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The Effective used of EPS-Geofoam at Bridge Approach Backfill: Godavari Bridge, Nashik, India

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Abstract. This paper presents a research study on a bridge site located along Indian NH-3 over Godavari River, Nashik, India. On 2018 bridge almost complete its age 58 year, it has weakened therefore Nashik Municipal Corporation decided Demolition Bridge. Before Demolition Bridge it found measurable bump at end of approach portion so, this problem need to consider during study for future Reconstruction of bridge. Differential settlement at end of the bridge Approach is creating many undesirable effects such as: decrease in vehicle's steering response, driver's distraction, increasing maintenance cost, in addition to reduction in a transportation agency's public image. Paper describes studies Finite Element Modelling [FEM] of bridge designed construction details of the reconstruction works performed on old existing bridge embankment system. Field monitoring studies were conducted for almost 5 month to study the settlements under the Conventional backfill with comparing PLAXIS 2D FEM result at newly constructed Approach system. FEM studies attempted in this study showed that settlements could be reasonably predicted by modelling these EPS-geofoam bridge approach backfilling. Based on the Numerical FEM studies, it's conclude that the effectiveness of utilizing EPS-geofoam as an bridge approach backfill material was addressed to mitigate the differential settlements under approach Transition slab.
Keywords: Differential Settlement, Bridge Approach, Expanded Polystyrene Geofoam Bridge Approach Backfill, Finite Element Analysis PLAXIS 2D.

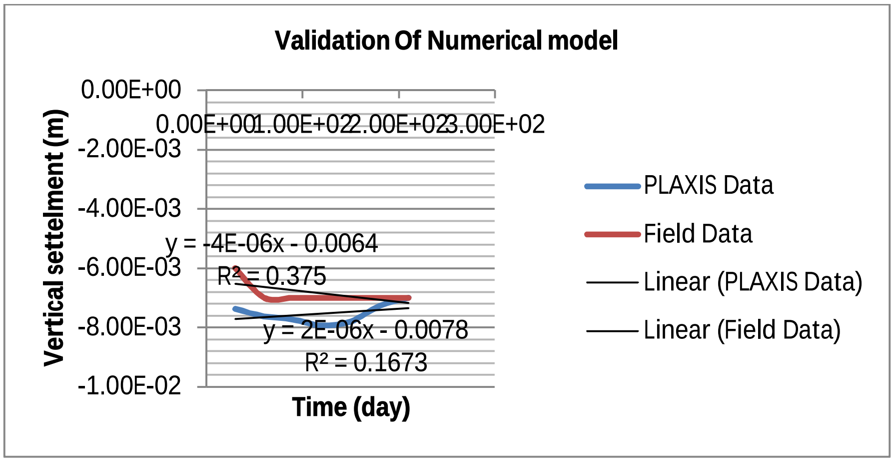
I. INTRODUCTION

The differential settlement at the interface between bridge deck and approach slab over an backfilling results formation of bump at bridge approach, which is a universal problem identified in many states across the world. [9] state that presences of the bump not only creates an unsafe and uncomfortable ride conditions but also results in millions of dollars for annual maintenance costs for DOT and reported that 78 percent of several hundreds of highway bridge approaches warrant some form of maintenance to mitigate the bump problem on either side of the bridge deck also, 30 percent of the bridges in the state of Texas has experienced differential settlements of the approach embankments on either side of the bridge slab deck. They stated that state DOTs agencies had to finance $100 million for annual maintenance. [28] estimated that the state of Texas annually spends $7 million for repairing the bump issue. Many state DOTs, including Iowa, required more funds to meet the annual bridge maintenance works [36]. Due to the low bearing capacity soil present at shallow depths, bridge columns are supported by deep foundation systems extending into very dense sand or hard rock to reduce the total settlement of the bridge structure compared to the Embankment Backfill material and directly support pavement infrastructure. In such conditions, embankments and underlying foundation layers experience settlements due to overburden and live traffic loading. The relative difference in settlement of the bridge and embankment creates a bump issue [29]. A number of researchers had performed studies to categorize the factors causing the bump problem and formulated this issue by summary of inspection of 192 no. of bridge site and conclude that 20% due to Natural subgrade, 45% is due poor construction practice, 50% is due to improper compaction and consolidation, 35% is due to void formation, 30% is due to drainage and soil erosion and 6% is due to other reasons. Mitigation technics to reduced settlement such as [1] Design of approach slab, [2] design of bridge foundation, [3] provide effective drainage [4] improvement of foundation soil, [5] improvement of backfill material, [6] erosion control methods. [3, 5- 9, 11, 12, 14, 15, 17, 19, 20, 22, 23, 28-32, 34-37]

A. Lightweight Geofoam Materials

According to [8] and European standard code [11] Geofoam Block used in used in geotechnical engineering applications which giving adequate compressive strength. During production, Block of come through standard test and quality check-up such as: compressive creep behaviour such as short term and long term behaviour test and behaviour under different temperature conditions [3].

