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Study and Compare Effect of Active (K_a), Passive (K_p) and Design (K^*) Earth Pressure on Integral Abutment Bridges by Soil-Structure Interaction.

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Abstract - Integral abutment bridges (IABs) are increasingly being used to eliminate undesirable effects of bridge joints on the long-term performance of bridges. Soil-structure interactions at the abutments occurring during loading of a bridge are complex in skewed and long span IABs. The goal of this study was to better understand the complex soil-structure interactions that occur in IABs and to develop design guidelines. Horizontal movements of the superstructure cause deformations in the infrastructure, resulting in a complex interaction with the soil. Geotechnical concerns may occur as a result of this interaction, compromising the bridge's and approach embankments' serviceability. The occurrence of bump at the end of the bridge (a difference in settlement between the abutment and the earth) is increased in IABs by reaching the active stress condition during deck contraction. The lateral earth pressure, on the other hand, increases as the deck expands. Ratcheting occurs behind the abutment as a result of the cyclic stress of the earth.

Key Words: Integral Abutment Bridges; Soil-Structure Interaction; Ratcheting; Effect of K*(Enhanced Lateral Earth Pressure due to Soil Ratcheting), MIDAS Civil (2019).

1 INTRODUCTION - The effect of soil-structure interaction (SSI) on the reaction of bridge structures is important. Despite the body of study on the subject, there are still several areas that remain unclear. Furthermore, design codes do not cover many aspects of SSI effect in their provisions. IRC SP-115:2018 is has included the effect of design earth pressure on integral abutment bridges as per the basis of European code (PD-6694-1:2011).

Integral bridges are characterized by monolithic connection between the deck and the substructure. This rigid connection allows integral bridges to act as a single unit in resisting thermal and brake loads.

The effect of SSI should be taken into consideration in the analysis for a better performance of an integral ridge. All civil engineering structures have at least one structural element in direct contact with the soil. It is vital to consider the response of the soil supporting the structure in order to determine the exact response of the superstructure, which is clearly explained in the soil structure interaction analysis. Several studies have found that the complicated soil structure relationship in integral bridges poses a significant challenge for engineers in terms of designing and predicting the behavior of integral bridges in use while taking into account the SSI impact. Integral bridge post-construction problems are primarily geotechnical in character, not structural. In this project, we will study the effect active, passive and design earth pressure on integral abutment bridges by soil structure interactions.

1.1 What are Integral Abutment Bridges?

An integral bridge are defined as having no expansion joints or sliding bearings, the deck is continuous across the length of the bridge. Integral bridges are alternatively referred to as integral abutment bridges, joint less bridges, integral bent bridges and rigid-frame bridges. Integral Abutment Bridges are structures where the superstructure and substructure move together to accommodate the required translation and rotation. They span from one abutment over intermediate support to the other abutment, without any joint in deck. Integral bridges are constructed all over the world including India. The Integral Abutment bridge concept is based on the theory that due to the flexibility of the pilling, thermal stresses are transferred to the substructure by way of a rigid connection between the superstructure and sub structure.

2 LITERATURE REVIEW –

- **Analysis of soil-structure interaction mechanisms on integral abutment bridge (shyam nandan roy1, umesh pendharkar2, raghvendra singh3)**Bridges constructed with joints are identified as conventional bridges. Bridges constructed without joints are known as integral bridges. The present research work includes the analysis of 3D numerical model with 5 m-high abutments, 40 m span length and 15 m length pile foundation with 0.85 m diameter in the integral bridge using the finite element analysis software MIDAS CIVIL (2011) that simulate the behaviors of integral abutment bridges to assess the soil-structure interaction between the pile and soil. In addition, this work evaluates and validates the suitability of integral abutment bridges for different types of foundation soil by a parametric study under the static loading conditions. The results obtained from the analysis, the vertical displacement estimated in dense sand and soft clay are 6.3 mm and 31.1 mm respectively. The maximum permissible deformation of group pile as per IS: 2911, part 4, 1985 is 12.0 mm

