RELIABILITY ANALYSIS OF COMPOSITE BRIDGES

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Abstract - The prediction of the ultimate load capacity of composite bridges of slab on I steel girder construction is necessary. This is dictated by design requirements for the ultimate limit states of such bridges. In this paper, the prediction of the most probable yield line patterns of failure for relatively wide composite bridges is presented. The prediction is based on a parametric study as well as on laboratory test results on composite bridge models. The degree of fixity between the transverse steel diaphragms and the longitudinal steel girders is considered with respect to influence on the ultimate load capacity of the bridge. Good agreement is shown between the theoretical and experimental results. A method of relating IRC truck loading to the collapse load is presented. The derived equations can be used either to predict the ultimate load capacity or the required ultimate moments of resistance for design of simple-span and of continuous-span composite bridges. An illustrated design example is presented.

Key Words: **Reliability index, probability failure, CSI BRIDGE software, Three span bridge, weided plate girder.**

1. INTRODUCTION

Highway and railway bridges show a significant role in transportation systems. The vibrations happen due to the passage of vehicles have become an important consideration in the project of bridges. In particular, the collaboration problem between the moving vehicles and the bridge structures has involved much consideration throughout the last three decades. This is in part due to the fast growth in the proportion of heavy vehicles and high-speed vehicles in the highway and railway traffic and the trend to use high quality materials and therefore more slender sections for the bridges.

Composite' means that the steel structure of a bridge is fixed to the concrete structure of the deck so that the steel and concrete act together, so reducing deflections and increasing strength. River bridges are unique steel concrete composite deck slab bridges they are use T-shaped steels with a satisfying projection on the outside surface of the flange as a shear connector.

1.1 Structural reliability theory

Reliability methods are useful tool for describes the ability of a system or component to function under stated conditions for a specified period of time. Reliability is closely related to availability, which is typically described as the ability of a component of system to function at a specified moment of interval of time.

1.2 First order reliability method

There are various sources of uncertainties present in the structure should be considered in engineering design. Reliability analysis methods provide a framework to account for these uncertainties in a sensible manner. In this reliability analysis there are two types. First Order Reliability Method (FORM) and the Second Order Reliability Method (SORM).These methods are used to design and analysis of composite bridge structure with academic examples. Engineering design purposes to provide minimum levels of serviceability and safety during the structural lifespan.

2. OBJECTIVE OF STUDY

The main objective of this paper to about determine the girder and web structural system can be applied to design the bridge structure. While using efficient methods with ensuring safety measures. In order to fulfil the above purposes, a procedure is developed to evaluate redundancy of any given bridge structure as part of the broader concept of toughness.

Based on the above discussion, the two major objectives of this thesis are:

- To improve a working definition and mathematical formulation for the reliability analysis of the bridges at the system level in probabilistic design.
- The developed procedure will be used to measure the redundancy level of vehicle interact and damaged bridges in case of an accident.
- The expected traffic loads on interact and damaged bridges are Modelled and an acceptable level of failure probability for the structure should be determined.

Procedure Main procedures used to design bridges are:

- Three-span composite bridge upto 45m.
- Concrete slab with I girder at a interval of 15m span.
- Analyse the bridge model and find out the design properties for the bridges.
- Find out reliability index of a structure by using first order reliability method.

- Use CSI BRIDGE software for the analysis of composite bridge
- To study the which type of load acting on surface of the bridges and vehicular acceleration.
- Find out reliability analysis of bridge structure by using FORM ad SORM.

3 CSI BRIDGE SOFTWARE

CSI bridge software is general purpose civil engineering software ideal tool for the analysis and design of any type of bridge structural system. The Analysis Engine integral to CSI bridge software drives a refined finite-element analysis procedure. CSI bridge software is the ideal tool for users of any experience level, designing any structural system. CSI bridge software particularly useful for practicing professionals .CSI bridge software program the most useful bridge analysis and design program in the industry. CSI bridge engineers can easily define complex bridge geometries, boundary conditions and load cases.

