International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 2, March-April-2021, ISSN (Online): 2395-566X

Structral Behavior of Concrete Bridge with Soil-Structure Interaction

(Observation Report)

M. Tech. Scholar Neeraj Sansiya, Prof. Sourabh Dashore
Department of Civil Engineering
Sanghvi Institute of Management & Science,
Indore, (M.P.) India

***Abstract*- An iterative plan technique of progressive straight unique reaction investigations that considers the non-direct conduct of the projections brought about by refill soil yielding is created. Likewise, a non-straight static investigation of the extension soil framework is directed. These examinations explore the impacts of the dirt projection association on seismic investigation and plan of vital scaffolds. Past experience and late examination demonstrates that dirt structure collaboration assumes a significant part on the seismic creation of scaffold structures. Projections pull in an enormous segment of seismic powers, especially in the longitudinal course. In this way, investment of refill soil at the projections must be thought of. A plan-driven system to show the projection firmness for either direct or non-straight examination, considering the inlay and the wharf establishment, is introduced. An extension with solid projections is chosen to exhibit the proposed methods. Parametric investigations show that, if the scaffold is examined with the proposed system rather than a basic methodology that disregards refill firmness decrease, the determined powers and minutes at the docks are more prominent by 25%- 60% and the removals by 25%-75%, contingent upon soil properties.**

***Keywords*- Soil Interaction, Refill Soil, Soil Interaction.**

I. INTRODUCTION

Establishment conduct assumes a significant function on the presentation of parkway spans during quakes. For some, expressway spans, projections draw in an enormous bit of the seismic power, especially in the longitudinal course. After India's ongoing quake, it turned out to be very obvious that numerous projections had been exposed to huge seismic powers.

On numerous scaffolds, projection harm was the main harm revealed demonstrating that projections pulled in a huge bit of the seismic power. Essential extensions are commonly thought about a horny different to standard scaffolds introducing the monetary preferred position of lower development and support costs. Nonetheless, the development of the fundamental scaffold presents elective difficulties principally emerging from the solid affiliation that exists between the development and the foundation. The recurrence of the day by day and occasional patterns of development and compression is such granular soils react as totally depleted materials.

This can be infrequently the situation for fine-grained soils. Overabundance pore pressures are created and a couple of voidances could happen. Notwithstanding, data and asset restrictions construct it unrealistic to precisely demonstrate this as time goes on. Warm stacking brings about day by day patterns of development and withdrawal superimposed on occasional cycles. This winds up in impressively higher soil-structure cooperation movement that will cause unnecessary earth pressures behind the projection and expected disappointment of the dirt and structure.

A steady amount study was distributed to measure the effect of alteration inside the refill soil boundaries and change inside the period of development on the world weights created behind the projection. Extra the need to frame presumptions concerning the temperature cycles and the porosity qualities debilitates the strength of the investigation. This non-linearity assumes significant function in the general basic.

Accordingly, there is an unequivocal need to build up a legitimate approach to configuration spans including the impacts of soil-projection cooperation. The connection between the structures, particularly establishment and soil medium is potential to modify the genuine conduct of any structure significantly contrasted with the investigation of the structure alone. Since Integral Abutment Bridge's conduct is reliant between its basic segments and soil medium, it is imperative to decide the important boundaries of soil to speak to its conduct.

When all is said in done demonstrating of the basic component for example the mind-boggling conduct of soil because of its heterogeneous, anisotropic and nonlinear in power relocation attributes should be represented in its

© 2021 IJSRET

displaying. In building up a handy model of partner basic scaffold, the essential stage was to reenact a made instrumented necessary extension that given estimated estimations of temperature, twisting and earth pressures as expected. This permitted the model to be legitimate and hence the affectability of the investigation to the boundaries evaluated.

One of the preeminent fundamental parts of extension style is that the decrease of deck joints and development heading. Joints fall apart gratitude to affect from ceaseless live hundreds yet as from temperature-prompted cyclic stacking that causes amplification and compression of the upper deck (Figure.1).

