FINITE ELEMENT ANALYSIS OF INTEGRAL BRIDGE USING MIDAS

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Abstract: *Now a day's all over the globe "Integral Abutment Bridges" is widely used. It is scientifically proved that the expansion joints which used in bridge created serious problem to natural contraction as well as expansion of bridge, lots of money and time is wastage annually in maintenance due to essential function deterioration in deciding debris or chemical. The natural function of bridge is widely affected by this drawback. As compare to conventional bridge the performance of integral abutment bridges is much better with no extra costs. In designing the piled abutments of integral bridges, it is essential to precisely predict the bridge's behavior which includes interaction between pile foundation and soils. Therefore, in this study finite element analysis is done using MIDAS CIVIL (V.1.1) on abutment bridge and behavior of pile in different type of soil is discussed on the basis of analysis.*

Keywords – INTEGRAL BRIDGE, Soil Condition, Dynamic Loading, MIDAS, Deformation

1. INTRODUCTION

Economic growth in the 20th century led to rapid infrastructure development. As a result, an increasing number of bridges are being constructed to cope with the rising road transportation demand. In the United Kingdom, the cost of construction and maintenance of this rising number of bridges has been significant and accounts for a substantial part of the annual expenditure of public funds.In the United States, there are approximately 13000 integral abutment bridges, of which about 9000 are full integral abutments bridges, around 4000 are semi-integral abutment bridges(Maruri and Petro, 2005 and NYSDOT, 2005).

Bridges may be constructed from several materials and may take one of several forms. This includes the Arch Bridge, Beam Bridge, Cable-Stayed Bridge, Cantilever Bridge, Suspension Bridge and Truss Bridge. However, the construction of these bridges may be classified under two main structural configurations bridges constructed with joints or bridges constructed without joints. Bridges constructed with joints are identified as conventional bridges. The joints provided in conventional bridges accommodate displacements mainly arising from thermal expansion and contraction of the bridge deck. These joints are usually found in the abutment and piers, providing spaces between the abutments or piers, and the longitudinal beams or slabs. The joints, known as expansion joints are designed to contain damaging forces resulting from torsion, compression or tension in all directions (Johnson, 1994). Bridges constructed without joints are known as integral bridges.

2. CHARACTERISTICS OF INTEGRAL BRIDGE

Integral abutment bridge construction has become an increasingly popular alternative in recent years and has been applied and constructed worldwide. These kinds of bridge have shown good structural performance due to their redundancy and durability. The design of integral bridges published by the Highway Agency's states that, in principle all bridges should be continuous over intermediate supports, and bridges with overall lengths not exceeding 60.0 m and skews not exceeding 300 are to be integral with their abutments. The most important is that integral bridges are rigid in their structure and conventional bridges are not.

Such bridges are the solution for small and medium- length bridges where expansion joints and bearing can either be reduced minimum or eliminated.. Their decks are continuous and connected monolithically to the abutment with a moment-resistant connection. This leads the structure to act as one unit. So far, this type of bridge has had a good record of initial cost savings, with economical use of material and maintenance. The absence of expansion joints at the abutment and bridge deck leads to reduced construction and maintenance costs. Engineers are therefore increasingly interested in using integral bridges, although there are still many problems to be overcome, such as soil-structure interaction and cracking. In Conventional bridges temperature changes effect such as expansion in summer is accommodated by expansion joint

3. MODELLING

MIDAS Finite element modeling software is used for modeling of 4.5 m-tall abutments, 40m span length,and 14 m height pile foundationintegral bridge .This FEM software helps in understanding of integral bridge behaviour with respect to soil-structure interaction between , pile and different type of soil.

Pile Geometry Model

A model for concrete friction pile, four no of pile of dia. 0.85m diameter with a spacing of 3.5 meter c/c and a height of 14 m is developed. The geometry of concrete group friction pile which is developed using software is represented by Figure 4.1. The section details and section properties of pile are represented by Figure 4.2.