Installation of different density EPS Geofoam block with vertical gap, Behaviour of EPS Geofoam under static and dynamic load, Mechanical properties of EPS Geofoam under various loading condition are within limit. Hence EPS Geofoam fulfils all required criteria when used as engineer material. [25, 29]. In design embankment construction practice elastic modulus in the range of 4 to 6MPa is recommended to use. Europeans standard lab test report also provides a value of as high as hardening soil model with 6MPa for EPS 100 [at 10% strain] EPS geofoam block having dimensions 4.9m×1.2m×0.8m [32]. [3] State that Compressive strength at 10% deformation and bending stress for different type of EPS Geofoam according to [11]. EPS-S generally not used in load bearing applications.
From review of literature mainly EPS 100 is used for construction of Highways, road and bridge embankment and also follow steps for methodology, data collection and for modeling. [1, 3, 5, 8, 12, 13, 17, 19, 20, 22, 29, 32, 33, 35]. In current project work, successful validation of PLAXIS 2D FEM tool by measuring actual settlement at Bridge approach and output Backfill material of PLAXIS 2D Finite element modelling by inspection Fig.3 of field records by considering output for January-May [2020] 5 month of period shown in Graph.1.



Graph.1. Validation of FEM PLAXIS 2D

Table.1.Test Backfill material soil [4]

Sr. No.	Test Parameter	Observed Result
1	Grain Size Analysis, % [Seive size]	
	(a) 100 mm	100
	(b) 75 mm	100
	(c) 19 mm	93.6
	(d) 4.75 mm	58.5
	(e) 2.0 mm	36.2
	(f) 425 micron	8.5
	(g) 75 micron	1.5
2	Heavy Weight Proctor Test	
	[a]Maximum Dry Density, gm./cc	2.02
	[b]optimum Moisture Content,%	13.4
3	Direct Shear Test	
	[a]Cohesion C, Kg/cm2	0.00
	[b] Angle of Internal Friction, ϕ	32.1
4	Atterberg's Limit %	
	[a]Liquid Limit	31.4
	[b] Plastic Limit	Not Possible
5	Density , g/cc	1.47 [1470 kg/m³]

II. SELECTION OF BRIDGE SITE FOR STUDY

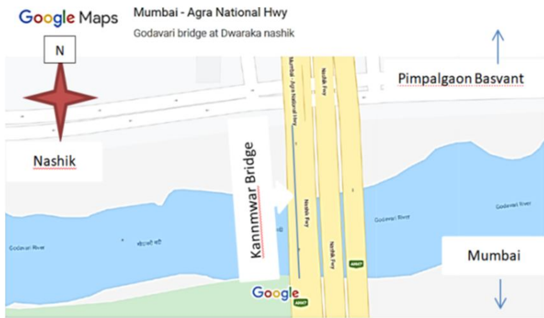


Fig.1. Study site of Kannamar bridge location

This project was performed under the guidance of NHAI Department of Transportation bridge site base on availability of material data and design drawing of project. Bridge site having a 146.710 m long and 18.9m high from bridge embankment of Indian NH-3 over Godavari River, Nashik, India [4]. The bridge was constructed in 1960's, using pre-stressed concrete girders connection placed on bridge abutments supported by reinforced concert pile foundations [drilled bore]. Whereas, the bridge approach slabs were placed on the adjacent reinforced concrete abutment construction. Renovation and reconstruction of bridge start in 2018, before demolition of existing bridge it's found the approach slabs of old bridge had experienced more than 10 cm of settlement over a span of 58 years. At bridge approach also disturb and collapse of drainage pipe and riprap wall. The field investigations and numerical modelling were directed to evaluate the sources of settlements occurred on the embankment in 2019-2020 respectively. According to bore log data from bore hole the layer wise classification is bottom 11.5m-16m is Basalt Rock then 10m-11.5m is Silty clay sand, 2m-10m is Black cotton soil and at top is 0m-2m Soil boulder. Current bridge constructed 7 m above ground level having existing old bridge embankment and 0.530m of flexible pavement thickness which design from 15 year Traffic forecasting, 14 % CBR value and design traffic in 108 MSA loading as shown in Chart IRC 37:2012 [4]. The embankment backfill was made of historically loaded over consolidated clay material with moderately high plasticity index [PI] and retained by the concrete retaining walls, as shown in Fig. 1 and Table.1. In this paper calculation from existing drawing details it assume and conclude that Approximately, 736 m^3 Volume of EPS geofoam blocks were required to place on the 7.00 m from bottom depth of the bridge approach embankments to mitigate undesirable settlements Fig.15. which calculated from study of numerical modelling [4].