- **INTEGRAL ABUTMENT BRIDGE- A review and comparison of the integral bridge and conventional bridge (amit bamnali1, P.J. Salunke2)** nowadays the methods of bridge construction is changing all over the world. The new innovative methods are developed and adopted over the traditional construction method as per the requirement of the field and the structural requirement. In this paper introduced a brief understanding of the concept of integral abutment bridge and its working. We tried to give an idea about the procedure of construction of the integral abutment bridge and explains its structural benefits. There are several advantages of the integral abutment bridge over the conventional bridge system they also elaborate on this paper. The paper listed the different types of bridges and different types of the integral abutment bridge. It tries to explain the need of integral abutment bridge in specific areas where maintenance cost is way more and the damages due to leakage and corrosion of the bridge components is a major problem. The structural system has the potential to fulfill the requirements and demands of the structural requirement. The paper presents an elaborate comparison of the integral abutment system with the conventional bridge system.
- **Performance analysis of geometrical irregularities of integral type bridge: state of art (meet vora1, abbas jamani2)** bridges are very important structures considering the connectivity of road network. The high initial cost, seismic/wind vulnerability and maintenance play a major role in any bridge. Integral Type Bridge overcomes this by eliminating expansion joint and hence bearing too. As the structure act as a single unit there is no moisture seepage which deteriorates the materials. This bridge is proposed to provide robust configuration against earthquake shaking and increase the durability due to exclusion of joints and bearings. The portal frame disperses the loads more evenly and the resulting sections can be more economical and aesthetic. The insight is provided into the behavior of these bridges
- **Behavior of integral abutment bridge with spring Analysis (1shaikh tausif, 2l.G.Kalurkar)**Integral abutment bridges (IAB) are joint less bridges in which the deck is continuous and monolithic with abutment walls, due to this continuity in the bridge the bridge have less expensive, esthetically pleasing appearance, safe riding, economical in construction, prevent the corrosion. 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.

- **Comparative analysis of abutment type integral bridge & simply supported bridge by providing different geometric irregularity (ashish A charaniya1, ankit D prajapati2, aakash R suthar3, abbas R jamani4)** the bridge construction methods are changing throughout the world. The new methods are only be accepted based upon the requirement of field & structural aspect. In this paper, we have introduced the concept of abutment integral bridge by providing a pier in between & comparing it, with conventional bridge. There are total 36 model is prepared for the research work. The 24 model without soil structure interaction for abutment integral bridge & simply supported bridge (12 for each) is prepared based upon the length 20m, 25m & 30m with a skew angle of 15, 30, 45, and 60. The result is displayed in form of graph which is dictated as deflection for moving load, self-weight, & temperature. The result in form of bending moment for moving load & self-weight are also shown in form of graph. The dynamic earth pressure is also taken into account and the graph showing bending moment on abutment for the earth pressure is also presented in this research paper. The seismic analysis on abutment for this 24 model is also viewed based upon is-1893(part-3)-2014. The 12 model of simply supported bridge which is mentioned in the above paragraph without pier spring was compared with 12 model of simply supported bridge with pier spring for soil structure interaction is prepared. The result for the bending moment at the bottom of pier for moving load is shown in form of chart.

3 OBJECTIVES OF THE STUDY –

- Study Integral abutment bridges, advantages & limitations for purpose of analyzing.
- Study the Soil-Structure Interactions affecting on Integral Abutment Bridges.
- Study the Coefficients of Lateral Earth Pressure.
- Study the effect of cyclic loading on the Integral Abutment due to which (K*) Design earth pressure is under consideration, as per Euro code (PD 6694-2011) & IRC. SP-115-2018.
- Study the effect of K* on different types of Integral Abutments for analyzing stresses and its deflections.
- Study Soil Structure interactions of different types of soils on abutments & pile foundations using spring method in MIDAS Civil (2019).