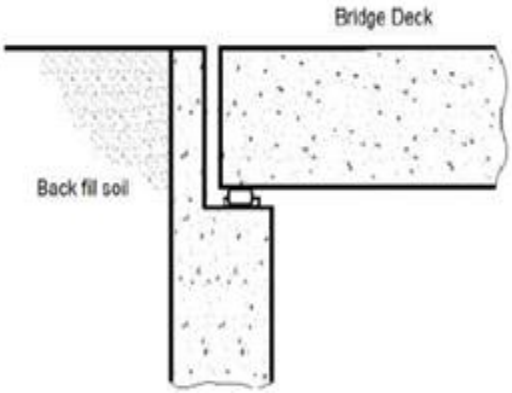

Fig 1. Conventional Bridge.

II. LITERATURE REVIEW

Research has been distributed on the various elements of the integral bridge, principally the piles, bridge structure, and supporting soil. These are principally distributed through field instrumentation of the structure and activity of environmental parameters, laboratory testing, and modeling.

A significant impact of the soil-structure interaction is that the development of earth pressure behind the integral bridge abutment wall. restricted investigations are distributed on this development. Investigations distributed are principally laboratory- based tests (Springman et al., 1996, Ng et al., 1998, European nation et al., 2000, Xu and Bloodworth, 2006).

Limited field observation has conjointly been distributed on the planet pressure (Darley et al., 1996, Darley et al., 1998, Barker and Carder, 2000, Barker and Carder, 2001).In general, there has been restricted analysis distributed on integral bridges through the sector instrumentation and observation. it's been tough to get conclusive proof on integral bridge performance underneath thermal induced loading from field instrumentation and monitoring. This can be as results of the long observation periods needed to watch the results of seasonal thermal athletics (Bloodworth et al., 2012).

The outline of previous analysis carried out on integral bridges given during this section, show that no data is available from analysis distributed through instrumentation on all part components of the bridge at the same time. These conjointly show that in modeling, the results of the muse soil, backfill and bridge structure haven't been at the same time evaluated inside one model.

Literatures reviewed, reveals linear dynamic response analyses have assigned influence on the behavior of soil-structure interaction. While over the past 35 years attempts has been made to study the soil-structure interaction, the gapping effects, however, has been ignored or neglected. Gapping effect has been prominent in the studies of pile behavior under lateral cyclic loading. Winkler model was used by to represent the gapping phenomenon.

The modeling and analysis process adapted which has been the basis for most of the researches in this area can be summarized as below:

- The foundation system was modeled as two series of detachable Winkler springs on either side of the pile.
- The soil adjacent to the pile was modeled with zero tensile strength, therefore when the force in a spring element reduced to zero, the spring detached from the foundation element.
- The element reattached when the forces in the soil were no longer tensile.

Below gives a brief description on the commonly used soil constitutive models in soil-structure interaction which have been discussed in several literatures.

1. Constitutive Model Brief description:

1.1 Winkler Model: Ideality the soil medium as linear and nonlinear elastic springs considered as oversimplified idealization of soil medium. However it is adequate and suitable for computational purpose for its reasonable performance and simplicity.

1.2 Mohr-Coulumb Model: It's an elastic-perfectly plastic model. The model's stress strain behaves linearly in the elastic range. Friction angles and cohesion of soil defines the failure criteria.

III. RESEARCH METHODOLOGY

General Structural Analysis (GSA) Version 8.5 is being used for finite element modeling. The usage of GSA would be considered pioneering in integral abutment bridge analysis. The proposed software packages were adopted based on their availability and capability in carrying out the proposed study where the scope expands from linear to nonlinear. Initially, models without soil meshing were developed to choose a suitable meshing density for the structural elements. Selection of a finite

© 2021 IJSRET

element mesh density for numerical analysis is very important in finite element modeling.

A convergence of results is obtained when an adequate number of elements are used in a model. This is practically achieved when an increase in the mesh density has a negligible effect on the results. Therefore, in this study a convergence study was carried out to determine an appropriate mesh density.Three models were developed to study the behavior of a single span Integral Abutment Bridge. These three models are:

- Finite Element Mesh (FSM), where both the soil media and structural elements are modeled as 5 or 10 node finite element members
- Finite Element Mesh with Spring element which connects the backfill soil media to abutment and pile
- Finite Element Mesh with Spring element which connects the backfill and riverside soil media to abutment and pile

These models were analyzed for various load cases for preliminary studies under linear static analysis. The result will of these preliminary analyses agrees well with previous work done on this subject. Conducted to expand the results of the numerical model to general cases under different variables.