4. METHODOLOGY

Table -1: Bridge Object Definitions Reference Line

Bridge Objects	Span Name	length m	Length m	Start Support	End Support
BOBJ1	Start Abutment	0.	0.	Abutment	Abutment
BOBJ1	Span 3	15.	15.	Abutment	BENT1
BOBJ1	Span 2	30.	15.	BENT1	BENT1
BOBJ1	Span 1	45.	15.	BENT1	Abutment

To fulfil the above objective of composite bridges can be done by the quantitative and qualitative research procedures were used. Quantitative Data collection Quantitative data was collected from Road Authority, The dimensions are include width of composite bridge, width of road, Width of pedestrian walkway. These were the basic inputs for the design of the composite bridge. Load system and load related data was collected from IRC load and resistance factor design manual.

4.1 Dimension of composite bridge

TABLE-2 Dimension of composite bridge

Types of bridges	Composite bridge	
Total length of composite bridge	45 mts	
Width of composite bridge	9.4 mts	
Number of spans	3nos	
Span distance	15 mts	
No of Lanes	2 nos	
No of columns	1 nos	
Restraints of structure	Fixed	
Pier size	0.9m	
Bent cap size	1m x 1m	
Type of vehicles	IRC CLASS A, IRC CLASS AA IRC CLASS 70R	
Vehicle speed	Lane 1	40kmph,
	Lane 1	60kmph,
	Lane 1	80kmph
IRC CLASS A and IRC CLASS 70R	Lane 2	40kmph,
	Lane 2	60kmph,
	Lane 2	80kmph

5 LOAD AND RESISTANCE MODELS

INTRODUCTION

- The composite bridge design mainly depends on the prime load combination such as dead load, live load and wind load, environmental load and other specific loads.
- The dead load components contains the deck (slab) weight, wearing service weight and barriers weight.
- Live load is divided into two components, static loads and dynamic loads.
- The moving truck represents the live load value such as IRC design code with suitable standards.
- The dynamic impact (IM) is added to live load as design requirements for this composite bridge.
- The environmental loads also included that temperature, wind and earthquake loads.
- The last ones are the specific loads, which include collision and emergency braking conditions.

6 DESIGN METHODS

Beam and slab design.

- Effective width method.
- Piegeaud's coefficient method.
- Westergaards method.
- Rankine rasshoff method.

Longitudinal girder design

- Guyon –massonet method.

- Hendry Jeagar method.
- Courbon's method.
- Also suitable standard IS Codes.

