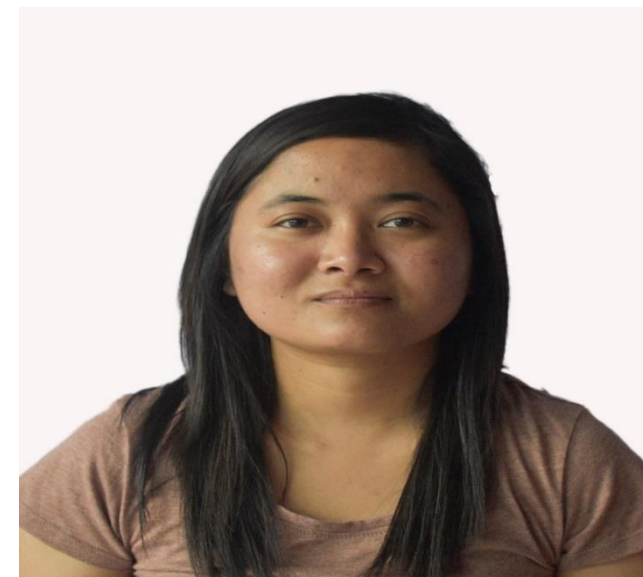


Effect of application of geo-grid on the optimization of bridge abutments on open foundation



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Introduction

Using geo-grid in the backfill behind an abutment, the earth pressure exerted by the backfill can be reduced significantly. So this study evaluates the reduction in lateral earth pressure and consequential reduction in the size of the abutment stem and its open foundation size as well as the cost. The increasing lateral pressure corresponding to the height at the backfill will be attenuated by using low stiffness and compressible materials behind abutments. Carder and Card (1997) studied the applicability of using different elastic-compressible materials, such as geo composites and polymers to reinforce backfill reducing high lateral pressures behind abutments. This study covers parametric examination on the use of Geo-grid reinforcement soil and normal soil as backfill in bridge abutment and its versatility impact, cost effectiveness in bridge abutment-open foundation obtaining the optimization of the project.

So, this study has been done to address the two variables, first one is angle of internal friction or repose of the backfill and the second one is the height of the abutment. During analysis, lateral earth pressure load show significantly highlighted due to insufficient tensile strength of soil ,than others load since backfill soil exert lateral earth pressure significantly to retaining structures as per IRC 6. So except EPF, most of the load are insignificant.

Objective:

- To generalized equation for the backfill soil of increased angle of friction of soil as a result of layered reinforced –Geo-grid embedded in normal soil retained in bridge, abutment.
- To visualize the effect of normal and reinforced (Geo-grid) backfill soil in the quantity

Methodology

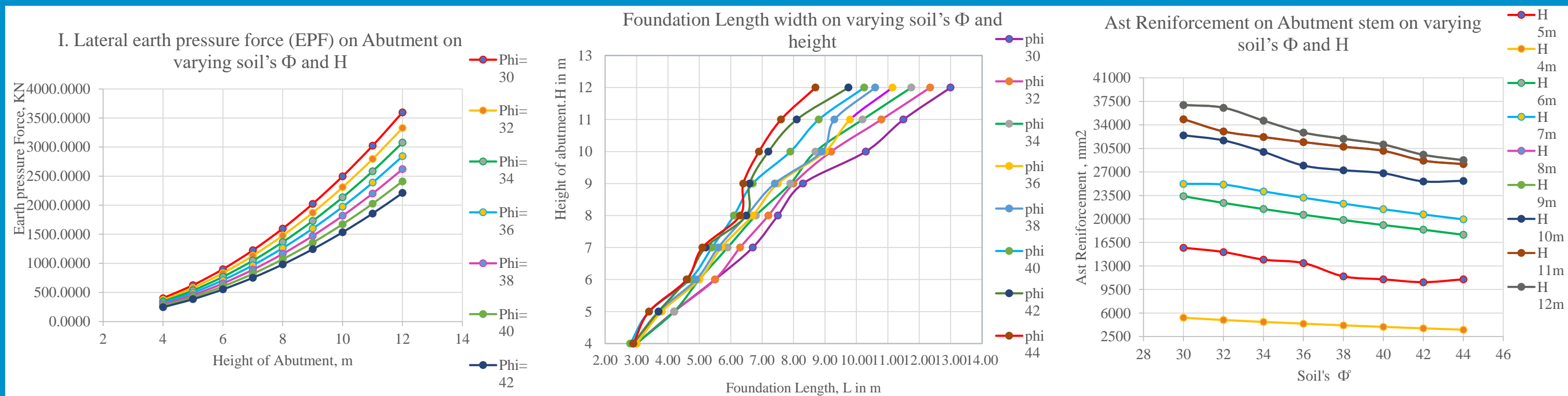
The design evaluation have been carried out from MS excel for superstructure and sub structure retaining both “normal backfill” and “reinforced backfill-Geogrid reinforced soil” for bridge span as 40 m and bridge height 10m of Pre-stressed Simply supported bridge with open foundation based on IRC 6, IRC112, IRC78..

