Extensive studies on the analysis of ramps under different load combinations have been reported in the literature. However, less attention has been paid to researching appropriate analytical techniques for heavily biased decks. Since bridges are currently an important structural element, efficient methodologies are important for accurately predicting the behavior of sloping bridges. Briefly, this study describes the behavior of tilted plate bridges with respect to supporting reaction forces and plate deflection under standard IRC70R wheel loads. Plates are modeled using both the finite element method and the grill method, and the results are compared. It has been found that when the skew angle exceeds 60 °, a high ve response occurs at the obtuse angle, and when the skew angle and aspect ratio increase, the maximum deflection approaches the obtuse angle.

Raj KK et. al. (2017), In this paper, the behavior of simply supported ramp bridges with different tilt angles of 0 °, 15 °, 30 °, 45 ° and 60 ° was presented. In this project, STAAD PRO structural analysis software was used to carry out a detailed investigation of the fluctuations in the bending moments of simple support ramps with different tilt angles, and the analysis was performed according to the Indian Code IRC 6: 2014-Deflection curve regulation. increase. The represented elemental model shows good agreement with the experimental data. Finite element analysis has confirmed that load deformation can be predicted accurately as in experiments. The maximum deviation of the tilt plate decreases as the tilt angle increases. The larger the overturn angle, the greater the load bearing capacity of the overturn plate. Up to a tilt angle of 15 °, the tilted panel behaves like a nearly rectangular panel.

Patrick Théoret, et. al. (2012), This paper presents the findings for determining the bending moments and shear forces required to design a sloping concrete slab bridge using the equivalent beam method. Straight and sloping plate bridges were modeled using grid and finite element models that characterize behavior under uniform and moving loads with the aim of determining the most appropriate modeling approach for the design. The parametric study was performed on 390 simply supported slabs with geometry covering a 1 to 4 lane bridge with a span of 3 to 20 m and an inclination of 0 to 60 °. The results of the parametric study showed that the shear force and the secondary bending moment increased with increasing spiral angle, and the longitudinal bending moment decreased. Within the framework of the equivalent beam method for tilt angles up to 60 °, equations have been proposed that include an increase in lateral force and a decrease in longitudinal bending moment.

Suiwen Wu et al. (2021), In this article, we will use a simplified method validated by the shaketable test to investigate the effects of the helix, aspect ratio, and basic period on the additional support length requirements of a single-span bridge due to tilt. I ran a parametric study. Gap closures can be simulated based on response spectrum analysis. When the angle is smaller than the critical value and decreases at an angle exceeding this value. This critical spiral angle increases almost linearly with the aspect ratio, with very little dependence on the base period of the bridge and the combination of span and width. In addition, as the aspect ratio changes from 3.0 to 5.0, the critical helix angle changes between 58 ° and 66 °. The results also show that the empirical formulas for the minimum support length requirements for ramps in current standards and specifications do not accurately reflect the effects of tilt position.

3. METHODOLOGY

The steps mentioned below were used in Analysis of performance of various skew angles of deck slab bridges in MIDAS Software.

3.1 Literature Review

A literature review is a study of scientific material, more specifically a survey, aimed at discussing published information about a particular topic or research question. To identify the problem statement various research paper were studied.

3.2 MIDAS Software

Midas Civil is Bridge Design & Analysis software that combines powerful pre- and post-processing capabilities with a very fast solver to easily, quickly and effectively model and analyze bridges. There are also several simple parameters change tools available for parametric analysis, resulting in an optimized and economical design. It makes it easy to create nodes and elements as if you were drawing a drawing, using the main features of your CAD program. It offers powerful auto-modeling features such as Auto Mesh Generation and various Bridge Wizards. With Bridge Wizards, you can quickly model your completed bridge. You can make changes to the model to get as close as possible to the actual structure. Other modeling approaches such as CAD import, table format modeling, and code format modeling are also available. It provides linear and non-linear structural analysis capabilities and can handle different types of analysis.

3.3 Processing of data

Skew slabs possesses a large variety of utility in gift instances due to numerous motives like, area regulations in city areas, while roads ought to increase or from time to time ought to byskip via abnormal area, places wherein there are a few different sorts of geographical constraints like mountains, while roads go the obstructions like rivers, from time to time due to spiritual ideals like Mosques, Temples, Church comes withinside the manner of roads. Also, there's much less studies on skew bridge. To analysis the statement the type of Bridge is Minor Bridge having length of 30 m with Spaning arrangement of 3*10 m. The thickness of slab-0.60 m, and angles considered are 0°, 20°, 40°, 60° and 65° with M-30 grade of concrete.

4. Result

The result for deflection and moments are as follows:

Table -1: Deflections

Deflections due to various skew angles	
Skew Angle	Deflection (m)
0 Skew	0.000954
20 Skew	0.001144
40 Skew	0.000836
60 Skew	0.000206
65 Skew	0.000155

Table -2: Wood Armer Moments

Skew Angle	Direction 1			Direction 2		
	Top (Negative) (kNm)	Bottom (Positive) (kNm)	Applied Shear Force (kN)	Top (Negative) (kNm)	Bottom (Positive) (kNm)	Applied Shear Force (kN)
0 Skew	495.57	424.33	332.583	105.09	138.32	204.425
20 Skew	570.41	453.6	500.408	160.08	153.13	488.007
40 Skew	622.28	372.59	587.877	250.21	171.37	914.897
60 Skew	502.41	183.86	377.035	227.7	144.37	904.498
65 Skew	437.6	145.21	317.279	201.61	130.81	806.581

5. CONCLUSIONS

As the bank or skew angle increases, there is reduction in deflection, The vertical moment is reduced, The point of maximum longitudinal moment shifts towards the corner of the buttock, Shear force concentrates on blunt corners and Lateral moment increases.

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