RELIABILITY ANALYSIS OF PRESTRESSED CONCRETE BOX GIRDER BRIDGE DECK

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Abstract - *In knower days the construction of pre-stressed concrete bridges will be maximum compare to the other type of bridges in universal. Because construction of pre-stressed concrete bridge will be quicker, more economical sections, better quality control, suitable for repetitive construction, etc. considered model will be analyses by the code IRC (Indian road congress).finding the failure of structure applying different load combination like moving load (IRC CLASS AA), vehicle 1 combination (IRC CLASS A) and vehicle 2 combination (IRC CLASS 70R).the probability of failure will be find out by reliability analysis method. Reliability values are within assumed percentage of failure of structure hence considered bridge will be safe.*

Key Words: *Pre-stressed concrete bridge, AFOSM, Reliability index,…*

1. INTRODUCTION

Pre-stressed concrete bridges of beam form can be designed using the working stress method and also by limit state method. In the working stress method, service loads are used in the whole design and the strength of material is not utilized to the fullest extent. In this method of design, stresses acting on structural members are calculated based on elastic method. In fact, the whole structure during the life span may only experience loading stresses far below the ultimate state. Under such scenario, the most economical design can hardly obtain by using working stress. In Limit state method, for each material and load, a partial safety factor is assigned individually depending on the material properties and loads. Therefore, each element of load and material properties is accurately assessed resulting in a more refined and accurate analysis of the structure. In this connection, the material strength can be utilized to its maximum value during its lifespan and loads can be assessed with reasonable probability of occurrence

1.1 Reliability analyses

Reliability engineering relates nearly to safety engineering and to system safety, in that they use common techniques for their analysis and may involve the input from each other. Costs of failure affected by system downtime, cost of spares, repair equipment, personnel, and cost of warranty claims are focused by reliability engineering. Safety engineering mainly deals with preserving life and nature than on cost, and hence deals only with particularly dangerous system failure modes. High reliability (safety factor) levels also result from good engineering and from attention to detail, and almost never from only reactive failure management.

1.2 Material properties

Material properties	Values M_{40}
Unit volume	40kN/m^3
Young's modulus	3.25×e^7 kN/m^2
Poisons ratio	0.2
Shear modulus	1.31×e^{10} N/m^2
Co-efficient of thermal expansion	5.5×e^{-6}/°C
Co- efficient of concrete	5.5×e^{-6} /°C
Compressive strength of concrete	40×e^3 kN/m^3