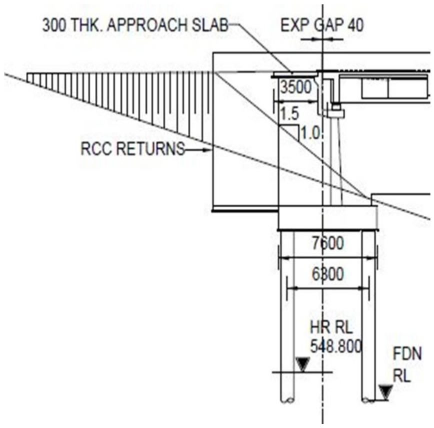


Fig.2. Schematic of Kannamwar Bridge Left Side abutment over Godavari River, Nashik, India.[4]

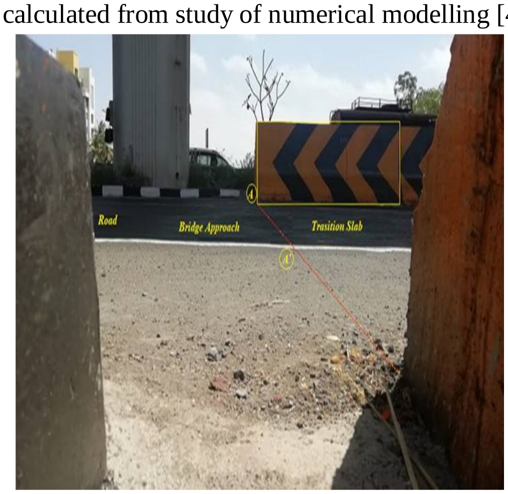


Fig.3. Site records for Settlement

These results jagged out that the foundation soil had previously undergone consolidation settlement and it was one of the major contributing factors to the approach slab settlements that occurred at this site. The local district Department of transportation decided to project to remove the concrete block walls, constructed 3:1 slopes rip rap with reinforced concrete retaining wall, repair bridge girders, and renew transition slab having 3.5m long and thickness of 0.3m of approach and pavement on both side of the bridge deck. Retaining wall of 3m height at bottom and abutment height 7.530m from river bed is to be taken, and Backfilling with well compacted conventional material with proper drainage system shown in table.1. case study of bridge done by Numerical modeling Using PLAXIS 2D used for analysis The EPS 22 geofoam blocks were used for replacing conventional backfill and used to replace depth of 7m the fill material of the embankment behind bridge abutment. The use of EPS geofoam was predictable to reduce future the settlements and erosion of the backfill, accordingly reducing the approach slab settlement causing bump problems at the end of the bridge. [6, 25, 31].

From study of literature review FEM is the tooled to define and analysis structural behaviour and study vertical deformation, effect of application Traffic load. The modeling of the bridge abutment backfilling is presented in Fig.9 & 10. For FEM parameters for flexible pavement Design thickness of all material having drained condition: Bituminous course 30 mm and dense bituminous macadam 50 mm were using as linear elastic model E= 3000000 KN/m^3, ν= 0.35 and $R_{internal}$= 0.70 and Water bound macadam 250 mm having Mohr coulomb model E=228600KN/m^3, ν=0.67, $R_{internal}$=0.67 and Granular sub-base 200 mm having Mohr coulomb model with E=2068000KN/m^3 ,ν=0.67 and $R_{internal}$=0.67 and subgrade material E=95287.2 KN/m^3, ν=0.3 and $R_{internal}$=0.67 [4] and Table.2. Showing backfill material properties were All material having Mohr coulomb model with $R_{internal}$=0.67, e=0.26 for sandy soil and backfill soil, m=0.5 for Existing embankment material, Material condition=Drained for all type of soil except basalt rock which having Non-drained condition.

A. Tire contact area and associated stress

As per IRC 06:2016 Fig.4, It is necessary to know the contact area between the tires and the road surface to be able to assume the area that the axle load will be uniformly distributed over it, Fig.5 showing how dual wheel' contact area could be considered as Equivalent to one large circle. The circle's total contact area contains the tires' areas plus the area between the duals.[10].

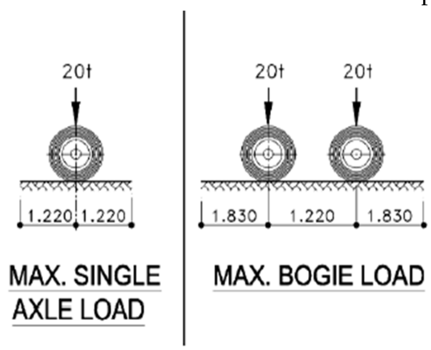


Fig.4. Wheel Arrangement for 70R [Wheeled Vehicle] [18]

