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INTEGRAL BRIDGE- Study of difference in Conventional Bridge and Integral Bridge as per Indian codes

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ABSTRACT

These days the method for bridge development are changing everywhere throughout the world. The new creative methods are created and embraced over the conventional development technique according to the necessity of the field and the auxiliary prerequisite. In this paper presented a short comprehension of the idea of Integral Abutment Bridge and its working. We endeavored to give a thought regarding the method of development of the Integral Abutment Bridge and clarifies its auxiliary advantages. There are a few focal points of the Integral Abutment Bridge over the regular bridge method they additionally expand on this paper. The paper recorded the various kinds of Integral Abutment Bridge and various components of the Integral Abutment Bridge. It endeavors to clarify the requirement for Integral Abutment Bridge in explicit territories where maintenance cost is far more and the harms to the bridge structure because of leakage in joints of the extension parts is an issue. The basic framework can possibly satisfy the prerequisites and requests of the basic necessity. The paper introduces an examination of the vital Integral bridge with the regular bridge.

1. Introduction

The bridge is only such structure which is built or utilized for the transportation over stream, valley, uneven surface or any obstacle. A bridge is to be structured with the end goal that it is safe, aesthetically pleasing, and financially useful. There is various bridge type dependent on their various criteria like - development strategy, the material utilized for development, visual appearance, working idea, the association of substructure and superstructure, range length and some more. For the most part, the bridges are divided into six type as Cantilever Bridges, Suspension Bridges, Cable-Stayed Bridge, Arch Bridge, Beam Bridge, Truss bridge. Be that as it may, with developing improvement the necessity of recently created bridge construction system and technique increments to get most extreme advantages from least expense and endeavors with this to lessen the other effect of structure on encompassing condition just as a public activity. Integral Bridge is one of those inventive types of the bridge and a lot of the number of nations on the planet are used this type of bridge over the regular bridge since its different advantages over Convention Bridge. Beginning in the mid-1960s, the utilization of jointless bridge pulled in heaps of individuals' advantage. The primary fundamental idea of Integral Bridge is the bridge which absolutely neglect joints from the deck which is given in a regular bridge system and the bearing are neglected or kept as per the requirement. When the bearing is not neglected only joints are neglected such type of structure comes under the semi-integral bridge. Due to removing joints from the deck and bearing from the abutment deck joint the damage to the structure due to leakage and corrosion which reduces the lifespan of the stricter is increases automatically. Which results in minimizing the overall cost of the bridge and make it economically more use full.

1.1 Integral bridges characteristics:

The basic working principle of the integral bridge can be explained as the stresses generated in the structure are transfer from the superstructure to the substructure by its single structure behaviour. An Integral bridge shows continuous moment connection in between the sub-structure and superstructure at the abutment area which leads to neglect the use of joints in a deck. In the other hand, a semi-integral bridge may not have deck joints but there should be bearing in deck abutment joints when it needed. This strategy is taken into consideration when ground conditions are not appropriate for a completely integral bridge in both two cases, the lateral forces acting on the superstructure is transmitted to the abutment. The Joint-less Bridge concept portrays a bridge with a continuous deck over the pear and abutment support. In some cases, there should be movement joints and bearing are provided. In multiple span integral bridge, the deck is jointless throughout its span from one end to other end or up to some specific distance by calculation for safe design.

1.2 Integral bridge classification:

There are four fundamental ways that the integral bridge can be classified, this classification is mainly based on the abutment type and its details. The four types of the integral bridge can be explained as:

1.2.1 Fully integral bridges (frame abutment):

The basic working of the portal frame and fully integral bridge in which the moment, axial force and shear force are transfer from the deck of the bridge to the supporting structure. The fully integral bridge holds the backfill behind it same as retaining walls.

1.2.2 Bank pad Integral Abutments Bridge:

Bank pad Integral Bridge is another type wherein rigid portal frame like structure. In this the end supports is totally fixed with beam of the deck of bridge. But in same situation the connection of the supports are not fixed with the ground. So they can rotate and slide.

1.2.3 Flexible support abutments:

In Flexible support abutment bridge method, Post gaps are made around the piles up to the depth of the piles. The posthole give enough space to the pile to move evenly in horizontal direction when thermal loads acting on it which causes pile to contact and expand. This will reduce foundation and soil interaction.

1.2.4 Semi-integral end screen abutments:

For this situation, additionally, end screen divider and deck shafts are necessary with one another however the end screen divider does not offer help to the deck bars. Structure with bearings which can suit even relocation is given as help to the deck bars. Since the help is discrete the dirt substructure collaboration is unimportant for this situation.