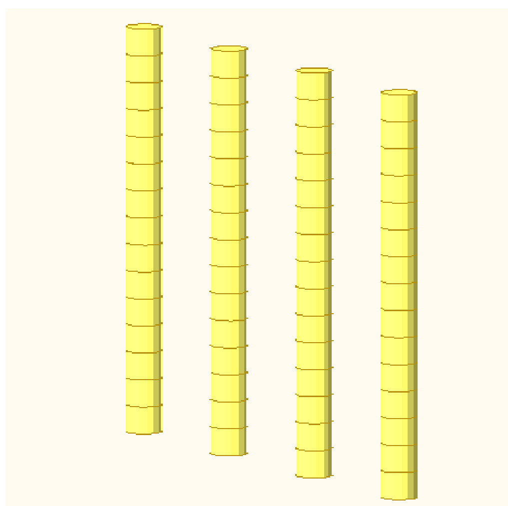


Figure4.1 Geometry of concrete pile

Table4.3 Input data for 4.5 m-highabutment

Description	Parameters	Unit/properties
Geometry	Abutment height	4.5m
	Abutment width	10.5m
	Deck length	40m

Soil parameter	Specific gravity	Dense sand : 2.65 Medium sand : 2.65 Stiff clay : 2.75 Soft clay: 2.70
	Void ratio	Dense sand: 0.45 Medium sand: 0.59 Stiff clay: 0.62 Soft clay: 0.76
	Cycle Factor (f_{cyc})	2
Thermal extension	Differential deck temp.	30
	Thermal expansion Coefficient of deck	1.00E-05/^{0}c

4. RESULT

Table 5.1 Vertical displacement, bending moment and bending stress behaviour of pile foundation in integral bridge

Description	Type of model	Displacement (mm)	Bending moment (kNm)		Bending stress (kN/m^2)
			+ve	-ve	
Pile Foundation behavior of integral bridge	Model 1: Dense sand	6.21	+1428.85	-589.78	-29730.5
	Model 2: Medium Dense sand	9.82	+1823.45	-518.23	-35425.4
	Model 3: Stiff clay	14.61	+2269.54	-324.38	-43195.5
	Model 4: Soft clay	30.94	+2307.73	-245.03	-42400.2

Table 5.2 Vertical displacement and bending stress behavior of Deck slab (girder) in integral bridge

Description	Type of model	Displacement in Vertical (mm)	Bending Stress (kN/m^2)	
			+ve	-ve
Deck slab behavior of integral bridge	Model 1: Dense sand	46.81	+72721.30	-55316.1
	Model 2: Medium Dense sand	52.28	+75865.30	-51411.1
	Model 3: Stiff clay	62.25	+84272.30	-41833.6
	Model 4: Soft clay	80.51	+87882.50	-37102.7

Table 5.3 Bending Moment in X,Y and Z direction behavior of Deck slab (girder) in integral bridge

Description	Type of model	Bending Moment (kNm)					
		M_X		M_Y		M_Z	
		+ve	-ve	+ve	-ve	+ve	-ve
Deck slab behaviour of	Model 1: Dense sand	22.82	22.82	12929.90	10657.80	428.60	428.60

integral bridge	Model 2: Medium Dense sand	21.85	21.85	13402.40	10057.60	406.99	406.99
	Model 3: Stiff clay	19.42	19.42	14687.00	8589.96	352.36	352.36
	Model 4: Soft clay	18.42	18.42	15242.20	7843.54	323.68	323.68