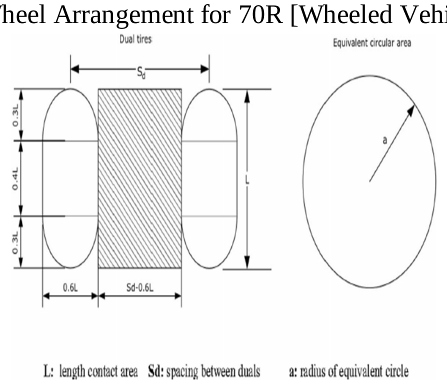


Fig.5. Dual wheels contact area transformed to a Equivalent circle with Radius, a [10]

The size of contact area depends on the contact pressure. The contact pressure is assumed as equal to the tire pressure. Load on Dual wheel is P_d= 40 KN i.e. 4078.86 kg and q= 5.710 kg/cm² kPa [i.e. 5.710 kg/cm² < 7 Kg/cm² circular imprint], S_d=12 cm is the clear distance between two wheel, area of contact of tire is calculated by equation [1].

$$A = \frac{P_d}{q} = \pi[a]^2 \qquad [1]$$

$$A = \frac{\frac{4078.86}{2}}{5.710} = \pi[a]^2 = 357.168 \text{ cm}^2 \text{ i.e. } 0.357 \text{ m}^2 \qquad [2]$$

Where, the load on the dual tires is 40 KN mean on single tier is equal to 20 KN and the tire pressure, q, is 560 kPa [i.e. 5.710 kg/cm² < 7 Kg/cm² circular imprint]. to determine the pressure on the pavement due to the load. For the dual tires, the contact area is determined using Eq. [3]:

$$\pi a^2 = 357.168\ cm^2$$

$$a = \sqrt{\frac{357.168}{\pi}} = 10.6625\ cm^2 \qquad [3]$$

Where, πa^2 = Area of the circle [cm^2]. Eq. [3][10]

III. NUMERICAL MODELING

EPS-Geofoam material were model using Hardening soil models [3], whereas backfilling with existing old Embankment where constructed using Mohr coulomb model and foundation subsoil were modeled using Mohr coulomb material. The linear elastic soil model, which is based on Hooke's law of isotropic elasticity, primarily uses two basic elastic parameters, Young's modulus E and Poisson's ratio ν, Laboratory compression strength tests EPS-Geofoam materials provided these characteristics [3, 6, 25], Table.2. Shows details of model Parameters used in the numerical modeling. More details on the modeling were described From the numerical modeling analysis and field test results, the maximum total vertical displacement of From chart.2.

Construction of pile as linear elastic model for plate material Non-porous EI= 1.264 x 10^6 KN-m/m, EA=2.022 x 10^7 KN/m, d=1.0 m, w=25 KN/m/m, ν= 0.150. properties of concrete material Non-porous having unit weight 25 KN/m³, E= 25000 MPa, ν = 0.15 and Properties of EPS Geofoam is model as Hardening soil model which having material properties type of material behavior is Drained, γ of EPS-Geofoam 0.2, E= 6000 KPa as per Europeans standards lab test report Table.2 Compressive strength at 10% deformation 100 kPa having Bending stress 150 KPa for EPS 100 and which is recommended for Road project in Embankment construction, ν = 0.1, $\nu_{unloading}$= 0.1, ϕ= 27º, c =35 KN/m² [3].

IV. RESULT AND CONCLUSION

After FEM it can be noted that there was a considerable amount of settlement of the approach without soil Backfill material was used and following points come into picture: EPS-geofoam has been easily handled and placed required shape, size & layers and thickness as per layout and design without used of any machineries and equipment. Time required for Construction of EPS geofoam Backfill is very much lesser than earthen backfilling layers from literature review. From chart.2 it is found from Numerical analysis that backfill with EPS geofoam Initial 30, 60, 90, 120 and 150 day maximum settlement i.e. 0.00279 m and after word for 365, 720 day is constant, which giving satisfactory result as compared with backfill without lightweight fill i.e. 0.007 m and goes up to 0.010 m. EPS-geofoam provides a better alternate to backfill material as an approach in which earthen backfill as local soil used for the construction.

From Fig.11 and Fig.12 we can conclude performance of EPS-geofoam used in the top of EPS Geofoam and bottom of transition slab has been found to be much better than conventional earth backfill with loose, or compressible soil foundation or places adjacent to structures where proper compaction equipment cannot required. From finite element modeling we conclude that the backfill overburden pressure in presences of lightweight backfill is found less on piles as comparative to backfill without lightweight backfill. Hence from study it is conclude that used of EPS Geofoam as backfill material gives satisfactory result and settlement within acceptable limit and also reduced passive Earth pressure of Abutment.

After comparing software result it is found that bridge approach with EPS-Geofoam give comparatively good result than site conventional backfill output and from software data it is also clear that not only reduced the vertical stress increase on foundation soil but also mitigated the soil erosion problem usually experienced in the upper embankment structure from moisture intrusion and surface runoff events due to rainfalls. Also, by comparing the field monitored data with the results obtained from the numerical modeling analysis using commercially available software, it can be stated that the finite element based numerical analysis and model input parameters used in this study have provided prediction results that are in good agreement with the monitored settlement of the test section. Though the predicted final settlement was in good agreement, the time rate of settlements did not match with the field measurements. This happen due to stiffness parameters used in the modeling analysis. Overall, the study has proven that the lightweight EPS geofoam material could be utilized to reduce the overburden stresses on underlying foundation subgrades thereby producing transportation infrastructure free from distress conditions.

