



Effect Of 70R Tracked Vehicle Loading On An Approach Embankment For Different Soils

Vianna De¹ and Maganti Janardhan Yadav²

¹Ph.D Research Scholar, JNTUH

²Professor of Civil Engineering, JNTUH

Abstract: As we travel along the length and breadth of the country the terrain changes and so does the properties of soil of the back-fill in the approach embankments. Though the IRC (Indian Road Congress) codes specify the quality of soil to be used as back-fill, there is no ideal soil. There is always a composition of different soils used as back-fill in the approach embankment. An effort is made to study the effect of the horizontal force of the 70R Tracked Vehicle, i.e., traffic load on the soils of different *modulus of elasticity* in the approach embankment and the displacements of the soil are obtained, using the laws of simple mechanics. In this study, a carriage way width of 5.3 m is assumed and height of the embankment to be 3 m. It has been concluded that even for soils having higher modulus of elasticity of 320 MPa, there is a significant magnitude of the displacement of 0.79 mm. Hence, attention has to be paid for the effect of lateral load of the vehicle on the approach embankments.

Index Terms: Back-fill soils, approach embankment, modulus of elasticity of soil, displacement.

I. INTRODUCTION:

Soil is defined as naturally occurring mineral aggregations which can be readily separated into elemental particles and in mass form contains numerous voids. These voids contain air, water, or organic materials in varying quantities. The elemental soil particles are formed from the decomposition of rock by mechanical (air, wind, water and ice) and natural chemical processes. Harvey E. Wahls (1990) has found that soil plays an important role whether in the foundation to support the abutment or as a back-fill in the approach embankment near the abutment. Behavior of the foundation soils beneath the embankment and abutment is one of the most important factors that affect the integrity of bridge approaches. Nature has bestowed India with all kinds of soil from the extracts of Metamorphic and Sedimentary rocks to the Black Cotton and Alluvial soils. If the soil is composed of black cotton soil and/or cohesive soil in the back-fill, the settlement is intense, and varies with the season. Therefore, ideal soil to be used as a back-fill is not readily available at the construction sites.

Soil is a complex engineering material, and its properties are not unique or constant. Balasubramanian (2017) has stated that the soils are formed by a combination of various geologic, environmental and chemical processes. They vary with many environmental factors. The U.S. Bureau of reclamation's earth manual (1990) states that an embankment refers to a volume of earthen material that is placed and compacted for the purpose of raising the grade of a roadway (or railway) above the level of the existing surrounding ground surface. As this is an artificial mound, the composition and the characteristics of the soil changes as it is transported from the barrow pit to the site. The voids ratio, compressibility and consolidation of the soil can increase or decrease, depending on the season of year.

The main desirable characteristics of the back-fill material should be a higher permeability as compared to clay, less primary consolidation and higher shear strength by virtue of their interlocking properties with higher angle of friction.

As illustrated by Kun Zhang *et al.*, (2023), the seasonal rains can cause havoc to some embankments, where the clay content is more. Hence only time will tell us its behaviour when subjected to repeated and heavy Traffic Load. Some Soils have tendency to liquefy in case of slight tremors or Earthquakes. One of the most important parameters in engineering studies is the *modulus of elasticity*. For Soil, modulus of elasticity is a complex parameter in foundation engineering practices due to different variable conditions. Abolfazl Eslami *et al.*, (2020) have stated that *modulus of elasticity* (E_s) is usually introduced as the deformability parameter for soil and relates to linear elastic behaviour for geo material.

Mohanned Q. Waheed and Noor A Asmael, (2023) have discussed that the modulus of elasticity represents soil stiffness, which is the representation of the ratio of stress to strain. This property is essential in engineering and materials science, as it determines a material's ability to support loads retaining its shape. As in the case of back-fill for the approach embankment, the soil's *modulus of elasticity* changes with the composition of the soil. Therefore, in terms of behaviour, the soils are simply described as cohesionless or cohesive. While cohesionless soils include coarser-grained granular materials such as sand, gravels, and non-plastic silts, cohesive soils include fine grained plastic materials such as clay and plastic silts. Lambe T.W. and Robert V. Whitman, (1969) have stated that in natural conditions a pit barrow from where the soil is fetched as a back-fill for embankments, there is no ideal cohesionless soil.