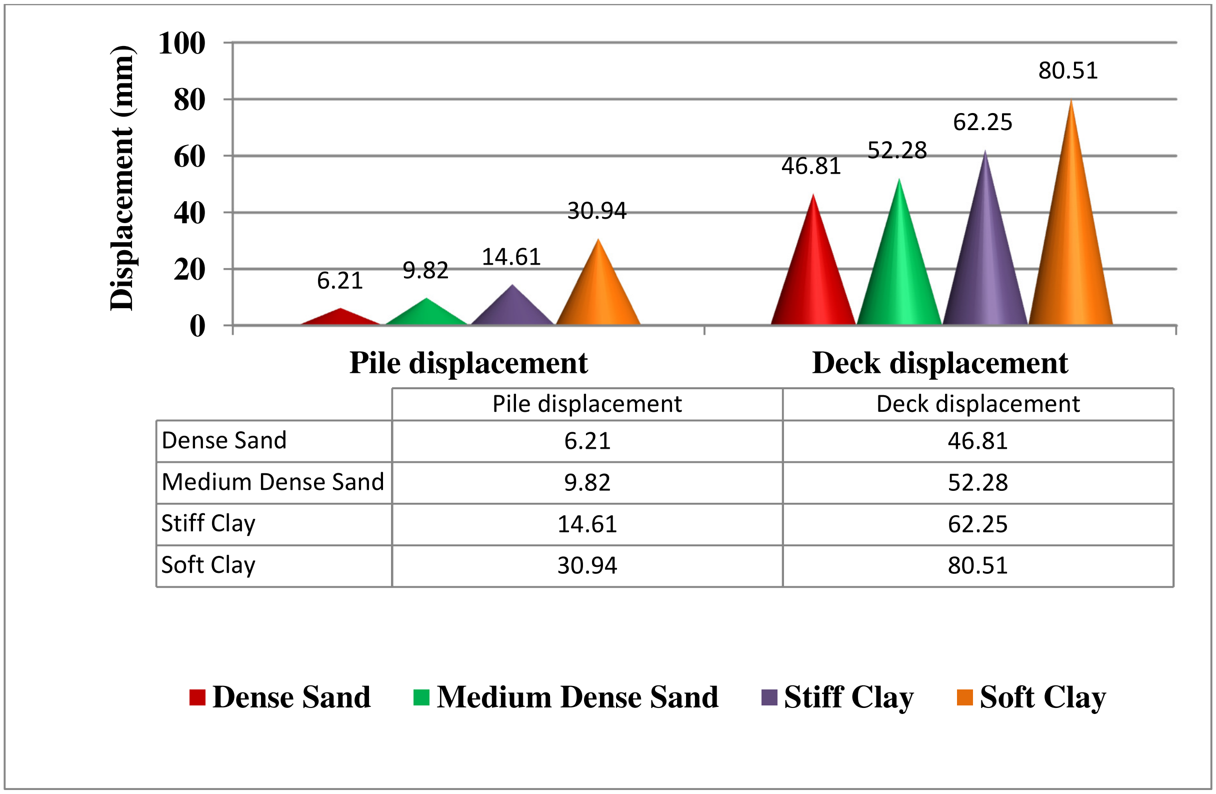
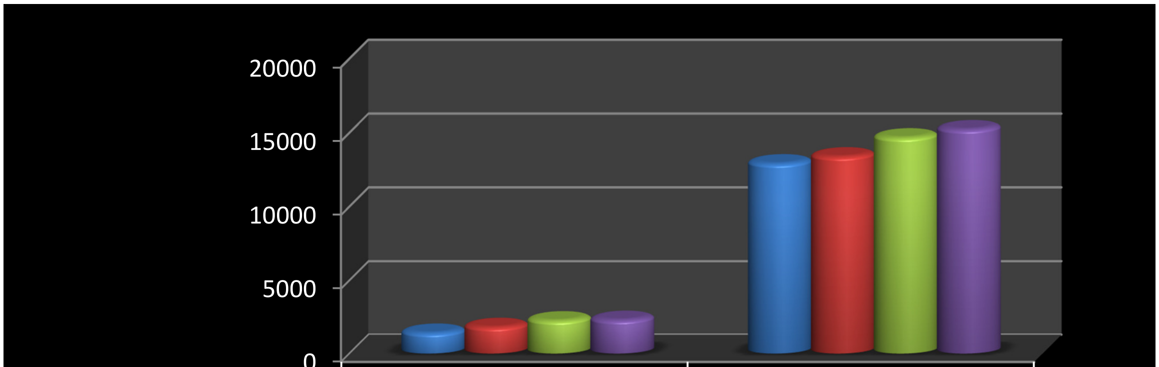
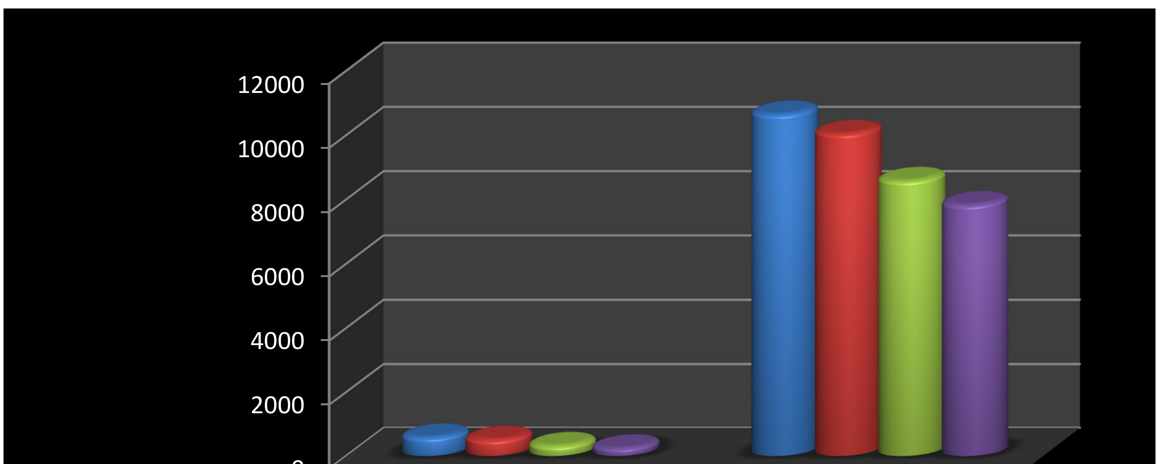