V. ACKNOWLEDGMENTS

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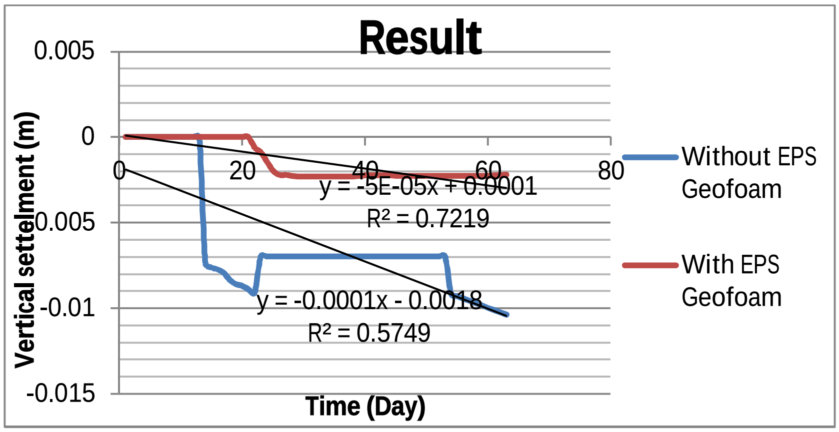


Chart.2. Vertical Settlement [m] vs Time [Day]

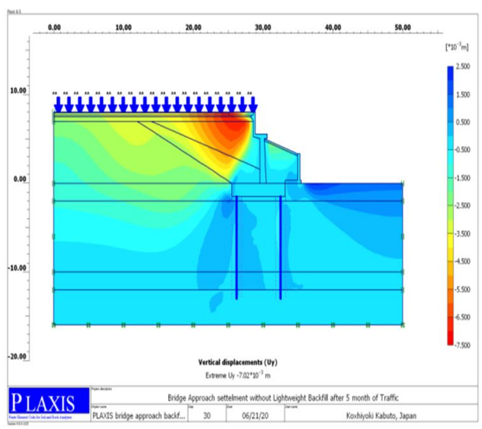


Fig.9. Output of FEM of bridge approach without considering EPS Geofoam

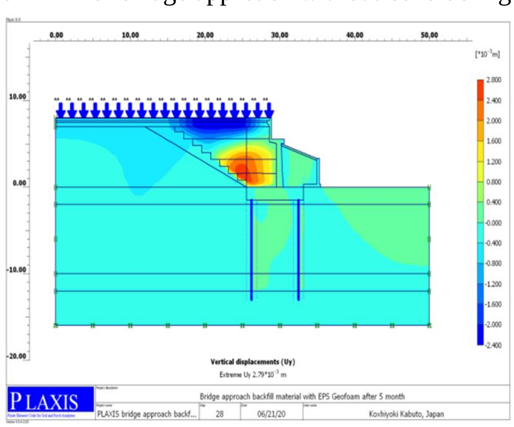


Fig.10. Output of FEM of bridge approach with considering EPS Geofoam

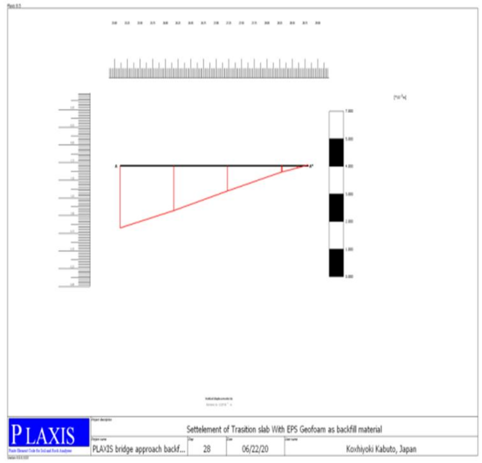


Fig.11.Vertical settlement of Transition slab With EPS Geofoam as Backfill material

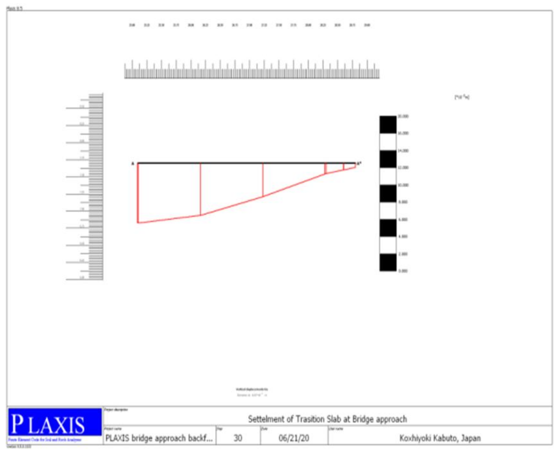


Fig.12. Vertical settlement of Transition slab Without EPS Geofoam as Backfill material