4 METHODOLOGY –

- To study IRC. SP-115:2018, that includes Integral Abutment Bridges & effect of Soil-Structure Interactions, considering (K*) design earth pressure effect on abutments based on European code.
- To study about Integral Abutment Bridges, types, advantages & limitations, to introduce design earth pressure (K*) effect.
- To study about Soil-Structure Interactions and its applications.
- To study the Coefficients of Lateral Earth Pressure & its Intermediate Values.
- To study the cyclic loading due to seasonal effect which includes the soil ratcheting phenomenon on the Integral abutments.
- To study the methods of analysis for purpose of earth pressure on Integral abutments.
- To study the effect of Active (Ka), Passive (Kp) & Design (K*) earth pressure on different types & sizes of integrated abutments, by using “Limit equilibrium methods” & “Soil structure Interactions”.
- To analayse soil structure interaction of integral bridge on MIDAS CIVIL (2019).

5 RESULT AND DISCUSSION-

Following results obtained from the analysis of integral bridge by FEM software is discussed in the following sub sections.

5.1 Vertical Displacement of Pile Foundation:

- In dense sand, medium dense sand, stiff clay, and soft clay, the findings obtained from finite element analysis for the calculation of vertical displacement (i.e. in z-direction) of friction pile (group pile) model are around 4.83 m, 4.73 mm, 4.5 mm, and 6.31 mm, respectively.
- The total permitted settlement of a pile foundation is 12.0 mm, according to the Indian code of practise (IS: 2911, Part 4, 1985), unless a figure other than 12.0 mm is indicated dependent on the nature and type of construction.
- According to IS code, vertical displacement in dense sand and medium dense sand is found to be within acceptable limits.
- Table -3 depicts the vertical displacement of pile foundation of integral bridge in stiff clay, which is found to be roughly the same as the allowable limit.