As soil can be treated as an elastic medium which is not man-made, has a composition of gravel, sand and clay components in different proportions. As per IS 1498 (1970), Soils are catalogued into various categories such as Gravels-GW, Sand well-graded-SW, Sand Uniform-SP Sand-GM, Gravel Silty-SM, while Obrzud and Truty (2012) have reported the values of modulus of elasticity for soil for various compactness like Loose, Medium and Dense.

Soil is basically considered as an elastic medium. Wave energy which is transmitted from the vehicles is transmitted through the underlying soil from the vibrating foundation. It is a known fact that the back-fill near the abutments consolidates over a period of time and either forms a ditch or a Camel's-back like situation. In this backdrop an effort has been made to study the effect of the Soil's *Modulus of Elasticity* on the displacement of soil due to the horizontal component of the 70R Tracked vehicle load as per IRC 6-(2017). As the back-fill is compacted in the approach embankment, the study has been done for the dense state.

II. METHODOLOGY:

A study is conducted to calculate the displacement of the soil for different values of *modulus of elasticity* of soil for the horizontal component of the 70R tracked loading (700kN) as per IRC 6 (2017), on the approach embankment. An attempt has been made to study the implications of the same load for different values of *modulus of elasticity* of soil, as its properties vary from place to place; time to time; and it is always a mixture of solids, semi-solids and silt. The ideal soil is very difficult to come by and sometimes the ideal soils even if found are very expensive to transport them to remote sites.

The Ruling Gradient of 3.3% has been considered for the approach embankment as per the Table 4.14, of the MORTH (2019) for Plain & Rolling Terrain. The height of abutment considered is 3 m and the run is approximately 90 m.

As per the clause 204.1.1 of the IRC: 6 (2017), no other vehicle is allowed on the two-lane when 70R tracked vehicle is plying on the road.

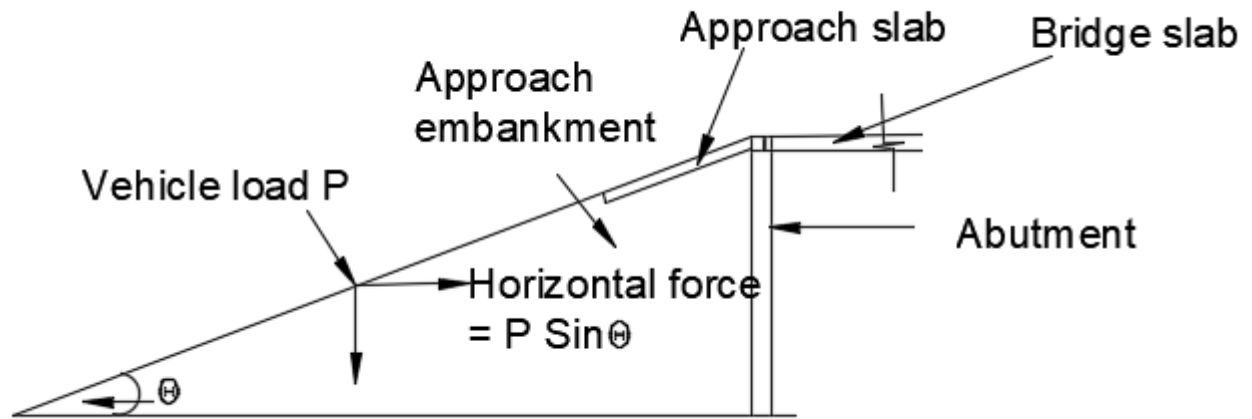


Fig1. Forces acting on the approach embankment

The displacement of soil due to lateral load can be given as $= \left[\frac{P \sin \theta \times L}{E t (a-b)} \right] \times \log_e \frac{a}{b}$

where:

P is the axial Load and $P \sin \theta$ is the Horizontal load $= 700 \times \sin \theta$ kN.