The stiffness of the bridge structure of a single-span IAB with stub abutments is much negligible thanks to the high flexibility of the piles. Therefore, the seismic response of the structure is powerfully dependent on the abutment-backfill interaction and also the far-field hill response thanks to the fact that the bridge structure doesn't have enough stiffness to resists the displacement imposed by the approach embankments.

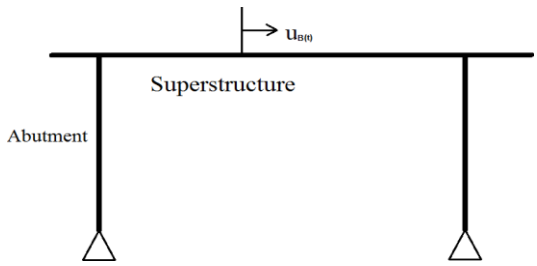

Fig 2. Basic Abutment

This is often conjointly valid for multi-span bridges with versatile bents, that is that the case of the Meloland Road span Analysis of the recorded information within the so much field of the embankments indicated that the response of stiff soils for low amplitude motion is controlled by surface Rayleigh waves (Carvajal and Ventura, 2009), thus no data concerning the basic periods might be obtained for the so much field. The conclusion of the Av testing campaign was that the consequences of the far-field hill response on the bridge structure are often neglected for terribly low amplitude motion.

$$K_B = \frac{F}{u_B} \qquad C_B = 2\sqrt{M_B K_B}\,\xi_B$$

For the finite element analysis of the overall structure system soil and pier are modeled as 30-node isoperimetric solid elements. For the modeling of the pile, comparison between 30-node solid element and 3-node fiber based beam element was carried out.

The constitutive models for soil and concrete described earlier were used for this analysis as well. Axial compressive stress of 1N/mm2 was considered to be acting on the pier and the footing was modeled as elastic body in all the cases.

Different analytical cases considered where as in case Mon1, pier alone is modeled with fixed foundation. Whereas in case Mon2 and Mon3, the soil-structure interaction is also considered by modeling them soil and pile system For case Mon2, soil and pile are all modeled using 3D 30-node solid elements. To simulate the gap formation between pile and soil, 15-node bond element was used between pile and soil surface.

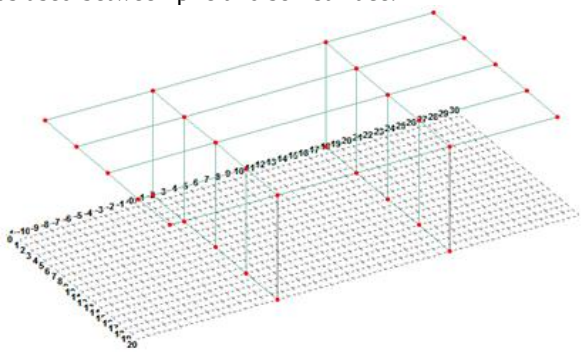

Fig 3. 30-Node Solid Elements.

Table 1. Parameters of the bridge structure component for a 1 m width.

LB m	MB tonne	KB MN/m	ξB%	CB MN/m/s	TBs
10	63.5	37.0	5	0.15	0.26
15	87.3	35.8	"	0.18	0.31
20	111.1	34.6	"	0.20	0.36
25	135.0	33.4	"	0.21	0.40
30	159.1	32.3	"	0.23	0.44
35	183.5	31.2	"	0.24	0.48
40	208.3	30.2	"	0.25	0.52
45	233.6	29.2	"	0.26	0.56

© 2021 IJSRET

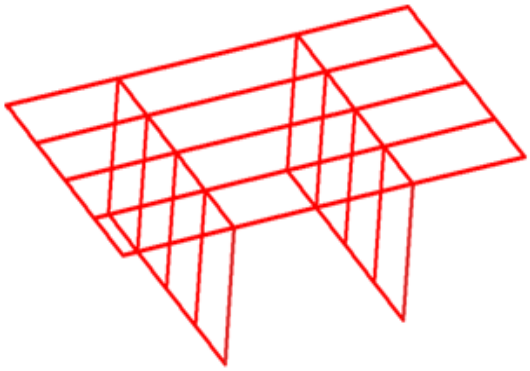

Fig 4. 30-Node Solid model.