2. METHODOLOGY

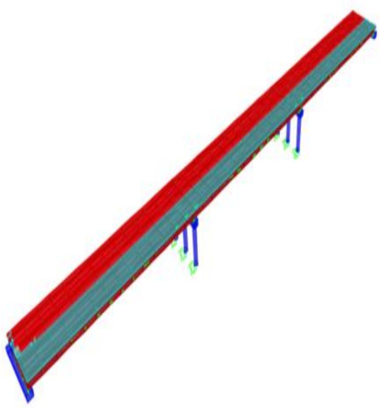


Fig 2.1 Bridge model

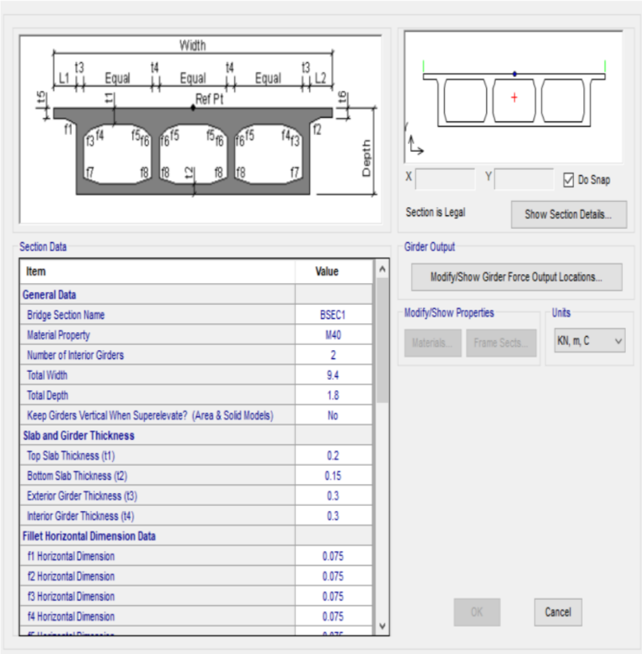


Fig 2.2 Cross section view of deck

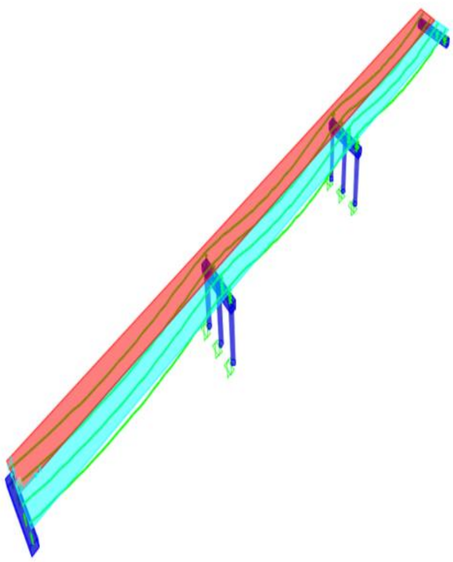


Fig 2.3 Tendons view

Table 2.1 Parameters considered for the Box Girder Bridge

Total length of the bridge	*120m*	
Width of the bridge	*9.4m*	
Number of spans	*3*	
Span distance	*40m, 40m, 40m.*	
Number of lanes	*2*	
Number of tendons	*3*	
Area of the tendon	*5.04×E-04*	
Number of columns	*3*	
Restraints	*Fixed*	
Pier size	*1m Circular*	
Bent cap size	*1mx1.2m*	
Lane width	*4.7m*	
Type of vehicle	*IRC class AA,IRC class A,IRC class 70R*	
Vehicle speed	Lane 1	40kmph,
	Lane 1	60kmph,
	Lane 1	80kmph
IRC CLASS A	Lane 2	40kmph,
	Lane 2	60kmph,
	Lane 2	80kmph
IRC 70R	Lane 1	40kmph,
	Lane 1	60kmph,
	Lane 1	80kmph
	Lane 2	40kmph,
	Lane 2	60kmph,
	Lane 2	80kmph

Formula for Reliability (R):

R = C+0.6(11-(L/D)-(0.026+0.05(L/D-11)*Wt)

Where,

R =Reliability in limit state of deflection

C = Parameter depends on span length.

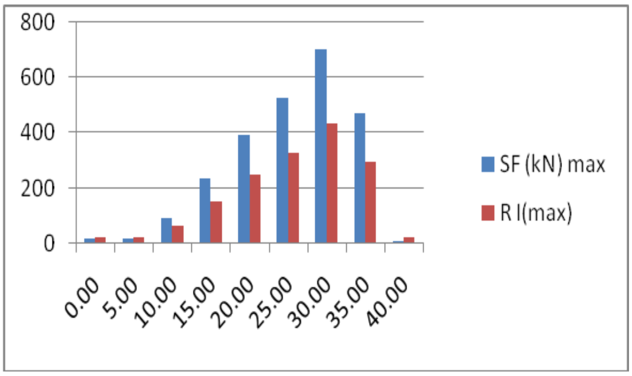
Values of C are given in table below:

Table 2.2 Values of C

L	4m	5m	6m	7m	8m	9m	10m
C	3.7	4	4.2	4.3	4.5	4.5	4.5

Table 2.3 Values of vehicle 1(IRC CLASS A) Shear force values

SPAN (m)	C	SF (kN) max	Wt	RI (max)	% FAILURE
0.00	2.95	20.52	0.80	21.80	5.86
5.00	4.00	22.78	0.90	22.78	10.39
10.00	4.50	93.54	0.78	66.88	28.51
15.00	5.30	234.84	0.64	152.06	35.25
20.00	5.96	393.63	0.53	247.71	37.07
25.00	6.62	526.93	0.49	328.10	37.73
30.00	7.28	702.49	0.62	433.20	38.33
35.00	7.94	472.99	0.85	296.34	37.35
40.00	8.60	9.77	0.43	21.04	53.56



2.3.1 Entire bridge moving load values Maximum values

R=C+0.6(11+ (LOAD)-(0.026+0.005(LOAD-11)*Wt)