θ is $3.3\% = 1.91$ degrees. (ruling gradient for plain & rolling terrain)

L is the Horizontal length of the approach embankment i.e. 90 m, 75 m, 60 m, 45 m, 30 m and 15 m, for which the displacement is calculated for a corresponding height of soil 0 m, 0.5 m, 1.0 m, 1.5 m, 2 m and 2.5 m respectively.

E_s is the Modulus of Elasticity of soil in MPa.

' t ' is the width of the two-lane road which is considered as 5.3 m.

' a ' is the height of the Abutment, (the thickness of approach slab considered as 300 mm $= 3 - 0.3 = 2.7$ m.

' b ' is the height of the soil considered at heights 0.5 m, 1.0 m, 1.5 m, 2 m, 2.5 m.

The displacement of soil at 0.5m height and at a distance of 75 m from the abutment and for $E_s = 20$ N/mm²

$$= \left[\frac{P \times \sin \theta \times L}{E t (a-b)} \right] \times \log_e \left(\frac{a}{b} \right) = \left[\frac{700 \times 10^3 \times \sin(1.90915) \times 75 \times 1000}{20 \times 5.3 \times 1000 \times (2.7 - 0.5) \times 1000} \right] \times \log_e \left(\frac{2.7}{0.5} \right) = 12.65 \text{ mm}$$

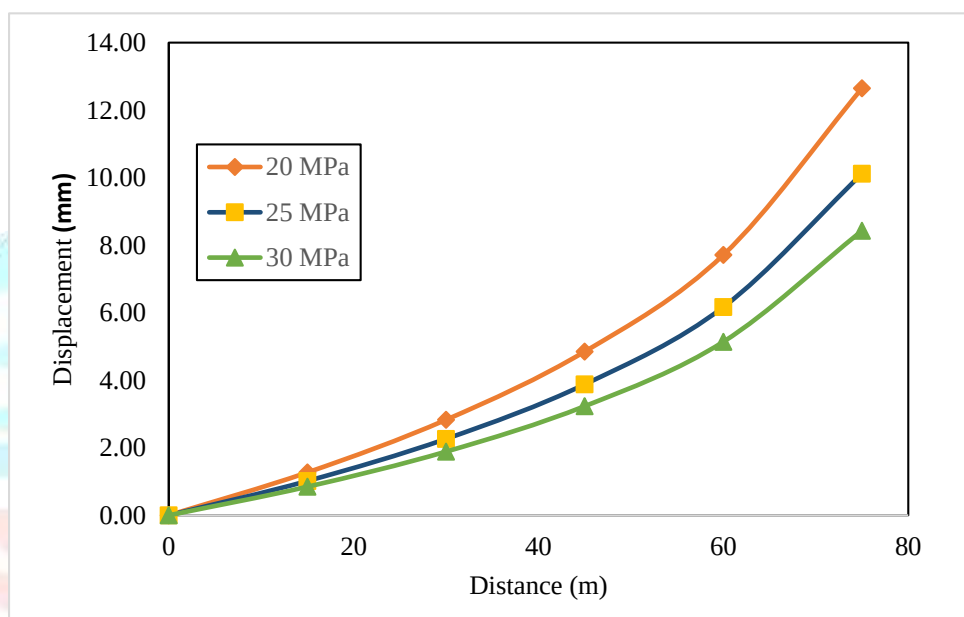
According to Obrzud & Truty (2012), different backfill soils have different E_s values. The values of E_s varies for Dense Sand/Gravel silty, from 20 to 30 MPa; for Dense Sand the E_s varies from 50 to 80 MPa; for Dense Gravels/Sand well-graded, the E_s varies from 160 to 320 MPa. For the approach embankment having a gradient of 3.3% the total run is 90 m for a rise of 3 m. The displacement of the soil is calculated for a ruling gradient of 3.3% for ' a ' = 2.7 m and ' b ' varying from 0, 0.5, 1.0, 1.5, 2.0 and 2.5 m for the lengths (L) of 90 m, 75 m, 60 m, 45 m, 30 m and 15 m respectively from the abutment.