Table 2. Longitudinal Analysis

Longitudinal Earthquake	Bent #2# My (kNm)	Bent #3# My (kNm)	Abutment #1# displacement δx(cm)
Analysis without SSI	-2564	-2603	1.02
Proposed analyses	-2756	-2456	1.13
	+31%	+27%	+23%

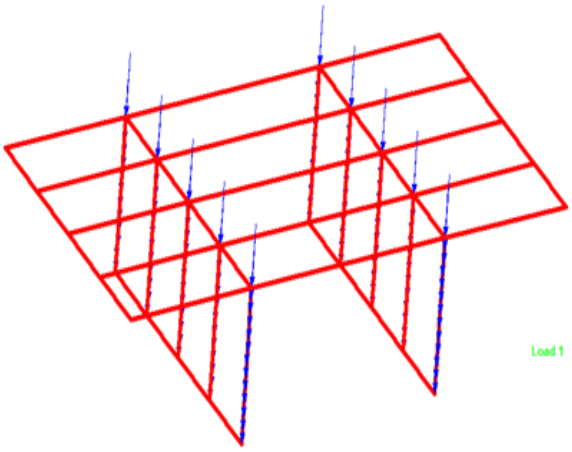

Fig 5. Longitudinal Motion.

Table 3. Longitudinal Motion Analysis.

Longitudinal Earthquake	Bent #2# Mx (kNm)	Bent #3# Mx (kNm)	Abutment #1# displacement δy(cm)
Analysis without SSI	3356	3312	1.357
Proposed analyses	4976	5062	3.030
	+59%	+56%	+72%

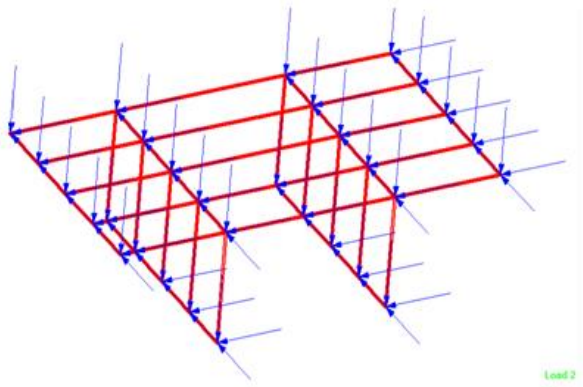

Fig 6. Transverse Motion.

The changes in bridge length were measured by installing laser distance-meter equipment between the opposing abutments. Abutment displacements were measured using ten long steel bars installed at three levels through the eastern abutment concrete abutment were installed on the outer surface of the abutment wall behind the abutment and in contact with the backfill soil. These were used to measure the earth pressures developed in the backfill soil at the interface between the abutment and the backfill soil. The earth pressure cell locations are presented in Figures.

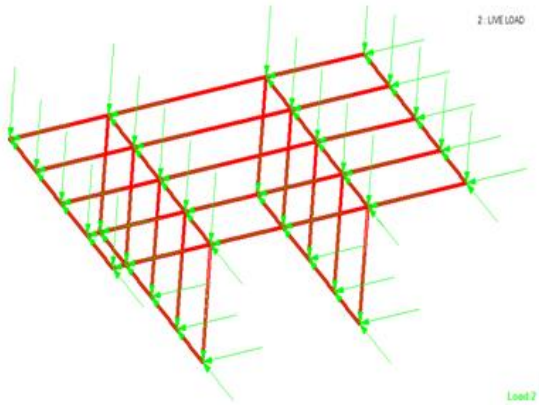

Fig 7. Longitudinal & Transverse Motion

The results of evaluating the impact of amendment in unit weight values inside the backfill soil on earth pressure values square measure given in Figures six.30 - 6.33. There seem to be a general increase within the earth pressure prices as unit weight value will increase across the changes within the backfill soil parameters evaluated. the most and minimum share amendment in earth pressure values developed as a results of the changes in unit weight values from 18 to 22kN/m3, inside the initial and therefore the absolutely drained model square measure eighteen and 1 Chronicles severally. This may be found in Figure six.30 ("50MPa Stiffness (Initial Model)" curve for max and "150MPa Stiffness (Fully Drained Model)" curve for minimum). The typical share change is 7.9%.