Figure No. 5.45 Vertical displacement of pile foundation and deck (steel girder) of integral bridge



	Pile Moment (kN-m)	Deck Moment (kN-m)
Dense Sand	1428.85	12929.9
Medium Dense Sand	1823.45	13402.4
Stiff Clay	2269.54	14687
Soft Clay	2307.73	15242.2

Figure 5.46 Maximum sagging bending moment (Y-direction) in pile foundation and deck (girder) of integral bridge



	Pile Foundation(kN-m)	Deck Girder (kN-m)
Dense Sand	589.78	10657.8
Medium Dense Sand	518.23	10057.6
Stiff Clay	324.38	8589.96
Soft Clay	245.03	7843.54

Figure 5.47 Maximum hogging bending moment (Y-direction) in pile foundation and deck (steel girder) of integral bridge

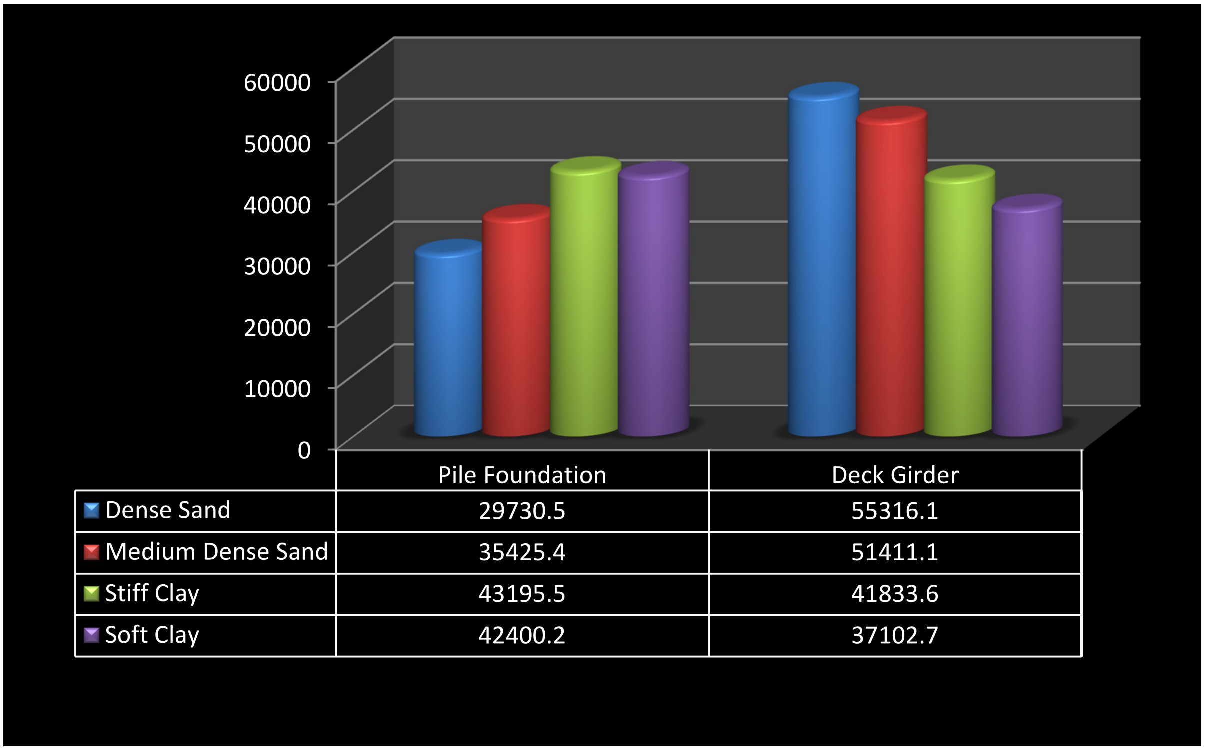


Figure 5.48 Maximum negative bending stresses in pile foundation and deck (steel girder) of integral bridge

5. CONCLUSION

The results of FEM analysis which includes the interaction behavior between pile foundation and the different types of soils are considered in the analysis. components are depending on the stiffness of foundation soil. The stiffer soils such as dense sand has permitted or allowed very less pile foundation vertical displacement and the soft soil has less stiffness as compared to the other soil. Hence for this case, the settlement of friction pile (group) foundation is more as compared to the other three types of foundation soil. .