Table.2. Material and soil properties used in PLAXIS 2D 8.5

Properties	Unit	Basalt Rock	Sandy soil	Black cotton soil	Existing Embankment Material	Fill boulder and soil	backfill soil
γ_{sat}	KN/m³	-	19	20	22	20	20
γ_{unsat}	KN/m³	21.67	17	18	20	19	18
E	KN/m³	49990000	40000	12022	200000	150000	100000
$\emptyset$	º	-	37	30	35	35	32.2
c	KN/m²	66000	0.010	6	0.01	0.001	0.00
ν	N/A	0.2	0.35	0.35	0.2	0.35	0.3
K_x	m/day	-	0.001	0.00001	0.00001	0.025	0.005
K_y	m/day	-	0.001	0.00001	0.00001	0.025	0.005

REFERENCES

[1] Abdelrahman, A., Tawfik, M. and El-Saify, A. [2018]. “Investigation on the performance of bridge approach slab.” MATEC Web of Conferences 162, 04014 DOI:org/10.1051/matecconf/201816204014 BCEE3-2017

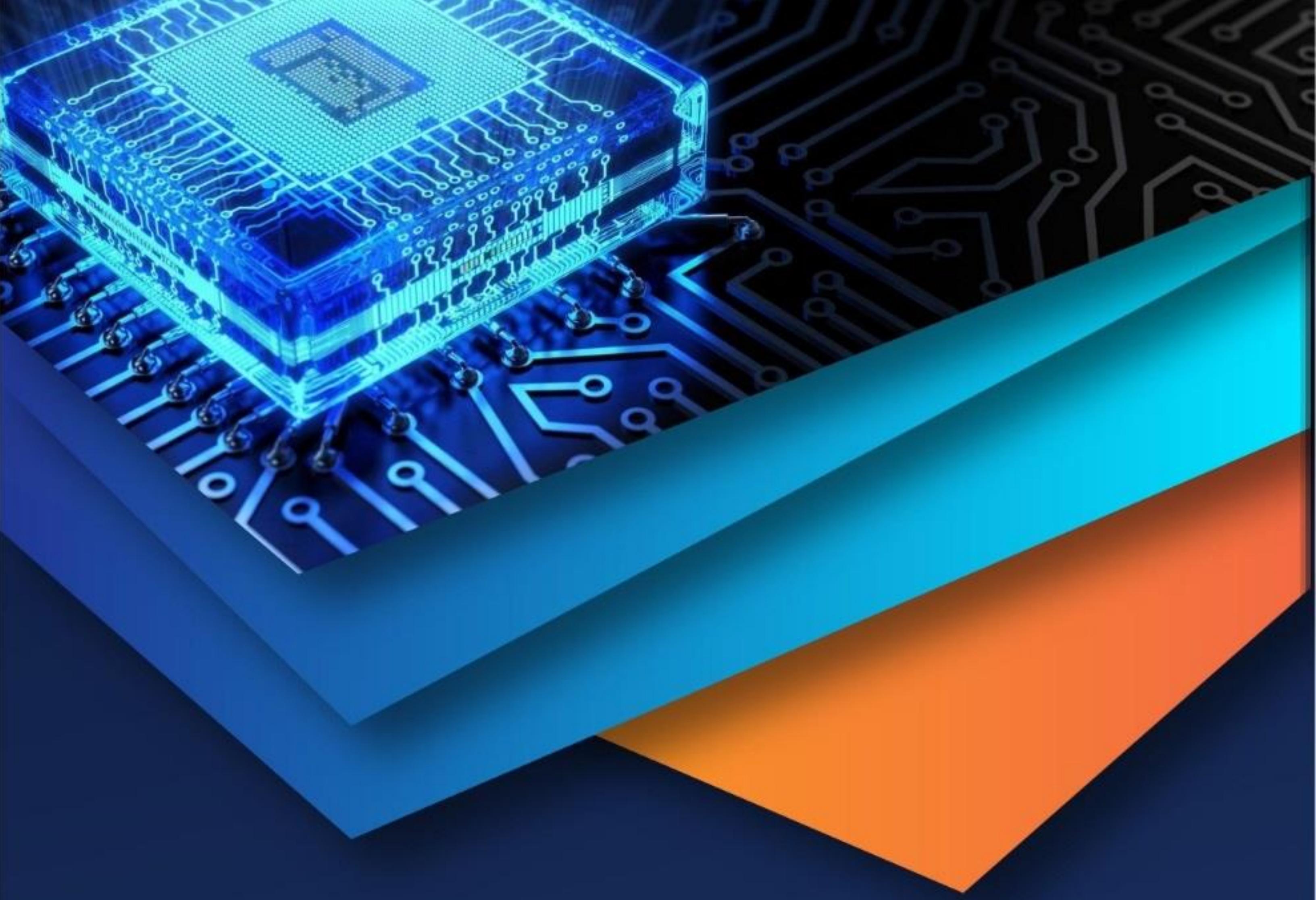
[2] Arellano, D., Ozer, A. T., Bartlett, S. F., Vaslestad, J. [2018]. “5th International Conference on Geofoam Blocks in Construction Applications.” Springer International Publishing AG,Springer nature, DOI.org/10.1007/978-3-319-78981-1.