III. Results and Discussion

The displacements of soil obtained for three different values of modulus of elasticity for Dense Sand/Gravel silty soils of 20 MPa, 25 MPa and 30 MPa, by considering different values of horizontal run. They are presented in the Table 1 and also in Fig.2. From the Figure 2, it is observed that as the horizontal run increases, irrespective of modulus of elasticity of soil, it is observed that the displacement is getting increased. Further it is also noticed that for the same horizontal run, the displacement is getting decreased with increase in modulus of elasticity of soil. The displacement of soil for $E_s = 30$ MPa is 33% lesser than that of the displacement of soil having $E_s = 20$ MPa.

Table 1. Displacement of soil for 70R loading on the approach embankment of gradient 3.3%

Horizontal run, L (m)	Displacement (mm) for different values of E_s		
	$E_s = 20$ MPa	25 MPa	30 MPa
0	0	0	0
15	1.27	1.02	0.85
30	2.83	2.26	1.89
45	4.85	3.88	3.23
60	7.71	6.17	5.14
75	12.65	10.12	8.43

**Fig2.** Variation of displacement of the soil for 3m high abutment

The displacements of soil obtained for four different values of modulus of elasticity for Dense Sand uniform soils of 50 MPa, 60 MPa, 70 MPa and 80 MPa, by considering different values of horizontal run. They are presented in the Table 2 and also in the Fig.3. From the Figure 3, it is observed that as the horizontal run increases, irrespective of modulus of elasticity of soil, it is observed that the displacement is getting increased. Further it is also noticed that for the same horizontal run, the displacement is getting decreased with the increase in modulus of elasticity of soil. The displacement of soil for $E_s = 80$ MPa is 37% lesser than that of the displacement of the soil having $E_s = 50$ MPa.

Table 2. Displacement of soil for 70R loading on the approach embankment of gradient 3.3%

Horizontal run L (m)	Displacement (mm) at different E_s			
	$E_s = 50$ MPa	60 MPa	70 MPa	80 MPa
0	0	0	0	0
15	0.51	0.42	0.36	0.32
30	1.13	0.94	0.81	0.71
45	1.94	1.62	1.39	1.21
60	3.08	2.57	2.2	1.93
75	5.06	4.22	3.61	3.16

