Behavior of Integral Abutment Bridge

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Abstract - Integral Abutment Bridges (IAB) are joint less bridges in which the deck is continuous and monolithic with abutment wall. They outperform their non-integral counterparts in economy and safety. Their principal advantages are derived from the absence of expansion joints and sliding bearings in the deck, making them the most cost-effective system in terms of construction, maintenance and longevity. The main purpose of constructing IAB is to prevent the corrosion of structure due to water seepage through joints. The simple and rapid construction provides smooth, uninterrupted deck that is aesthetically pleasing and safer for riding. The single structural unit increases the degree of redundancy enabling higher resistance to extreme events. To get a better understanding of the behavior of IAB in different situation, a comparative study is carried out on a typical IAB and a simply supported bridge (SSB) of same geometry and loading conditions, and compares these bridges with spring and without spring analysis at both ends. A total of three bridges were analyzed for this work by using Midas Civil Software.

Keywords - Bridge, SSB, IAB.

I. INTRODUCTION

Integral bridges in simple words can be defined as bridges without joints. Bridges constructed without any expansion joint (between spans or between spans and abutments) and without any bearings are called integral bridges. Integral bridges are characterized by monolithic connection between the deck and the substructure (piers and abutments). They span from one abutment, over intermediate support to the other abutment, without any joint in the deck. Integral bridges have been constructed all over the world including India.

The integral abutment bridge concept is based on the theory that due to the flexibility of the piling, thermal stresses are transferred to the substructure by way of a rigid connection between the superstructure and substructure.

The expansion joints and bearings, by virtue of their functions are sources of weakness in the bridge and there are many examples of distress in bridges, primarily due to poor performance of these two elements.

II. SYSTEM MODEL

Description of structure

The bridge under consideration is an RCC Fly Over (T-beam) bridge of 151.5 m total length between two abutments excluding the length of approach stabs on either side. Further the bridge is divided into seven equal spans; each span is 21.5 m effective length i.e. center to center distance between two consecutive supports and 10.55 m wide in cross section(Two Lane Bridge with footpath). The bridge deck is 300 mm thick for inner panels to resist the traffic load as per IRC Class AA single train or two trains of Class A (IRC-6-2000). Portion of deck provide as a footpath is over hang for a clear length of 1.45 m on either side from the face of external girder rib. Thickness of overhang portion of the deck is 300 mm at the face of external support which gradually reduces to 200 mm at free end. A parapet wall or anti crash barrier is provided at the free end of the footpath of 200 mm thickness and 900 mm height while at the end of the overhang other side a median verge (divider) of 300 mm thickness and 240 mm depth is provided.

There are four longitudinal girders provided across the width of the bridge, each of them is spaced 2.45 m center to center from each other, and the longitudinal girder is a T-beam of 2.45 m flange width. 0.3 m web thickness, provided with a bottom bulb of trapezoidal section with base width 0.55 m. In addition to the longitudinal girders there are some cross girders provided to distribute the loads from the deck to the longitudinal girders. These cross girders are provided at a center-to-center of 3.75 m it means there are five cross girders between two consecutive Piers, and it is 300 mm wide and 450 mm deep in section.

Longitudinal girders rests on bearings of size 300x450 mm provided with spiral reinforcement which rests on pier cap. The pier cap is equal in width that of carriage way of the bridge 8.4 m and 2.5 m deep rest on top of the piers. There are four circular piers of 1.2 m diameter provided to support the superstructure of the bridge, which rest on spread foundation. On either end of the bridge, the super structure rests on abutments, rigidly connected to the deck slab in

Integral Abutment Bridge, and simply supported in case of conventional bridge.

III. PREVIOUS WORK

Many researchers have their own experience on this topic by various researchers. Observations of field performance of IAB and related issues reported by different researches are summarized in this literature review along with the detailed discussion of the previous finite element studies on IAB. Mourad et al. [8] compared deck slab stresses in IAB with those in simply supported (conventional) bridges by applying loading of HS20-44 trucks. A finite element analysis using computer program ALGOR was carried out for this purpose. The results indicated a more uniform distribution of loads and 25-50% lower maximum stresses in the transverse direction in IAB as compared to the corresponding simply supported bridges. IAB Alampalli et al [9] concluded that the higher the skew of the bridge deck, the lower the Condition and performance ratings were for the deck, approach slab and abutment stem. Arockiasamy et al. [1] conducted a parametric study for the response of laterally loaded piles supporting Integral bridges with an emphasis on predrilled holes, elevation of the water table, soil types and pile orientation by using finite-difference program LPILE and finite-element program FB-Pier. The study concluded that horizontal displacement at the pile top, maximum shear , axial force and moments in the pile significantly depend on the type of the soil around the pile, its degree of compaction and the orientation of pile axis: while the water table elevation has very little significance. Springman et al. [2] studied the behavior of abutments of IAB and how it differed from that of simply supported bridges subjected to cyclic loading conditions Effects of temperature variations on the soil-structure interaction were investigated by using the centrifuge modeling technique. Displacement –controlled loading was employed in the centrifuge model tests, which were conducted on a spread-base integral bridge abutment.This was done by imposing controlled cyclic displacements at the top of the abutment wall thereby simulating the thermal expansion and contraction of the bridge. According to Khondair et al [3] the secondary stresses in the bridge deck due to temperature changes and substructure settlement can be significantly higher than those permitted by current design specifications, thus highlighting the lack of sufficient knowledge base with reference to IAB based on the results of a literature review, field inspections, and a finite element analysis , the following conclusions are drawn concerning the behavior of integral abutment bridge.(3) Integral abutment bridges perform well with fever maintenance problems than conventional bridge. Without joints in the bridge deck, usual damage to girders and piers caused by water and contaminants from the roadway is not observed. Very few detailed analytical studies with focus on thermal loading have been carried out on IAB.