1.3 Advantages of integral bridges over the other bridge:

- The integral bridge gives improved design efficiency and improved riding quality more than the conventional type of bridges.
- The improved earthquake seismic performance make is easy constructing embankments.
- The integral bridge gives us an advantage like the elimination of water leakage.
- The construction speed is increased due to the simplifying process.
- Simplified widening and replacement detail useful for the strengthening of existing bridges.
- When seismic forces are overwhelming or critical and the blast forces are acting on structure this type of bridge method is a very good option among the other.
- The construction cost is more but if we consider overall it is less expensive.

Table-1
The structural difference in bridges

Structural type	Bearing support	Expansion Joints	Girder adjustment of expansion from thermal changes
Conventional bridge	Install	Install	Deform by the foundation
Integral abutment	Uninstall (rigid frame)	Uninstall	Deform by the flexible pile foundation
Portal frame	Uninstall (rigid frame)	Uninstall	Resist by the rigidity of the back wall and foundation

2. Existing Major Integral Bridge:

- Kalkaji FlyoverDelhi.

Place - vital T-junction on Ring Road.

Length -150m. The five-span jointless deck (25m + 30m + 40m + 30m + 25m), has voided slab RC deck with a depth of 1.70m, which was expanded to 2.20m at the piers supporting the 40.0m obligatory main span.

- A11, Bruges.

Place -Bruges, Belgium.

Total length –approx. 770m+300m (K032+K031), approx. 220m (K034), approx. 150m (K112), Regular span - 35 m, max. Span -55 m, width-35.20 m, Total bridge areas - 39,000 m² (K032 + K031). 7,900 m² (K034). 5,900 m² (K112).

- Happy Hollow Creek.

Place -Tennessee.

Length -358m, it is a super-long curved bridge at over 358m. The bridge has 9 spans of precast and prestressed bulb-T concrete girders with no expansion bearings. The spans are ranging from 38.8 to 42.2 m. The two-column pier bents vary in height from 15.5 to 27.7 m.

Isola Della Scala.

Place - Isola Della Scala Italy.

The end to end length of the bridge is 400 m with 13 spans, which is the longest integral bridge in the world up to now (Zordan & Briseghella, 2007). Therefore, it would be of necessity to have specialty grid-lines for existing and future construction of integral abutment bridges.

3. Planning considerations

The planning considerations for the structure include the following parameters,

1. The span of the Structure (length of the deck).
2. Tapered edges of composite beams.
3. Grillage model for the bridge deck.
4. Seismic Zone of a bridge located in the region and soil condition.
5. Type of Superstructure.
6. Type of Foundations and Sub-Soil Conditions.

3.1 Construction stage:

The general analysis is carried out by considering that all loads simultaneously applied to complete structure. This assumption is not valid in the real construction sequences because most bridges constructed by segment, dead loads act sequentially, and hence we required construction stage analysis to get correct results.

3.2 Construction stage for integral bridges (analysis):

The general examination is performed under the presumption that all loads are at the same time connected to the structure. This assumption is not valid in the real construction sequences because most bridges are constructed by segment and dead loads act sequentially and hence we required construction stage analysis to get correct results.

- Consider before and after composite properties of the deck.
- Changes in end boundary conditions can be done.
- Allows considering deck pouring and grouping for better streamlining of areas.
- Each development organize is related to the actuated or deactivated component limit and burden gatherings.
- Every construction stage has a special element group, load group, boundary groupcreating Independent-structure.

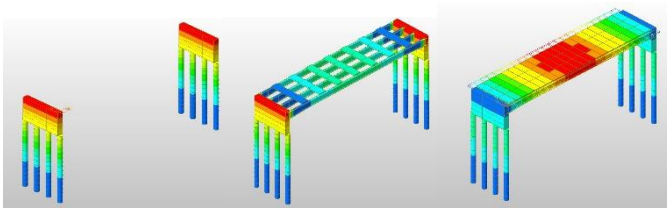

Fig 1: *Construction Stage 1, 2 and 3 (respectively).*
Construction Stage 1-Only abutment and pile.
Construction Stage 2-Abutment pile and steel structure.
Construction Stage 3-All bridge member.

3.3 Applications Integral Bridge:

The integral bridge is beneficial in an area where culverts and small brides are needed due to its simple design and working method, construction speed, the cost required for construction and cost for maintenance purpose. Integral bridge improves the visual look of the bridge and gives a smoother driving experience to the public. It increases the sustainability is the seismic force. It can likewise use for the restoration of the existing bridge. IAB can be developed using structural steel, RCC, or Composite of both.

3.4 Practical significance of work:

The structures must be safe, economical and provide good serviceability. These needs are fulfilled by integral bridges. By removing expansion joint and bearing which leads to saving the construction cost and the maintenance cost as well. After completion of work, it will prove how the construction stage analysis is easy and more realistic results shows, which match to the real practical life conditions.