Due to limitation of the real and actual site based laboratory test data of Geogrid reinforced soil, it is tried to innovate the experimental equation to correlate the equivalent frictional angle of the normal backfill as ‘Φ’ and modified improved frictional angle as ‘Φ’ which is attained by the provision of the geogrid reinforcement at certain spacing ‘Sv’ for specific height of the bridge abutment. The equation is generalised in terms of function as.

$$\Phi' = f(\Phi, Sv, H).$$

Analysis was done for the 10m abutment were considered, with different soil’s frictional angle varying from 28° to 50°. And with the inclusive of the geogrid at different spacing of ‘Sv’ satisfying the tensile strength check. And then, stability of the geogrid system, i.e. overturning was calculated and analyzed for different soil’s frictional angle, geogrid spacing and computed the Factor of safety based on IRC SP 102. And the same Fos was computed for normal Backfill varying the Φ. With the series of data of 19 number frictional soil’s phi value, with the normal soil phi’s when reinforced by the no of reinforcement layer with certain spacing considering the soil property is increased. The content is the FOS is kept same in abutment with and without Geogrid reinforcement.

Results

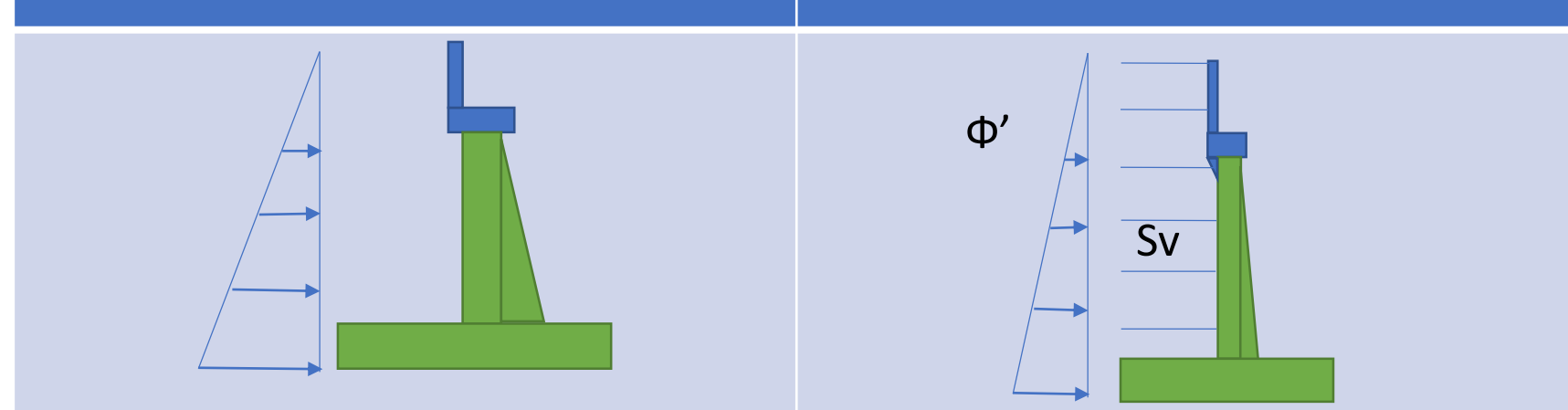


The results shows when the soil internal friction angle is increased which is achieved by the inclusion of Geogrid for constant height, exerted lateral pressure decreases, decreases the foundation length, and consequently decrease in steel requirement in abutment stem.