IV. PROPOSED METHODOLOGY

Notations:-

IAB: - Integral Abutment Bridge
SSB: - Simply Supported Bridge
IAB WSA: - Integral Abutment Bridge With Spring

V. EXPERIMENTAL RESULTS

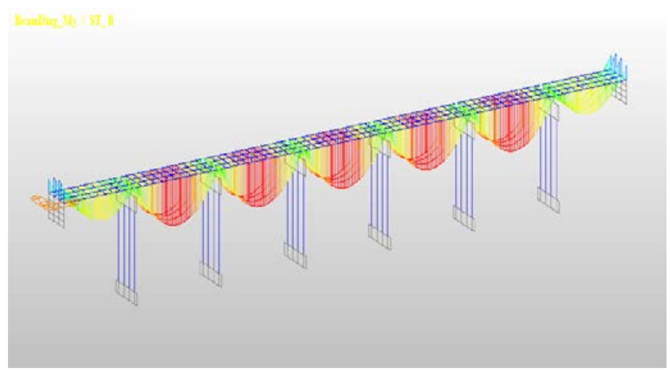


Fig 1 Simply Supported Bridge Bending Moment Diagram

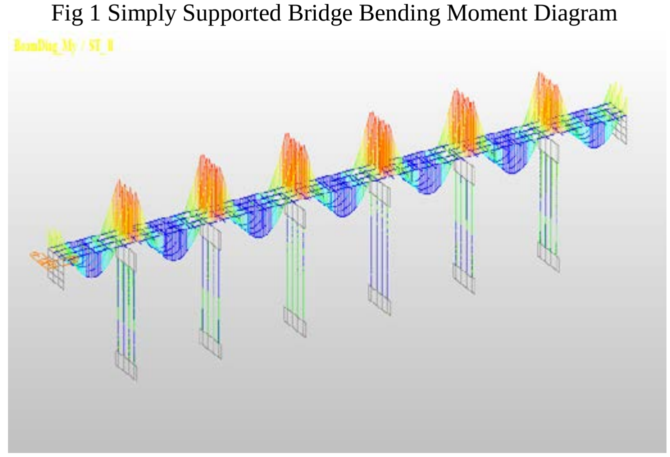


Fig 2 Integral Abutment Bridge Bending Moment diagram

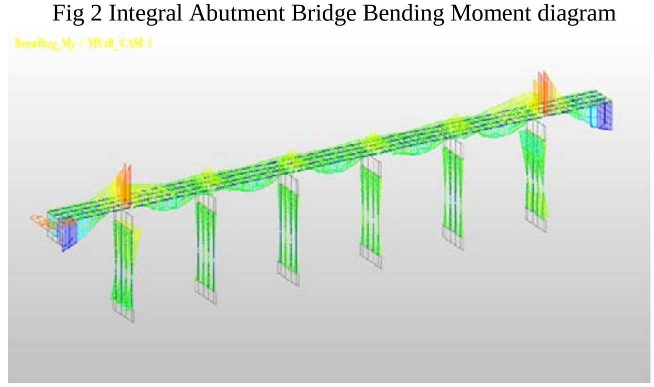


Fig 3 Integral Abutment Bridge (Spring Analysis at Both End Abutments Bending) Moment Diagram (IAB WSA)

TABLE1. OUTER GIRDER MAXIMUM BENDING MOMENT

Load Cases		SSB Max M_z (kNm)	IABWSA Max M_z (kNm)	IAB Max M_z (kNm)
Dead load	Hogging	0	86.484	210.37
	Sagging	-447.38	-355.47	-423.59
Load Case 2	Hogging	0	125.86	187.38
	Sagging	-610.37	-467.74	-617.37
Load Case 50	Hogging	0	122.454	143.470
	Sagging	-416.86	-345.56	-402.54
Load Case 96	Hogging	0	96.54	137.30
	Sagging	-683.47	-287.43	-453.27
Temperature	Hogging	9.73	3.651	14.33
	Sagging	-186.35	-98.76	-157.38
Backfilling	Hogging	0	0	0
	Sagging	-18.37	-48.33	-11.38
DI+TI	Hogging	0	34.56	64.38
	Sagging	-638.48	-327.27	-511.38
Combination	Hogging	0	3.568	58.38
	Sagging	983.48	-503.37	-767.39