[3] Awol, T. A. [June 2012]. "A Parametric Study of Creep on EPS Geofoam Embankments." Geotechnics and Geohazards.
[4] B. P. Sangale construction pvt. Ltd. Nasik. [2017]. "Geotechnical investigation carried out for [NHAI] national authority of India"
[5] Bartlett, S. F. [July 2008]. "Title: Evaluating the Seismic Stability and Performance of Freestanding Geofoam Embankment Authors: Evaluating the Seismic Stability and Performance of Freestanding Geofoam Embankment." DOI: 10.13140/2.1.2399.7449.
[6] Bartlett, S. F., Lawton, E. C., Farnsworth, C. B., Newman, M. P. [October 2012]. "Design And Evaluation Of Expanded Polystyrene Geofoam Embankments For The I-15 Reconstruction Project, Salt Lake City, Utah." Utah Department of Transportation: Research division.
[7] Bartlett, S. F., Stark, Timothy D., Arellano, David., STARK CONSULTANTS, Inc. "Expanded Polystyrene [EPS] Geofoam Applications & Technical Data." The EPS Industry Alliance.
[8] Bartlett, Vaslestad, J., Steven F., Aaboe, R., Burkart, H., Ahmed, T. and Arellano, D. [2019]. "Bridge Foundations Supported by EPS Geofoam Embankments on Soft Soil." Springer International Publishing AG, 5th International Conference on Geofoam Blocks in Construction Applications, DOI.org/10.1007/978-3-319-78981-1_23.
[9] Briaud, J. L. [1997]. "Bump At End Of Bridge Approach." Research Sponsored By The American Association Of State Highway And Transportation Officials In Cooperation With The Federal Highway Administration.
[10] Djellali, A., Houam, A., Saghafi, B., Hamdane, A., Benghazi, Z. [2016]. "Static Analysis of Flexible Pavements over Expansive Soils." International Journal of Civil Engineering, DOI 10.1007/s40999-016-0058-6.
[11] EN 1991-2 [2003]. [English]: Euro code 1: Actions on structures - Part 2: Traffic loads on bridges [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]BS EN 1991-2:2003, EN 1991, 2:2003 [E].
[12] glund, T., aaboe, R. [December 2001]. "Long term performance and durability of EPS as a lightweight Filling material." EPS Geofoam 2001, 3rd International Conference, Salt Lake City.
[13] Hassona, F. Hashem, M. D., Abdelmalak R. I., and Hakeem, B. M. [2018]. "Bumps at Bridge Approaches: Two Case Studies for Bridges at El-Minia Governorate, Egypt." Springer International Publishing AG 2018 H. Rodrigues et al. [eds.], Facing the Challenges in Structural Engineering, Sustainable Civil Infrastructures, DOI 10.1007/978-3-319-61914-9_21.
[14] Hoppe, E. J., [1999]. "Guidelines For The Use, Design, And Construction Of Bridge Approach Slabs." Virginia Transportation Research Council.
[15] Horvath, J. S. [2000]. "Integral-Abutment Bridges: Problems and Innovative Solutions Using EPS Geofoam and Other Geo-synthetics." Manhattan College Research Report No. CE/GE-00-2.
[16] Horvath, J. S. [2005]. "Expanding the Use of Expanded Polystyrene [EPS] Geofoam in Practice." ASCE Geo-Institute 2005 Geotechnical Engineering Seminar.
[17] Ikizler, S. B. A., Nas, M. E. [2008]. "Laboratory study of expanded polystyrene [EPS] geofoam used with expansive soils." Geotextiles and Geo-membranes, Elsevier Ltd. 26, [189–195].
[18] Indian Roads Congress 37:2012, December [2012].
[19] Kalinski, M. E. and Pentapati, D. P. [2006]. "Numerical Simulation of Dynamic Behavior of Geofoam Embankment." Transportation Research Record: Journal of the Transportation Research Board, No. 1975, Transportation Research Board of the National Academies, Washington, D.C, pp. 89–95.
[20] Meguid, M. A. and Khan, M. I. [2019]. "On the role of geofoam density on the interface shear behavior of composite geosystems." International journal of geo-engineering.
[21] Mitoulis, S. A., Palaiochorinou, A., Georgiadis, I. and Argyroudis, S. [2016]. "Extending the application of integral frame abutment bridges in earthquake-prone areas by using novel isolators of recycled materials." Earthquake Engineering & Structural Dynamic, 45:2283–2301, DOI:10.1002/eqe.2760