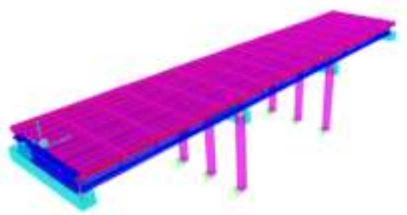

Fig 1 3D Model of Bridge structure

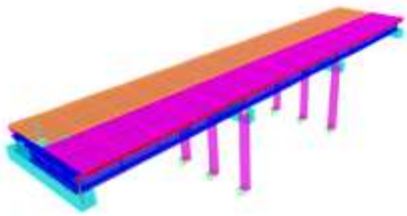

Fig 2 lane detailing

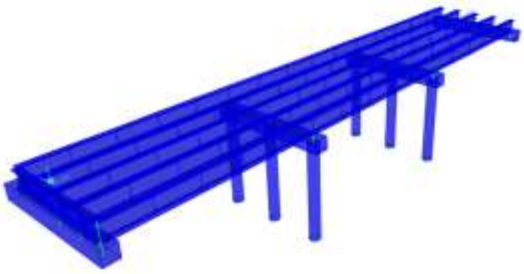

Fig 3 3D Girder Detailing

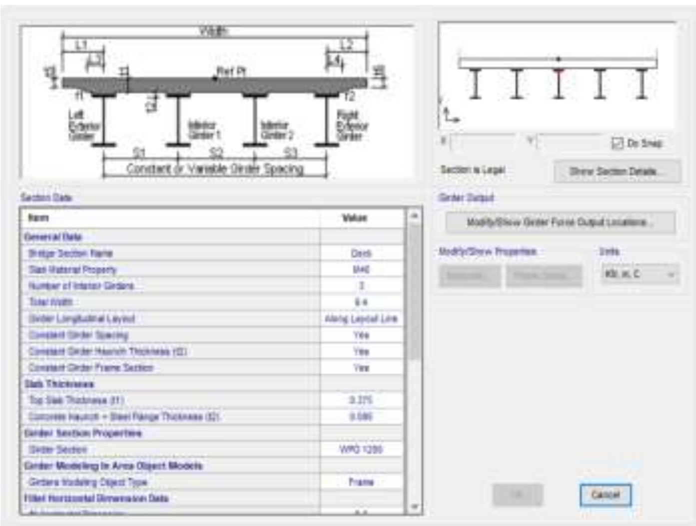

Fig 4 bridge girder and deck dimensions

The figure 1, 2, 3 and 4 represents the Model of Bridge structure, lane detailing, Girder Detailing, bridge girder and deck dimensions.

7 RESULTS AND DISCUSSIONS

The analysis of bridge models considered are carried out by static and analytical methods the results are obtained for the parameters like force stress and displacement acts at beam slab and girder section

TABLE 3 LOAD CONSIDERATION

Span (m)	P (KN)	V (KN)	T (KN-m)	M(KN-m)
0	35.06	92.38	929.73	0
3	98.83	189.27	917.34	2597.67
6	149.98	502.07	1179.19	3522.74
9	220.08	802.07	1474.73	3056.08
12	274.94	1064.13	1783.79	1467.13
15	287.32	1206.94	1993.81	463.08
18	300.27	159.38	1038.4	1507.1
21	237.88	361.07	1034.8	2774.81
24	268.31	566.31	1264.03	2824.19
27	341.79	957.83	1576.35	1615.56
30	341.81	1143.32	1877.9	372.92
33	266.92	91.96	950.08	1574.3
36	232.12	289.33	1066.56	3156.11
39	169.74	546.28	1251.37	3612.36
42	104.33	845.45	1495.93	2619.02
45	36.19	1060.37	1819.86	0

The Table 3 represents the load, bending, torsion and shear force occur in the composite bridge

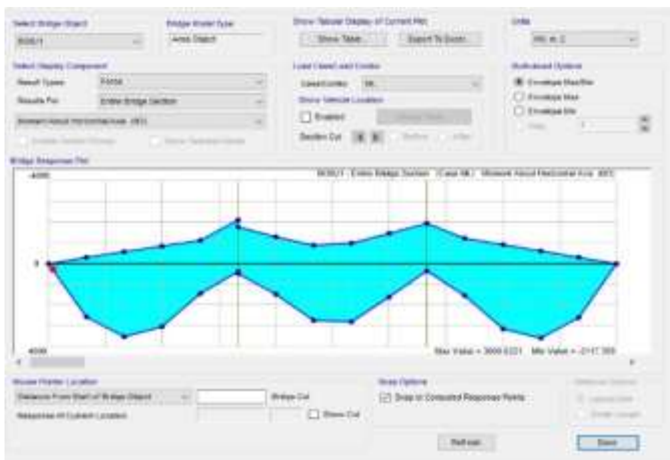

Fig 5 moment diagram at entire bridge section.

Fig 6 vertical displacement at entire bridge section

Fig 7 longitudinal stress at beams

Fig 8moment diagram at entire bridge section

The figure 5, 6, 7 and 8 represents the maximum and minimum bending moment of entire bridge section with moving vehicle load based on IRC loading.