6. REFERENCES

[1] *Alampalli, S. and Yannotti, A.P. (1998). In-Service Performance of Integral Bridges and Jointless Decks. TransportationResearchRecord: Journal oftheTransportationResearch Board, Vol. 1624.*

[2] *Arosy,S., Duncan, J.M. and Baker, R.M. (2002). Performance of Piles Supporting Integral Bridges.Transportation ResearchRecord: Journal of the Transportation Research Board, 1808, 162-167.*

[3] *Atkinson, J. (2007). TheMechanics of Soiland Foundations, London, Taylor&Francis.*

[4] *Card, G.B. and Carder, D.R. (1993). Literature Review of the Geotechnical Aspects of the Design of Integral Bridge Abutments.TRLReport;52.CrowThorne:Transport Research Laboratory.*

[5] *Carder, D.R. and Card, G.B. (1997). Innovative Structural Backfills toIntegral Bridge Abutments. TRL Report; 290.Crowthorne:Transport Research Laboratory.*

[6] *Carder, D.R. and Hayes, J.P. (2000). Performance underCyclic Loading of the Foundations of Integral Bridges.TRLReport; 433. Crow Thorne:TransportResearchLaboratory.*

[7] *Desai, C. S. and Abel, J. F.(1972).Introductionto theFinite Element Method,New York,Van Nostrand Reinhold Company.*

[8] *Dicleli, M. and Albhaisi, S.M. (2004b). Estimation ofLength Limits forIntegral Bridges Built on Clay. Journal of Bridge Engineering, 9, 572-581.*

[9] *Dicleli, M. and Albhaisi, S.M. (2005). Analytical formulation of maximum length limits of integral bridges on cohesivesoils. Canadian Journal of Civil Engineering, 32, 726-738.*

[10] *Dicleli, M. andErhan, S. (2008). Effect of Soil and Substructure Properties on Live-Load Distribution in Integral Abutment Bridges. Journal of Bridge Engineering, Vol.13, 527-539.*

[11] *Dicleli, M. and Erhan, S. (2010). Effect of Soil-Bridge Interaction on the Magnitude of Internal Forces in Integral Abutment Bridge Components due to Live Load Effects.Engineering Structures, 32,129-145.*

[12] *England, G.L. and Dunstan, T. (1994). Shakedown Solutions for Soil Containing Structures as Influenced by Cyclic Temperatures Integral Bridge and Biological Filter. 3rdInternational Conference on Structural Engineering, 159-170.*

[13] *Ford, A. (1999). Modeling the Environment: An Introduction to System Dynamics Models of Environmental Systems,Washington D.C.,Island Press.*

[14] *Faraji, S., Ting, J.M., Crovo, D.S. and Ernst, H. (2001). Nonlinear Analysis of Integral Bridges: Finite-Element model . Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127.*

[15] *Horvath, J. S. (2005). Integral - Abutment Bridges: Geotechnical Problems and Solutions Using Geosynthetics and Ground Improvement. The 2005FHWA Conference on Integral Abutment and Joint less Bridges. Baltimore, USA.*

[16] *Husain, I. and Bagnariol, D. (2000). Performance of Integral Abutment Bridges. Report BO-99-04, Ministry of Transportation Ontario, Toronto, Ontario, Canada.*

[17] *Husain, I., Huh B., Low J. and McCormick, M. (2005). Moose Creek Bridge - Case Study of a Prefabricated Integral Abutment Bridge in Canada. Integral Abutment and Jointless Bridges (IAJB 2005), Baltimore, Maryland, 148-160.*

[18] *Horvath, J. S. (2005). Integral - Abutment Bridges: Geotechnical Problems and Solutions Using Geosynthetics and Ground Improvement.The 2005Fhwa Conference on Integral AbutmentandJoint lessBridges.Baltimore, USA.*

[19] *IS 800:2007.Indian standard code of practice for General Construction in Steel, Bureau of Indian Standards, New Delhi.*

[20] *IS 6:2000.Indian standard code of practice for General Construction in Road Bridge section-2, Load and Stress, Bureau of Indian Standards, New Delhi.*

[21] *IS 456:2000. Indian standard code of practice for General Construction in concrete, Bureau of Indian Standards, New Delhi.*

[22] *IS 2911:1987.Indian standard code of practice for General Construction and Design of Pile foundation, Bureau of Indian Standards, New Delhi.*

[23] *Johnson, I.D. (1994). PerformanceofDeckExpansionJoints,London: E & FN Spon.*

[24] *Kumar, J. and Rao, K.S.S. (1997). Passive Pressure coefficients, critical failure surface and its kinematic admissibility.Geotechnique, 47, 185-192.*

[25] *Katsikadelis, J.T. and Nerantzaki, M.S. (1999).The boundaryelement method for nonlinear problems. Engineering Analysis with BoundaryElements, 23, 365-373.*