© 2021 IJSRET

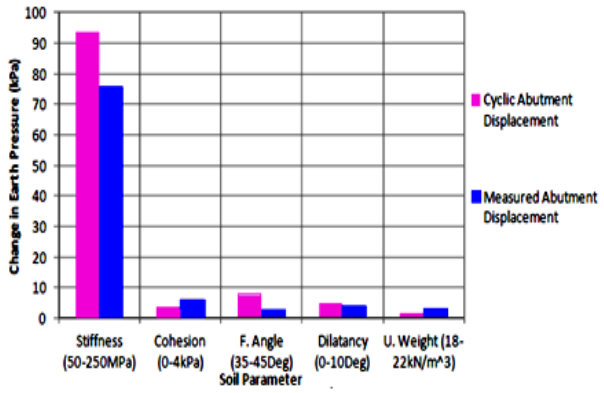

Fig 8.Fully Drained Backfill Soil Analysis

While the magnitude of the model abutment displacement within the cyclic displacement pattern is a smaller amount than the magnitude of the model abutment displacement within the measured displacement pattern (see Figure six.1), the modification in earth pressure developed from the cyclic abutment displacement vary as a results of similar changes within the backfill stiffness parameter is appreciably above that generated from the measured abutment displacement. This results support previous findings on the character of cyclic loading on granular materials as analysis by Carder and Hayes (Carder and Hayes, 2000) on the integral bridge and as delineated by many different researchers together with Bolton and Steedman (2000) on earth holding structures (Bolton and Steedman, 1982). Results generated from the initial model and therefore the totally drained models seem to indicate a consistent trend of behavior between the measured and cyclic abutment displacement.

However, there's a considerably larger impact as a results of the changes within the unit weight in the initial drained model. the planet pressure ranges developed within the initial model are also found to be not up to that generated within the totally drained model.

Different behavior pattern as a results of the assumptions on state of the fine grain soils. Further analysis supported the second constant variation (described in Section vi.3) was carried out to produce additional details from the analysis of the impact of those changes. These analyses thought-about the concurrent impact of the changes within the subject and variable parameter on the planet pressures.

VI. CONCLUSIONS

Two procedures to think about non-linear soil-abutment interaction below seismic hundreds are developed. The first through linear dynamic response analyses and there second through non-linear static analysis. The procedures area unit comparatively easy and straight forward to use for bridge style. But one in every of the best uncertainties in applying these procedures is that the determination of Associate in Nursing applicable price of the soil shear modulus.

Determination of soil shear modulus with unaltered measurements at many bridge sites would be a valuable contribution during this space. Incorporation of abutment stiffness in style and retrofit analysis of route bridges leads to a additional reliable estimation of the general seismic load level and distribution of seismic hundreds among bents and abutments. Additional significantly, it ends up in higher estimation of displacements. Constant quantity studies demonstrate that, if the bridge is analyzed with the projected methodology rather than an easy procedure that ignores backfill stiffness reduction, the calculated forces and moments at the piers area unit bigger by 25%-54% and therefore the displacements by 25%-72%, counting on soil properties.

Integral bridges square measure usually thought of to own lower construction and maintenance prices than typical bridges for brief and medium span bridges. However, the integral bridge presents challenges caused by the exaggerated level of soil- structure interaction activity in construction and use. This arises from the restricted understanding of the soil-structure interaction behavior in response to the thermal evoked lateral displacement of the abutment.

The soil-structure interaction issues primarily occur inside the soil. Though the application of this idea presents challenges to engineers and lecturers alike, generally acceptable style or construction tips haven't been developed.

This thesis reports the findings of a constant quantity study meted out exploitation the finite component methodology to higher understand the impact of thermal load on the world pressures behind the integral bridge abutment. The constant quantity study was meted out with a read to determine style tips based on its findings, towards a additional economical integral bridge style, construction and use.

Detailed rationalization of the construct of the integral bridge was bestowed during this thesis. A comprehensive literature review was meted out. The literature review highlighted the increasing use of the integral bridge construct. The benefits of constructing associate integral bridge and therefore the challenges encountered.

REFERENCES

[1] Anoosh Shamsabadi, Kyle M. Rollins and Mike Kapuskar (2007) Nonlinear Soil- Abutment-Bridge Structure Interaction for SeismicPerformance-Based Design Journal of Geotechnical and Geo environmental Engineering ASCE/ June 2007.