TABLE-4 Reliability analysis for bending moments for moving load

Span (m)	C	B.M (KN-m)	Wt	R.I
0.00	4.75	0.00	0.80	11.37
3.00	5.10	2597.67	0.56	1563.04
6.00	5.42	3552.74	0.65	2132.14
9.00	5.79	3056.08	0.78	1834.14
12.00	6.30	1467.13	0.70	888.06
15.00	6.55	463.08	0.65	289.51
18.00	6.88	1507.10	0.73	912.26
21.00	7.20	2774.81	0.84	1667.06
24.00	7.66	2824.19	0.74	1698.35
27.00	7.99	1615.56	0.74	977.97
30.00	8.31	372.92	0.24	238.23
33.00	8.48	1574.30	0.58	955.08
36.00	8.86	3156.11	0.57	1900.17
39.00	9.06	3612.36	0.55	2173.10
42.00	9.32	2619.36	0.54	1580.50
45.00	9.81	0.00	0.52	16.43

The Table 4 represents the span bending moment and reliability for entire bridge section for a moving vehicle load consideration

FIG 8 Reliability analysis for bending moments for moving loads

This Figure 6 represents the Relaiability analysis of composite bridges upto a span of 45m here we plotted graph reliability index V/S bending moment probability failure will be 24% hence the result will safe as per the design criteria.

TABLE-5 Reliability analysis for shear force for moving load

Span (m)	C	SF (KN)	Wt	R.I
0.00	4.75	92.38	0.80	119.83
3.00	5.10	189.27	0.56	178.15
6.00	5.42	502.07	0.65	365.05
9.00	5.79	802.57	0.78	544.22
12.00	6.30	1064.13	0.70	701.07
15.00	6.55	1206.94	0.65	786.81
18.00	6.88	159.38	0.73	161.95
21.00	7.20	361.01	0.84	282.31
24.00	7.66	655.01	0.74	458.26
27.00	7.99	957.83	0.74	639.17
30.00	8.31	1143.32	0.24	752.95
33.00	8.48	91.96	0.58	123.40
36.00	8.86	289.33	0.57	241.65
39.00	9.06	546.28	0.55	395.33
42.00	9.32	845.45	0.54	574.33
45.00	9.81	1060.37	0.52	703.27

The Table 5 represents the span shear force and reliability for entire bridge section for a moving vehicle load consideration

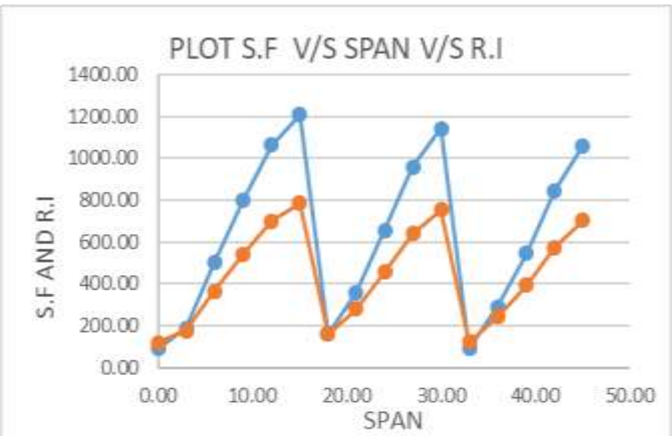

FIG 9 Reliability analysis for shear force for moving loads

The Figure 9 represents the Relaiability analysis of composite bridges upto a span of 45m here we plotted graph reliability index V/S shear force probability failure will be 24% hence the result will safe as per the design criteria.

TABLE-6 Reliability analysis for bending moments for live load

Span (m)	C	B.M (KN-m)	Wt	R.I
0	4.75	0	0.8	11.33
3	5.1	1330.85	0.56	813.92
6	5.42	1800.86	0.65	1098.37
9	5.79	1524.37	0.78	932.93
12	6.3	542.13	0.7	340.06
15	6.55	0.06	0.65	13.17
18	6.88	190.54	0.73	128.48
21	7.2	1203.22	0.84	740.76
24	7.66	1212.33	0.74	746.12
27	7.99	207.54	0.74	139.86
30	8.31	0.05	0.24	14.93
33	8.48	615.76	0.58	386.32
36	8.86	1579.59	0.57	967.69
39	9.06	1837.45	0.55	1123.2
42	9.32	1349.14	0.54	829.02
45	9.81	1.31	0.52	17.18