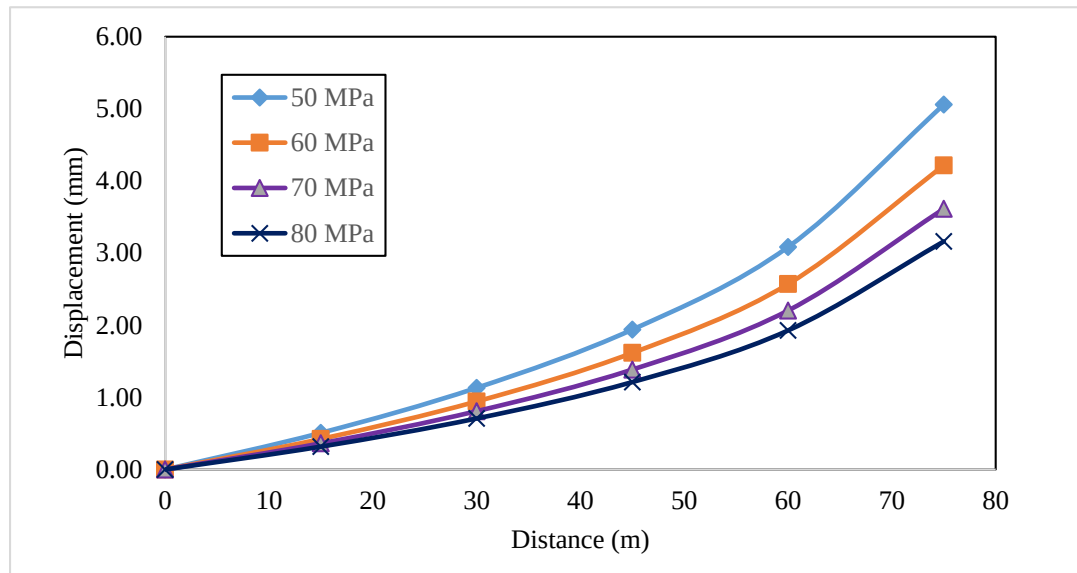


Fig 3. Variation of displacement of the soil for 3m high abutment

The displacements of soil obtained for five different values of modulus of elasticity for Dense Gravels/Sand well graded soils of 160 MPa, 200 MPa, 240 MPa, 280 MPa and 320 MPa by considering different values of horizontal run. They are presented in Table 3 and also in Fig.4. From the figure 4, it is observed that as the horizontal run increases, irrespective of modulus of elasticity of soil, it is observed that the displacement is getting increased. Further it is also noticed that for the same horizontal run, the displacement is getting decreased with the increase in modulus of elasticity of soil. The displacement of soil for $E_s = 320$ MPa is 50% lesser than that of the displacement of soil having $E_s = 160$ MPa.

Table 3. Displacement of soil for 70R loading on the approach embankment of gradient 3.3%

Horizontal run L (m)	Displacement (mm) at different E_s				
	$E_s = 160$ Mpa	200 Mpa	240 Mpa	280 Mpa	320 Mpa
0	0	0	0	0	0
15	0.16	0.13	0.11	0.09	0.08
30	0.35	0.28	0.24	0.2	0.18
45	0.61	0.48	0.4	0.35	0.3
60	0.96	0.77	0.64	0.55	0.48
75	1.58	1.26	1.05	0.9	0.79