[22] Newman, M. P., Bartlett, S. F., and Lawton, E. C. [February 2010]. "Numerical Modeling of Geofoam Embankments." Journal of Geotechnical and Geo-environmental Engineering, DOI: 10.1061/[ASCE]GT.1943-5606.0000203
[23] Phares, B. M., Faris, Adam S., Greimann, L., F.ASCE and Bierwagen, D. [2013]. "Integral Bridge Abutment to Approach Slab Connection." American Society of Civil Engineers. Journal of Bridge Engineering, Vol. 18, No. 2, ASCE, ISSN 1084-0702/2013/2-179-181.
[24] Puppala, A. J., ASCE, F., Ruttanaporamakul, P., Bheemasetti, T. V., Shafikhani, A. [2018]. "Laboratory and Field Investigations on Geofoam." Journal of Pipeline Systems Engineering and Practice, ISSN 1949-1190, ASCE, DOI: 10.1061/ [ASCE] PS.1949-1204.0000364.
[25] Puppala, A. J., Ruttanaporamakul, P., Congress, [2019]. "Design and construction of lightweight EPS geofoam embedded geomaterial embankment system for control of settlements." Geotextiles and Geo-membranes, Elsevier Ltd.
[26] DOI.org/10.1016/j.geotexmem.2019.01.015.
[27] Razmi, J., Ladani, L., and Aggour, M. S., ASCE, F. [2013]. "Fatigue Life of Piles in Integral-Abutment Bridges: Case Study." ASCE, Journal of Bridge Engineering, Vol. 18, No. 10, October 1, 2013, ISSN 1084-0702/2013/ 10-1105–111, DOI: 10.1061/ [ASCE] BE.1943-5592.0000434.
[28] Saride, S., Puppala, A. J., Archeewa, E. [2009]. "Bridge Approach Settlements—An Issue Due To Design Or Construction Practices?" IGC 2009.Gunter, INDIA, 210-214.
[29] Seo, J. B. [2003]. "The Bump At The End Of The Bridge: An Investigation."
[30] Shafikhani, A., Bheemasetti, T. V., Puppala, A. J. [2017]. "Effect of Seasonal Changes on a Hybrid Soil–Geofoam Embankment System." International Journal of Geosynthetics and Ground Engineering [2017] 3:39, https://doi.org/10.1007/s40891-017-0116-4.
[31] Short, T. H., Wierschem, N. E., Denavit, M. D., Bennett, R. M. [2018]. "Bump at the End of the Bridge: Review and Analysis of Rider Discomfort." Civil and Environmental Engineering Reports.
[32] Srivastava, D.M. [2018]. "Sustainability assessment of EPS-geofoam in road construction: a case study." International Journal of Sustainable Engineering, Teller and Frances plublication, ISSN: 1939-7038.
[33] Stuedlein, A. W. and Negussey, D. [2016]. "Use of EPS Geofoam For Support Of A Bridge." Sound Geotechnical Research to Practice, ascelibrary.org, [334-345].
[34] Tefera, T. H., Aaboe, R., Bruun, H., Aunaas, K. [2012]. "FEM simulation of full scale and laboratory models test of EPS." The Norwegian Public Roads Administration.
[35] Thiagarajan, G., Ajgaonkar, S. V., Eilers, M. G., and Halmen, C. [2012]. "Cost-Efficient and Innovative Design for Bridge Approach Slab." Transportation Research Record: Journal of the Transportation Research Board, No. 2313, Transportation Research Board of the National Academies, Washington, D.C.,pp. 100–105. DOI: 10.3141/2313-11.

[36] Thompsett, D. J., Walker, A., Radley, R. J. and Grieveson, B. M. [1995]. “Design and construction of expanded polystyrene embankments.” Construction and Building Materials, Vol. 9, No. 6, pp. [403-411].

[37] White, D. J., ASCE, A.M., Mekkawy, M. M., Sritharan, S., ASCE, A.M., Suleiman, M. T., ASCE, A.M. [2014]. “Underlying” Causes for Settlement of Bridge Approach Pavement Systems.” Journal of Performance of Constructed Facilities, Vol. 21, No. 4, August 1, 2007, ISSN 0887-3828/2007/4-273–282.

[38] Yasrobi, S. Y., Ng, K. W., Edgar, T. V., Menghini, M., [2016]. “Investigation of approach slab settlement for highway infrastructure.” Transportation Geotechnics, Transportation Geotechnics 6, http://dx.doi.org/10.1016/j.trgeo.2015.12.002 ,2214-3912, 1–15.



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