3.5 Methodology of the study:

The following stages of work done as per a required analysis of the integral bridge,

- Select the composite integral bridge with fixed width and single span.
- Model the selected structure in MIDAS Civil 2019.
- Analyze the structure for a live load considering IRC-6 2017.
- Obtain the grillage model and tapered girder with loads and boundary condition.
- The behavior of a bridge with respect to the construction stage.
- The behavior of a bridge in without the construction stage.
- Observation of results and discussion.

Table-2
Structural details

No.	Structure	Configurations	No.	Structure	Configurations
1	Type	Integral bridge	6	Type of material	Composite concrete and steel
2	Span	40m	7	Width of footpath	1.5m at each side
3	Total Width	12m	8	Pile diameter	1m
4	Width of 2 lane	9m	9	Pile depth	15m
5	No of lanes	2	10	Abutment size	1.2m x 5m x 9m

3.6 Construction stage analysis details:

The function allows us to define construction stages to analyze a bridge structure showing the effects of structure configuration, elastic, displacements and time-dependent like creep and shrinkage.

The results of all earlier stages aggregated and connected to the present stage. When initiated components, boundary conditions and loads stay active until they deactivated.

Table-3
Construction Stage Analysis

Stage no.	Duration of stage	Details
CS1	15	In the first stage, the abutment and the pile are activated And all supports are activated And the self-weight and the earth pressure is activated
CS2	15	In this stage, the main girders of the deck activated with cross bracing and the wet concrete load activated.
CS3	15	In this stage, only the transverse grillage member activated to distribute the load.
CS4	100	In this stage, the parapet load and crash barrier load activated.

4 Concluding Remarks

For the analysis of Integral Bridge with two different methods 1.With construction stage method and 2.Without construction stage method, respectively the following observations made:

1) The present study was performed to understand the basic difference between using the construction stage method because as we know the conventional method does not give the exact practical result. Therefore, the construction stage that gives more improvised & better results.
2) For the same model of the bridge with the same loading condition, same parameters, material, and sectional properties both methods are applied and analysis carried out gives different results.
3) The results vary in some parameter and some situations that is the minimum values and maximum values are different in another method from the first method and the nodes where they act. However, in some parameters, the situation both method gives approximately the same results.

4.1 Results from comparison:

Table-4
Results in tabular form (CS= Construction stage)

Parameter	Description
Vibration mode shape values for 15 mode.	CS is more
Influence line maximum displacement in Z-direction.	CS is more
Influence line- beam shear force in Z-direction.	CS is more
Influence line beam moment in Z-direction.	CS is more
Maximum and minimum reaction force in XYZ- Direction.	CS is more in SUM & DL load case
Maximum and minimum reaction moment in XYZ- Direction.	CS is more in SUM, DL & LL load case and less in RS load case
Deformed shape resultant in X, Y, Z.	CS is more in SUM & LL load case and less in DL & RS load case
Maximum displacement resultant.	CS is more in the DL load case and less in SUM, LL & RS load case
Maximum beam shear force in Z-direction.	CS is more in LL load case
Maximum beam moment in Z-direction.	CS is more SUM, DL & LL load case
Maximum beam shear force diagram in YZ-Direction for all load cases.	CS is more in LL load case and less in DL & SUM load case
Maximum beam moment diagram in YZ-Direction for all load cases.	CS is more in SUM, DL & LL load case

4.2 Conclusion:

From all the above results, it can be stated that as we do software and theoretical calculation is not the same as the results are coming when construction is done on the actual site. The duration of the construction of the member and the effect of the loads changed with time so for analysis the structure this point should take in consideration so we can get the exact results of the structure and this requirement can be fulfilled by the construction stage method analysis.

The integral abutment bridge is nothing but an excellent option for the replacement of conventional bridge method. The integral bridge is the best method when the maintenance cost of the bridge is high and the frequent maintenance is required and damage to the structure occurs because of leakage. The integral bridge gives lots of advantages over other conventional bridge construction methods like the seismic response of the integral bridge is very good and suitable for earthquake-prone areas. And helps to improve load distribution and durability of the structure. The construction speed is also increased in case of the integral bridge due to its simple structural system. The integral bridge is used in situations like strengthening of existing conventional bridges and better option to replace or widening conventional bridge. The all around the world majority of the country are accepted the integral bridge and India is also moving forward in integral bridge system.

The construction stage method for analysis of structure is used then it will give us exact results which we cannot achieve in the conventional analysis method. The Midas civil is a best and suitable tool (software) to do an analysis of the bridge structure as per the construction stage method.

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