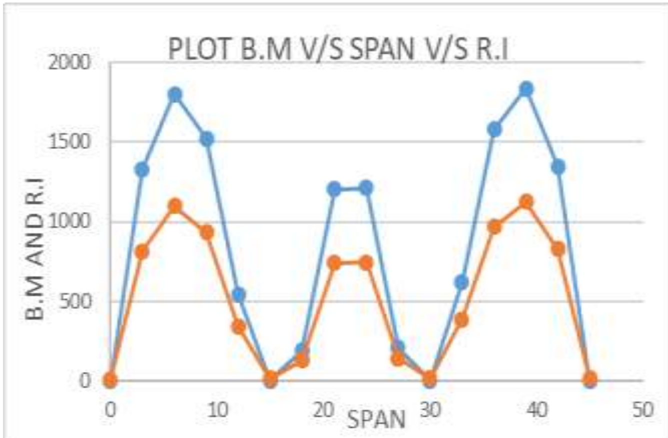

FIG 10 Reliability analysis for bending moments for live loads

This Figure 6 represents the Relaiability analysis of composite bridges upto a span of 45m here we plotted graph reliability index V/S bending moment probability failure will be 24% hence the result will safe as per the design criteria.

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TABLE-7 Reliability analysis for bending moments for live load

Span (m)	C	S F (KN)	Wt	R.I
0	5.96	0	0.8	12.54
3	6.62	14.43	0.56	21.9
6	6.75	129.34	0.65	91.36
9	6.89	329.44	0.78	212.41
12	7.02	524.05	0.7	329.86
15	7.15	666.79	0.65	415.97
18	7.28	10.74	0.73	20.34
21	7.41	10.74	0.84	20.48
24	7.55	344.28	0.74	221.97
27	7.68	611.91	0.74	383.67
30	7.81	829.38	0.24	513.01
33	8.04	3.77	0.58	16.9
36	8.2	3.77	0.57	17.05
39	8.35	135.33	0.55	96.51
42	8.51	377.87	0.54	242.83
45	8.66	548.14	0.52	345.57

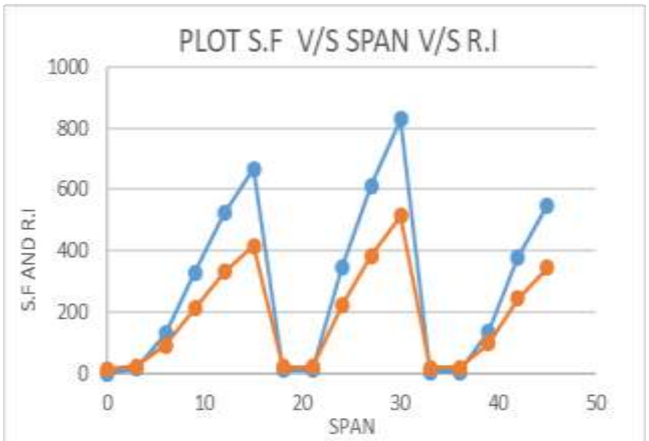

FIG 11 Reliability analysis for bending moments for live loads

This Figure 6 represents the Relaiability analysis of composite bridges upto a span of 45m here we plotted graph reliability index V/S bending moment probability failure will be 24% hence the result will safe as per the design criteria.

8. CONCLUSIONS

- The results also show that the ultimate load is a function of the longitudinal and transverse moments of resistance for both maximum and minimum bending moment.
- An investigation was conducted to calculate the ultimate collapse loads of continuous composite bridges subjected to IRC truck loading.
- The results show that the first order reliability method can be used to predict the ultimate collapse loads of such bridges.
- Test results from several skew composite bridge models are in respectable contract with those predicted from the theoretical study as well as from the finite element analysis.
- Probability failure will be less than 50% hence the structural will be safe.
- Present study considers theoretical parametersfurther investigation for existing bridges with first order reliability method to find reliability index and probability failure of a structure.
- Numerical computing technique scan be used to generate this type of composite bridge model.

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