RI = 2.95+.6(11+20.52)-(.026+.005*(23.3-11)*0.8
RI= 21.80

RI = 4+.6(11+20.41)-(.026+.005*(6.4-11)*0.9)
RI =22.78

RI = 4.5+.6(11+93.54)-(.026+.005*(16.73-11)*0.78)
RI =66.88

RI =5.3+.6(11+234.84)-(.026+.005*(36.91-11)*0.64)
RI =152.06

RI = 5.96+.6(11+393.63)-(.026+.005*(50.62-11)*0.53)
RI =247.71

RI = 6.62+.6(11+526.93)-(.026+.005*(47.74-11)*0.49)
RI =328.10

RI = 7.28+.6(11+702.5)-(.026+.005*(18.35-11)*0.62)
RI =433.20

RI = 7.94+.6(11+472.99)-(.026+.005*(17.36-11)*0.85)
RI =296.34

RI = 8.6+.6(11+9.77)-(.026+.005*(24.35-11)*0.43)
RI =21.04

Percentage of failure

% of failure = ((higher value – lower value)/higher value)*100

% of failure = ((21.80-20.52)/ 21.80) *100 =5.86

% of failure = ((22.78-22.78)/ 22.78)*100 =10.39

% of failure = ((93.54-66.88)/ 93.54)*100 =28.51

% of failure = ((234.84-152.06)/ 234.84)*100 =35.25

% of failure = ((393.63-247.71)/ 393.63)*100 = 37.07

% of failure = ((526.93-328.10)/ 526.93)*100 =37.73

% of failure = ((702.49-433.20)/ 702.49)*100 =37.35

% of failure = ((472.99-296.34)/ 472.99)*100 =30.29

% of failure = ((21.04-9.77)/ 21.04)*100 = 53.56

Average % of failure = 31.56

CHART 2.1 Shear force (max) v/s Reliability index (max)

The structure is considered in the study the probability of failure obtained is 31.56%. According to the theory of reliability, the probability of Failure within the limit Hence the structure is considered in study is safe

Table 2.4 Values of vehicle 1(IRC CLASS A) Bending moment values

SPAN (m)	C	BM(kN-m) min	Wt	RI (min)	% FAILURE
0.00	2.95	10.41	0.80	15.8	33.99
5.00	4.00	86.49	0.90	62.1	28.16
10.00	4.50	195.07	0.78	127.4	34.69
15.00	5.30	299.77	0.64	190.8	36.37

SPAN (m)	C	BM(kN-m) min	Wt	RI (min)	% FAILURE
20.00	5.96	401.44	0.53	252.4	37.13
25.00	6.62	452.63	0.49	283.7	37.32
30.00	7.28	1295.99	0.62	787.5	39.23
35.00	7.94	2958.01	0.85	1776.8	39.93
40.00	8.60	5909.4	0.43	3548.2	39.95

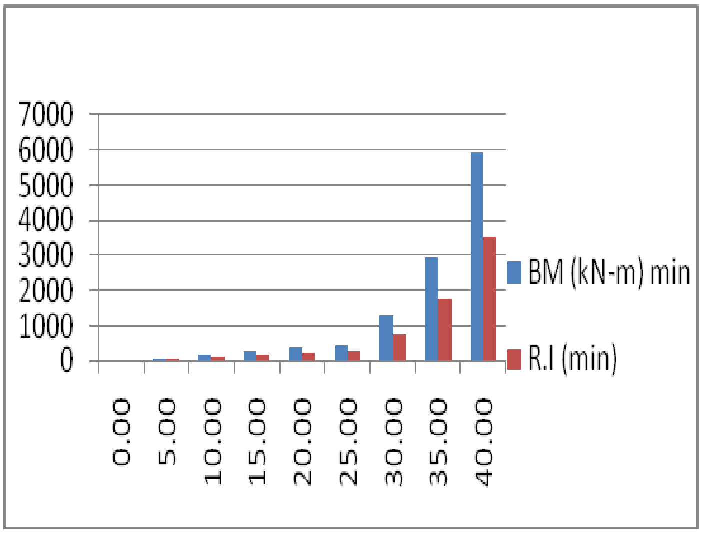


CHART 2.2 Bending moment (min) v/s Reliability index (min)

The structure is considered in the study the probability of failure obtained is 36.31%. According to the theory of reliability, the probability of Failure within the limit. Hence the structure is considered in study is safe