TABLE 2. INNER GIRDER MAXIMUM SHEAR FORCE

Load Cases		SSB Max Fy (kN)	IABWSA Max Fy (kN)	IAB Max Fy (kN)
DEAD LOAD	Max –ve	192.398	270.432	201.22
	Max +ve	0	0	0
LOAD CASE 2	Max –ve	389.283	281.245	409.992
	Max +ve	0	0	0
LOAD CASE 50	Max –ve	240.128	214.374	270.181
	Max +ve	0	0	0
LOAD CASE 96	Max –ve	187.283	153.287	200.133
	Max +ve	0	0	0
TEMPERATURE	Max –ve	0	0	0
	Max +ve	-22.736	-53.573	-54.283
BACKFILLING	Max –ve	0	0	0
	Max +ve	-2.182	-5.385	-3.20
DI+TI	Max –ve	320.236	189.367	273.23
	Max +ve	0	0	0
COMBINATION	Max –ve	330.28	183.575	232.193
	Max +ve	0	0	0

TABLE3. STRESSES DEVELOPED IN DECK SLAB

Load Cases	SSB		IABWSA		IAB	
	Top	Bottom	Top	Bottom	Top	Bottom
Dead Load	4.76	-0.53	0.5	0	0.59	-0.98
Load Case 2	6.78	-3.67	2.46	-0.23	4.85	-0.67
Load Case 50	2.95	-0.58	0.789	-0.02	2.86	-0.74
Load Case 96	2.63	-0.43	1.234	-0.11	1.65	-0.75
Temperature	9.86	-9.54	7.234	-9.45	9.64	-17.76
Backfilling	0.66	-0.86	1.457	-1.22	1.63	-2.64
DL+TL	5.45	-10.65	7.845	-6.34	7.646	-7.68
Combination	4.74	-9.56	9.457	-10.53	12.74	-12.65

Chart 1: Outer Girder Maximum Negative Bending Moment

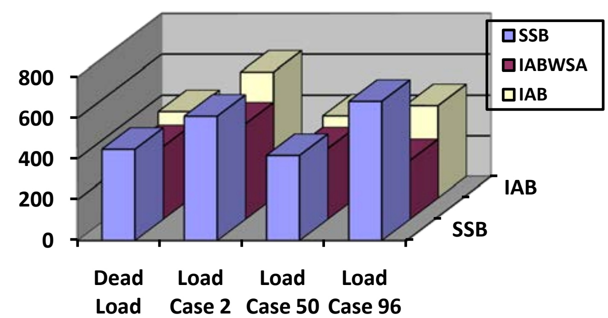


Chart 2: Inner Girder Maximum Negative Shear Force

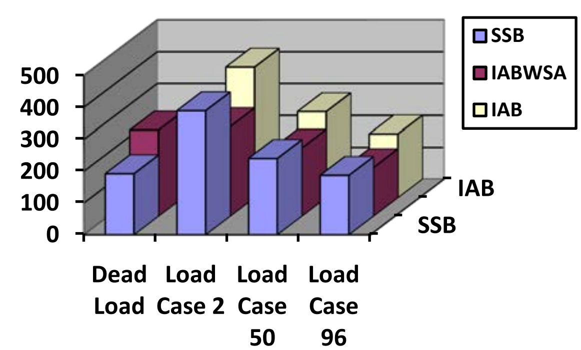
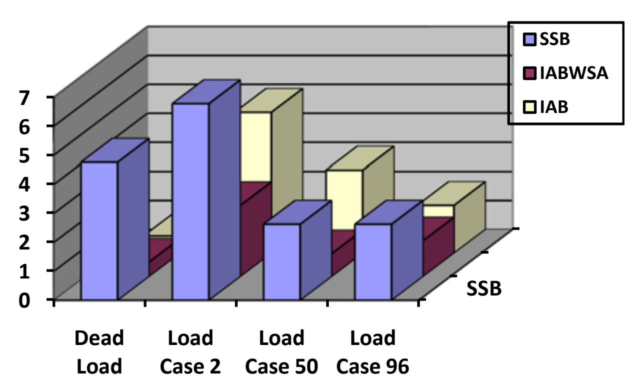


Chart 3: Stresses Developed in Top Deck Slab



VI. CONCLUSION

Near the junction of deck slab and abutment IAB has lesser stresses than SSB, because of rigid connection between abutment and deck slab, there is transfer of stresses, but in case of IAB WSA (Integral Abutment Bridge With Spring Analysis) the stresses is more as compare to SSB and less as compare to IAB because at ends abutments a spring force is develop.

Bending moment is more in SSB as compare to IAB and bending moment is less in IAB WSA as compare to both. Overall we can say that moment and shear stress developed in various components of IAB is higher than SSB, so it can be concluded that moments, stresses and forces developed in IAB is higher than the equivalent SSB because of monolithic connection between various components of the bridge, but if we provide spring analysis at both ends of the end abutment then the shear force, bending moment and forces will reduce as compare to IAB.

VII. FUTURE SCOPES

Now a day's Integral abutment bridge is becoming more popular due to its benefits like maintenance cost initial cost its life smooth riding etc, but much more research yet to be required regarding its length width and its moment and much more scope to design curve integral abutment bridges.

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