Quantity estimate is carried out for the abutment height H=10m, Normal backfill soil, Φ=16.85 eqv. to 20° (take) Geogrid backfill soil, Φ'

$$\Phi' = 4.46*20 - 1.78*1.3 - 34.89 = 38^\circ$$

Normal backfill system (Normal soil wall /NRS)	Geogrid backfill system (Geosynthetic Reinforced soil wall /GRS)
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Quantity	Abutment-foundation with	Backfill Abutment-foundation with Geogrid Backfill	Reduction in quantity %
Concrete, m3	343.43	233.16	32.11 %
Steel, T	21.24	14.89	29.85 %
Geogrid, Sq m	-	764.4	Added item

Paralink 100 (100 KN/m) for abutment height, H= 10m.
 Cost = 450 per sq m
 $L = 0.7*H = 7m$ BS 8006: 2010
 $B = 8.4m$
 Area = 58.8 Sq m
 No of layer = 13 no
 Required Geogrid area provided at 10m = 58.8*13sq.m = 764.4 sq m

Discussion

With the computed data in table, regression analysis was done with the two dependent variable and independent variable, and the equation was computed with the best fit in terms of

$$\Phi' = f(\Phi, Sv, h)$$

$$\Phi' = a. \Phi + b. Sv + c$$

After analysis, the equation with the variable is generalized as;

$$\Phi' = 4.46. \Phi - 1.78. Sv - 34.89$$

With the above equation, approximate modified internal friction angle Φ' can be calculated mathematically with the provision of Geogrid at different spacing Sv in a same soil type of internal friction angle Φ.

Further, Based on varying internal friction, different graphical analysis was carried out.as

$$EPF = \frac{1}{2} * \gamma * Ka / Ca * H^2 \dots i$$

$$EP \propto H^2$$

$$EP \propto 1 / \Phi$$

$$EP \propto Ka / Ca$$

Here,

$$Ka / Ca = f(\Phi)$$

Where

EPF = Earth lateral pressure force
 Ka/ Ca = Coefficient of static/ dynamic active earth pressure
 Φ = Angle of internal friction of soil
 H = Height of abutment

Factor of safety.	Φ' (Geogrid soil), degree	Sv (Geogrid spacing), m	Φ (Normal soil), degree
1.08	28°	0.8	14.31°
1.1	29°	0.8	14.65°
1.11	30°	0.8	14.83°
1.13	31°	0.9	15.19°
1.16	32°	1.1	15.77°
1.16	34°	1	15.85°
1.17	35°	1.1	16.17°
1.18	36°	1.2	16.18°
1.2	37°	1.2	16.62°
1.21	38°	1.3	16.85°
1.22	39°	1.4	17.06°
1.23	40°	1.4	17.30°
1.25	42°	1.6	17.75°
1.26	43°	1.65	17.97°
1.28	44°	1.8	18.50°
1.29	45°	1.9	18.71°
1.3	46°	2	18.97°
1.32	48°	2.2	19.47°
1.34	50°	2.4	20.00°

Conclusion

In abutment –open foundation, where the significant imposed load is due to the Earth Pressure Force at the backface of the Abutment stem. When abutment retain normal soil as backfill (Φ) as per IRC 6, cl 214 and reinforced backfill soil (Φ') IRC SP 102, decrease the earth pressure force respectively. It is because since soil is weak in tensile strength and backfill soil tend to slides at rest position, consequently exerts the high pressure. But with the inclusive of the Geogrid at ‘Sv’, the tensile strength of the soil is increased and simultaneously decreases the exerting earth pressure on the sub structures.

Due to decrease in earth pressure being a significant load in sub structure, the resulted section size, steel requirement reduced accordingly.

For abutment height, H= 10m, when retained the normal soil of Φ= 20°, and reinforced backfill soil (Φ') = 38°, result in reduction in concrete and steel quantity by 32.11% and 29.85% respectively.

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 Vieira S. Castorina, Lopesa Maria, Caldeirab Laura, 2011 “Earth pressure coefficients for design of geosynthetic reinforced soil structure.”
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