Table 2.5 Values of vehicle 2(IRC CLASS 70R) Shear force values

SPAN (m)	C	SF (kN) max	Wt	RI (max)	% FAILURE
0.00	2.95	63.85	0.80	47.62	25.41
5.00	4.00	63.51	0.90	48.44	23.72
10.00	4.50	180.44	0.78	118.68	34.23
15.00	5.30	360.18	0.64	226.86	37.01
20.00	5.96	411.82	0.53	258.57	37.21
25.00	6.62	962.72	0.49	588.51	38.87
30.00	7.28	1343.08	0.62	815.57	39.28
35.00	7.94	1608.17	0.85	972.63	39.52
40.00	8.60	1817.4	0.43	1101.75	39.38

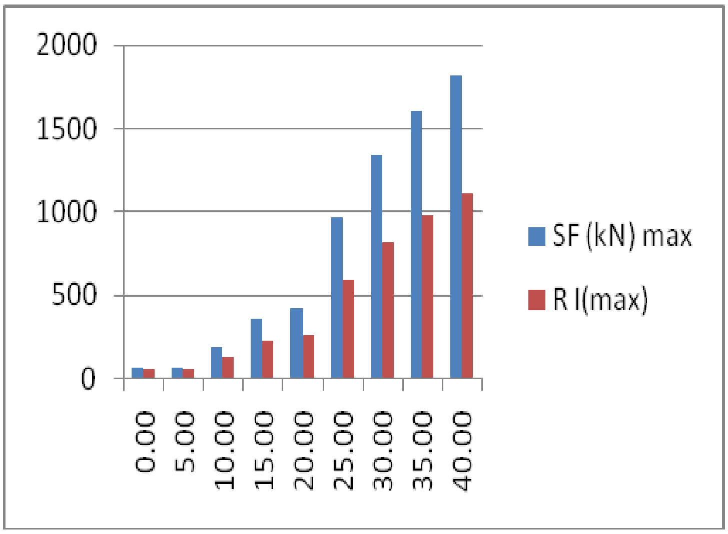


CHART 2.3 Shear force (max) v/s Reliability index (max)

The structure is considered in the study the probability of failure obtained is 34.96%. According to the theory of reliability, the probability of Failure within the limit Hence the structure is considered in study is safe

Table 2.6 Values of vehicle 2(IRC CLASS 70R) Bending moment values

Span (m)	C	BM(kN-m) min	Wt	R.I (min)	% FAILURE
0.00	2.95	21.52	0.80	22.4	4.06
5.00	4.00	255.8	0.90	163.0	36.2
10.00	4.50	607	0.78	372.9	38.55
15.00	5.30	937.5	0.64	571.4	39.04
20.00	5.96	1249.16	0.53	758.8	39.29
25.00	6.62	1570.32	0.49	951.6	39.49
30.00	7.28	2637.22	0.62	1588.0	39.78
35.00	7.94	5838.76	0.85	3493.0	40.17
40.00	8.60	11055.6	0.43	6624.9	40.07

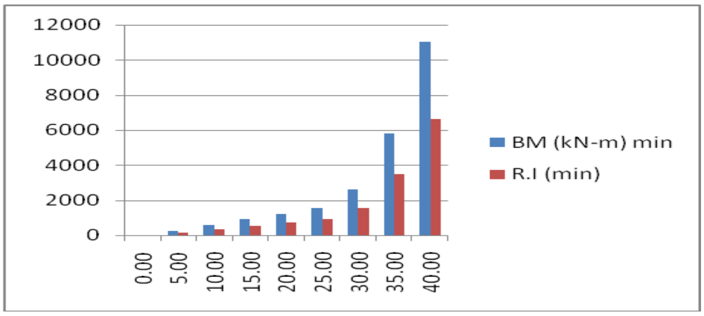


CHART 2.4 Bending moment (min) v/s Reliability index (min)

The structure is considered in the study the probability of failure obtained is 35.18%. According to the theory of reliability, the probability of Failure within the limit . Hence the structure is considered in study is safe

3. CONCLUSIONS

- Reliability index of flanged girder in limit state of deflection is determined by using advanced first order second moment method.
- The probability failure of load case will be 33.05%, Failure within the limit hence structure is safe
- The probability failure of shear force of vehicle 1 load will be 31.56%, Failure within the limit hence structure is safe
- The probability failure of shear force vehicle combination 2 will be 34.96%. Failure within the limit hence structure is safe
- The probability failure of Bending moment vehicle combination 1 will be 36.31%, Failure within the limit hence structure is safe
- The probability failure of Bending moment vehicle combination 2 will be 35.18%, Failure within the limit hence structure is safe
- Hence the probability of failure will be within the limit structure will be reliable

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