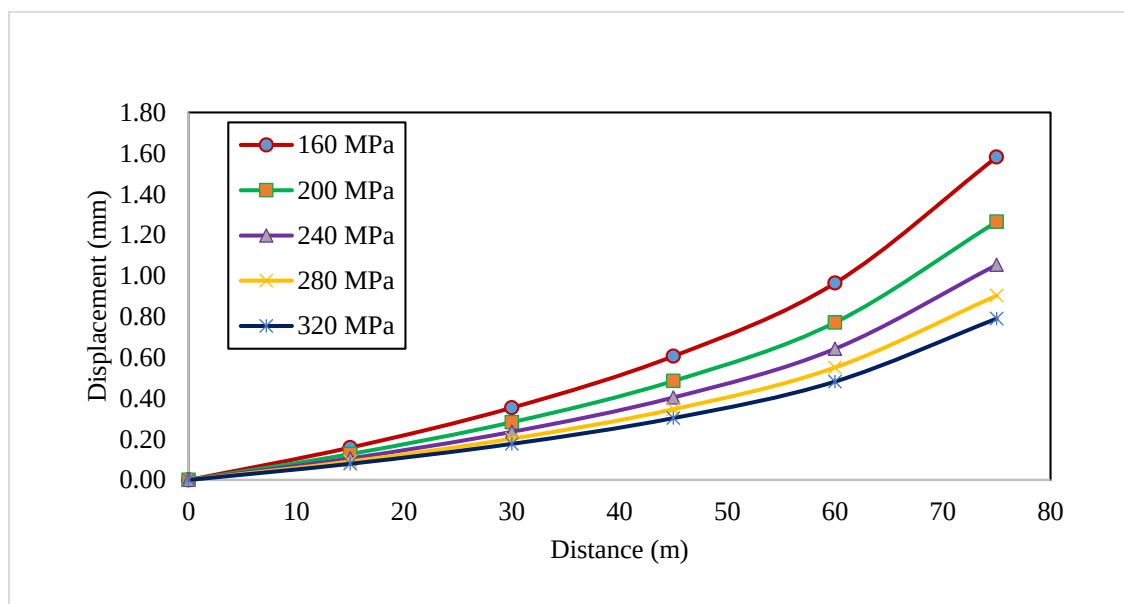


Fig.4 Variation of displacement of the soil for 3m high abutment

IV.CONCLUSION:

Following are the conclusions drawn based on the analytical work carried out to find the displacement of the soil in the approach embankment for different *modulus of elasticity* of soil when a 70R tracked loading (700kN) is passing through the approach embankment for bridges:

1. It is concluded that there is a sizeable displacement of the soil due to the horizontal component of the 70R tracked Traffic Load.
2. It can also be concluded that the displacement is inversely proportional to the *modulus of elasticity* of soil. For a particular *modulus of elasticity* of soil, in case of lower gradients, it took longer time for the soil to settle. The settlement causes a bump while it has taken shorter time for the bump to be created in the embankment for higher gradients.
3. It is noticed that even for soils having higher *modulus of elasticity* of 320 MPa, there is a sizeable displacement of about 0.79 mm. Hence, attention has to be paid for the effect of lateral load of the vehicle on the approach embankments.

REFERENCES:

- [1] A Balasubramanian March (2017); **Chemical Properties of Soil**. Technical Report <https://www.researchgate.net/publication/315669865> Page 1-10.
- [2] AbolfazlEslami, Sara Moshfeghi, Hossein MolaAbasi, MohammadM.Eslami **Geotechnical parameters from CPT records** Piezocone and Cone Penetration Test (CPTu and CPT) Applications in Foundation Engineering, 2020, <https://doi.org/10.1016/B978-0-08-102766-0.00004-3>. Page 81-110
- [3] Harvey E. Wahls. National Cooperative Highway Research Synthesis of Highway Program **Practice 159 Design and Construction of Bridge Approaches; North Carolina State University, Raleigh, North Carolina**. (1990) Page 1, 36.
- [4] Indian Road Congress; **Standard Specifications and Code of Practice for Road Bridges, Section:II. IRC:6-2017** page 10-11
- [5] Indian Standard Classification and Identification of Soils for General Engineering Purposes **IS: 1498-1970**.

- [6] Kun Zhang¹, Di Feng^{1*} and Zhikui Wang² Zhang K, Feng D and Wang Z, **Study on the mechanical properties of embankment soil under long-term immersion conditions**. DOI 10.3389/fmats.2023.1270082; Frontiers in Materials (2023).
- [7] Lambe, T.W. and Robert V. Whitman, **Soil Mechanics**, Published by John Wiley and Sons, New York, (1969), Pages 137 - 149.
- [8] Mohammed Q. Waheed and Noor A Asmael, **Evaluation of Elasticity Modulus of Clayey Soil from Undrained Shear Strength** E3S Web of Conferences 427, 01028 (2023) <https://doi.org/10.1051/e3sconf/202342701028> ICGEE (2023). Page 1-10
- [9] Ministry of Road Transport and Highways; Pocket Book for Highway Engineers (Third Revision) January 2019 Page 54.
- [10] Obrzud & Truty (2012) compiled from Kezdi 1974 and Prat et al. 1995. **Soil Elastic Youngs Modulus** Geotechdata.info. Soil Youngs Modulus <http://geotechdata.info/parameter.'soil-elastic-youngs-modulus.html> Updated 17-09-2013. Page 1-2.
- [11] R.K.Bansal –(2004) **Strength of Materials** Published by M/s.Laxmi Publications (P) LTD. Page 31-33.
- [12] The U.S. Bureau of Reclamation's Earth Manual. (1990) Page 1-4.