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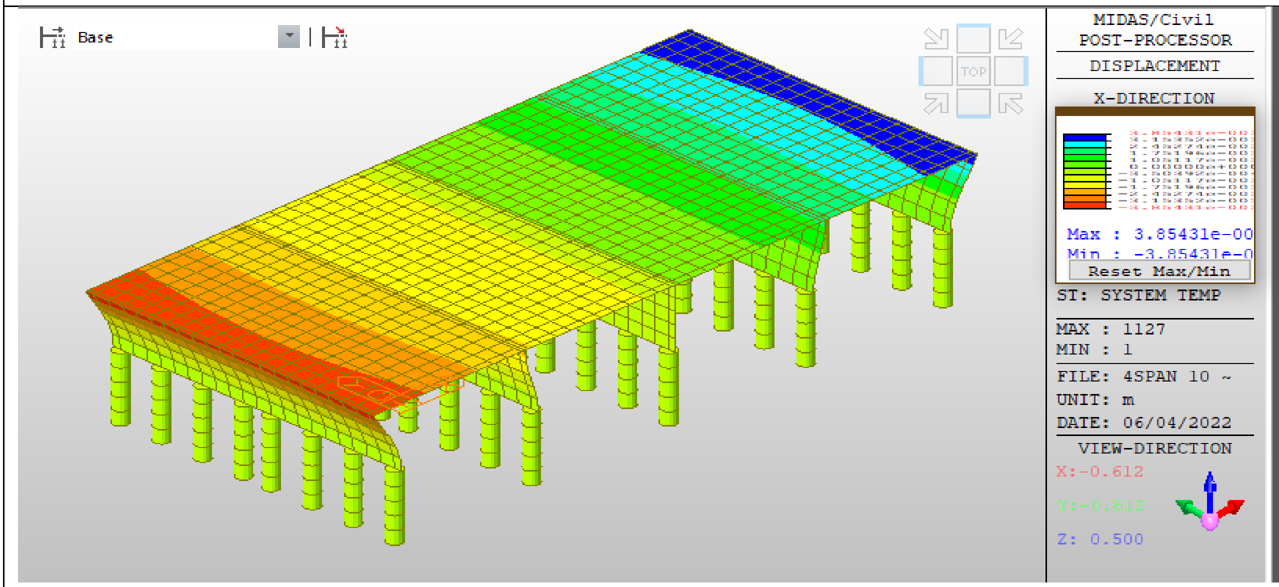
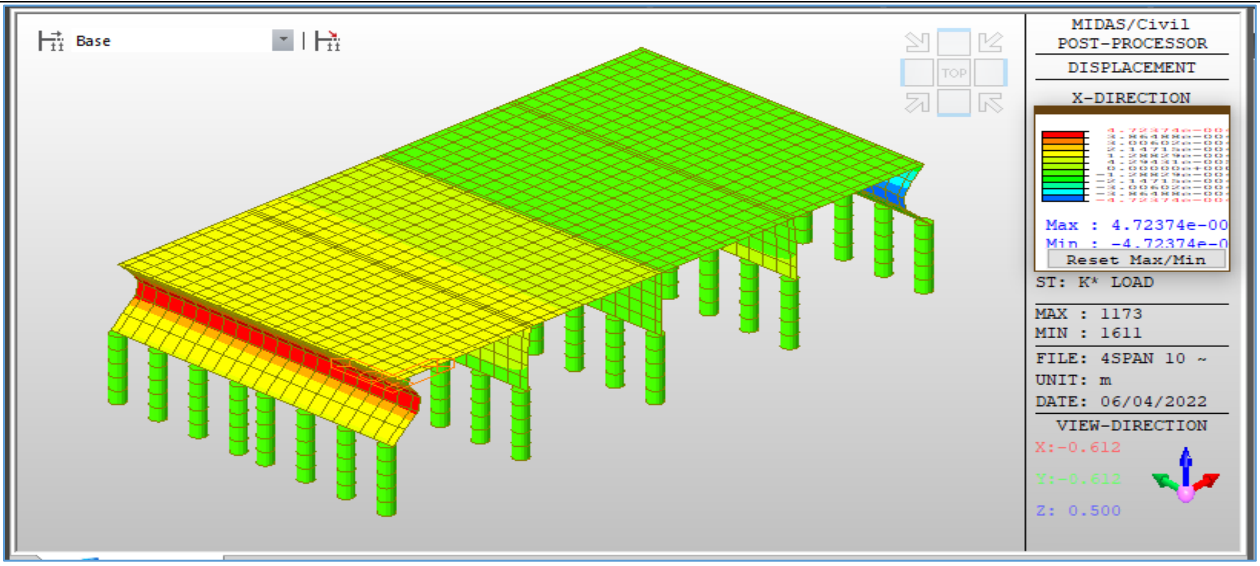
Type of Soil	Vertical Displacement of pile foundation	Vertical Displacement of Deck Slab
Dense Sand	4.83mm	40.6mm
Medium Dense Sand	4.7243mm	42.3mm
Stiff Clay	4.5435mm	51.0mm
Soft Clay	6.31mm	74.7mm

Vertical Displacement of Pile Foundation

Dense Sand:

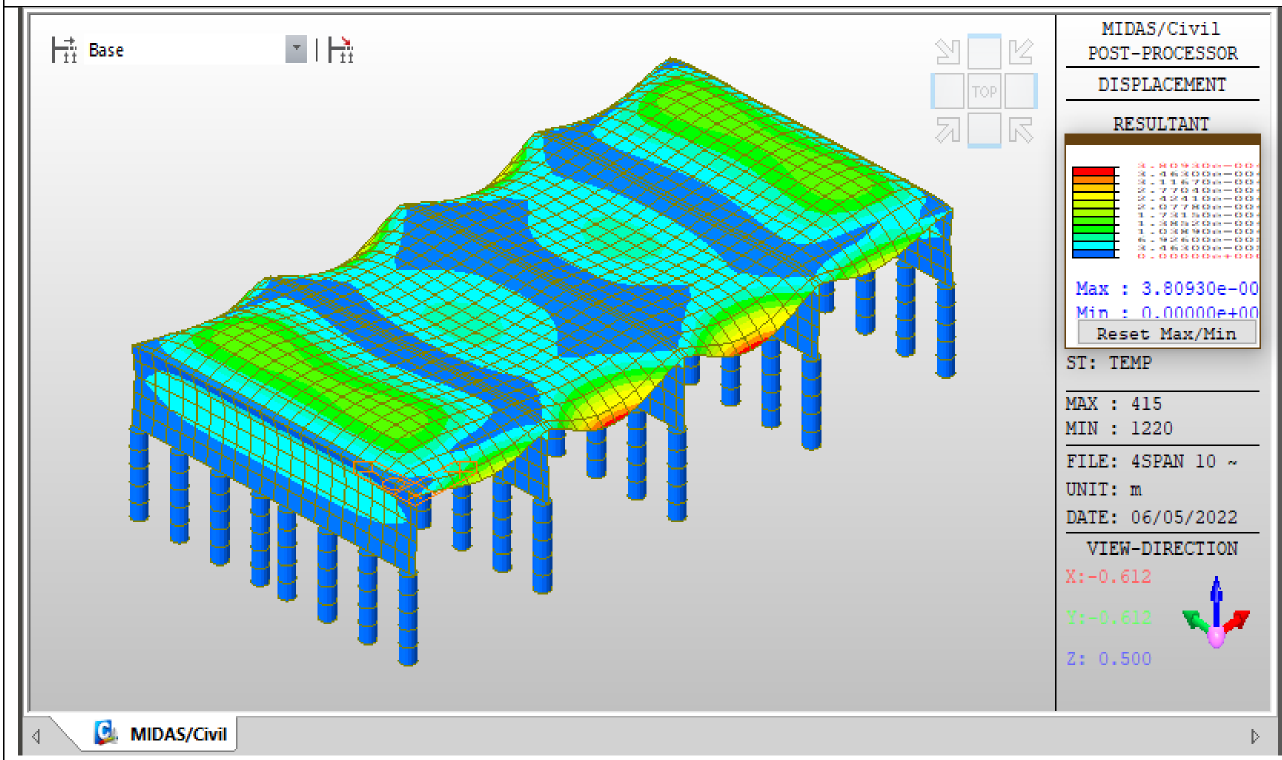


Displacements due to Earth Pressure Load on Dense Sand

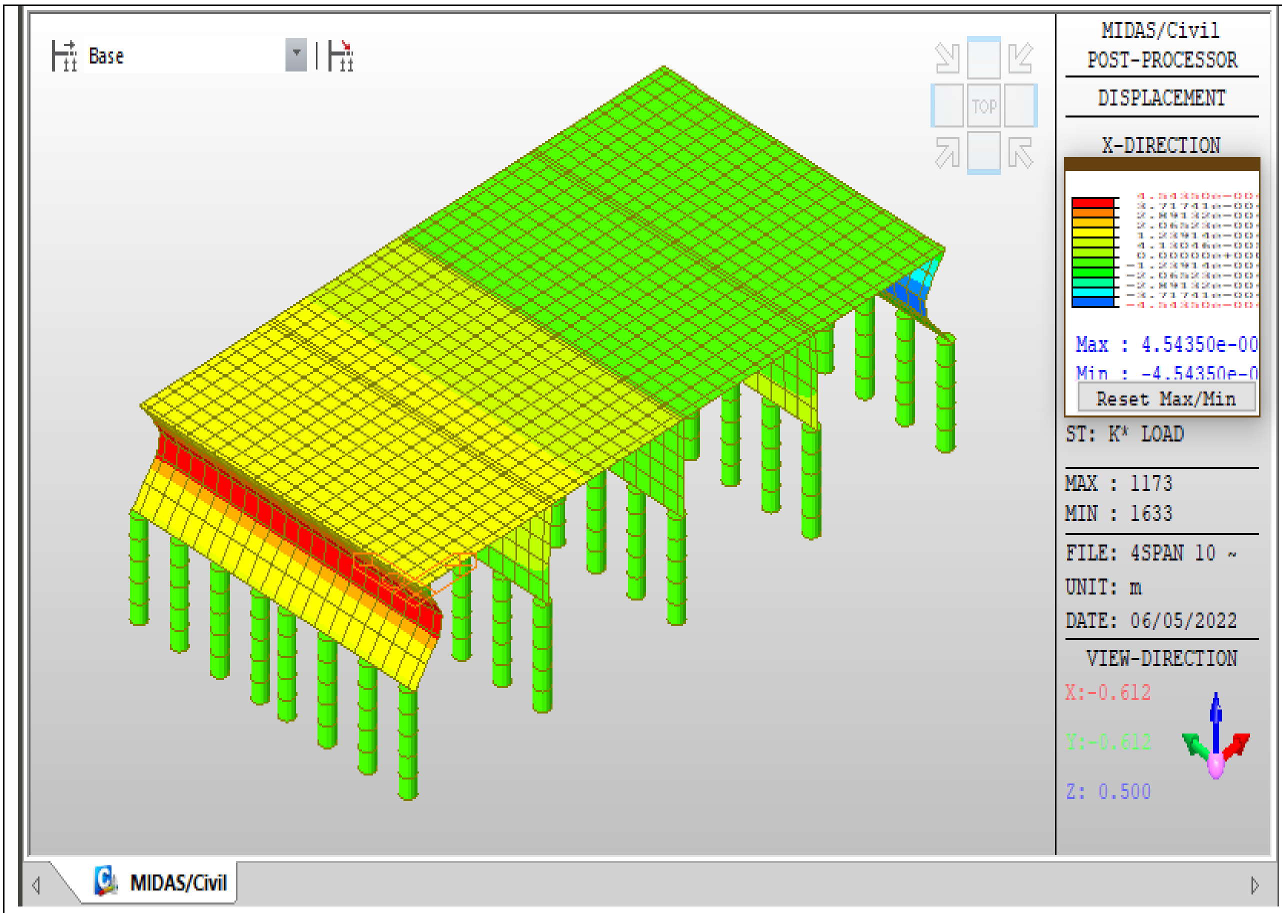


Displacements due to K* Earth Pressure Load on Dense Sand

Stiff Clay:



Displacements due to Earth Pressure Load on Stiff Clay



Displacements due to K* on Soft Clay

6 CONCLUSION –

- According to the findings, the vertical displacement in dense sand and soft clay is estimated to be 4.83 mm and 6.31 mm, respectively.
- According to IS: 2911, Part 4, 1985, the maximum allowed deformation of a group pile is 12.0 mm.
- In dense and medium sand, vertical pile displacement is within legal limits, while in soft soil, vertical pile foundation displacement exceeds permissible limits.
- The vertical displacement of the deck slab of an integral bridge supported by abutment and friction pile foundation is calculated to be 40.6 mm, 42.3 mm 51.0 mm, and 74.7 mm in dense sand, medium dense sand, stiff clay, and soft clay, respectively
- According to IS 800:2007 (2007), the maximum permitted deformation of the deck slab for four spans at a span of ten metres in an integrated bridge is 67.0 mm.

- The results showed that the vertical displacement of the deck slab of the bridge model is within limits in dense sand, medium sand, and stiff clay, but that the vertical displacement of the deck slab in soft clay is 74.7 mm, which is greater than the permissible limit of IS code (IS: 2911, Part 4, 1985), indicating that soft clay is not safe for design

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