© 2021 IJSRET

[2] Arsoy S, Experimental and Analytical Investigations of Piles and Abutments of Integral Bridges, Faculty of the Virginia Polytechnic Institute and State University December 15, 2000.
[3] Arsoy S, J. M. Duncan, and R. M. Barker (2004) Behavior Of A Semi-Integral Bridge Abutment Under Static And Temperature Induced Cyclic Loading Journal Of Bridge Engineering © Asce / March/April 2004.
[4] Damien Kachlakev, Thomas Miller, Solomon Yim (2001) Finite Element Modeling of Reinforced Concrete Structures Strengthened with FRP Laminates – Final Report SPR 316, 2001 Washington DC.
[5] Faraji, S., Ting, J.M. and D.S. Crovo. 2001. "Nonlinear Analysis of Integral Bridges: Finite-Element Model", J. of Geotechnical and Geoenvironmental Engineering: 454- 461.
[6] Hamid Z Z Jahromi (2009) Partitioned Analysis of Nonlinear Soil Structure Interaction, PhD Thesis, Department of Civil and Environmental Engineering, Imperial College London, 2009.
[7] Karantzikis , M.I., (1997), Seismic Analysis and Design of Integral Bridges with Soil- Abutment Interaction,Master Thesis, Department of Civil Engineering, National Technical University of Athens (NTUA), Athens.
[8] Lam, I.P., G.R. Martin, R. Imbsen, "Modelling bridge foundations for seismic design and retrofitting", Transportation Research Record 1290.
[9] Maragakis, E.A., G. Thornton, M. Saiidi, R. Siddharthan, (1989), "A simple non-linear model for the investigation of the effects of the gap closure at the abutment joints of short bridges", Earthquake Engineering and Structural Dynamics, Vol. 18, pp. 1163- 1178.
[10] Abusharar, S. W., Zheng, J.-J. & Chen, B.-G. 2009. Finite Element Modeling of the Construction Behavior of Multi-Column Supported Road Embankment. Computer and Geotechnics, 36, 676-685.
[11] Alampalli, S. & Yannotti, A. P. 1998. In-Service Performance of Integral Bridges and Jointless Decks. Transportation Research Record: Journal of the Transportation Research Board, Vol.
[12] Arockiasamy, M., Butrieng, N. & Sivajumar, M. 2004. State-of-the-Art of Integral Abutment Bridges: Design and Practice. JOURNAL OF BRIDGE ENGINEERING, 9, 497-506.
[13] Arockiasamy, M. & Sivajumar, M. 2005. Time-Dependent Behavior of Continuous Composite Integral Abutment Bridges. Practical Periodical on Structural Design and Construction, 10, 161-170.
[14] Barr, P., Stanton, J. & Eberhard, M. 2005. Effects of Temperature Variations on Precast, Prestressed Concrete Bridge Girders. Journal of Bridge Engineering, 10, 186-194.
[15] Bloodworth, A. G., Xu, M., Banks, J. R. & Clayton, C. R. I. 2012. Predicting the earth pressure on integral bridge abutments. Journal of Bridge Engineering, 17, 371-381.
[16] Richards, K., Bithell, M., Dove, M. & Hodge, R. 2004. Discrete-element modelling: methods and applications in the environmental sciences. Phil. Trans. R. Soc. Lond. A, 362, 1797- 1816.
[17] Shamsabadi, A., Rollins, K. M. & Kapuskar, M. 2007. Nonlinear soil- abutment-bridge structure interaction for seismic performance-based design. Journal Of Geotechnical And Geoenvironmental Engineering, 133, 707-720.
[18] SIMPSON, M. J. & CLEMENT, T. P. 2003. Comparison of finite difference and finite element solutions to the variably saturated flow equation. Journal of Hydrology, 270, 49-64.
[19] Soubra, A. H. 2000. Static and seismic passive earth pressure coefficients on rigid retaining structures. Canadian Geotechnical Journal, 37, 463-478.
[20] Tachibana, S., Iizuka, A., Kawai, K., Kobayashi, I., Pipatpongsa, T. & Ohta, H. 2007.Numerical investigation on the failure criterion of normally consolidated clays. International Journal for Numerical and Analytical Methods in Geomechanics, 31, 809-833.
[21] Clayton C, Xu M and Bloodworth A. (2006). "A laboratory study of the development of earth pressure behind integral bridge abutments". Geotechnique, 56(8): 561-571.
[22] Faraji S, Ting J, Crovo D and Ernst H. (2001). "Nonlinear analysis of integral bridges: finite element model". J. Geotech. Geoenviron. Eng., 127(5), 454-461.

© 2021 IJSRET