TENAX

Technical Reference GRID-DE-3

DESIGN OF SOFT SOIL STABILIZATION WITH TENAX GEOGRIDS

grid-de-3
Feb., 2001

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1. Bearing Capacity of Soft Subgrade

According to Rodin's research, before a complete failure of soft soil subgrade occurs, local over-stressing in shear takes place and results in punching shear failure or local shear failure in the soil. The bearing capacity of the subgrade under such conditions is low and can be quantified by

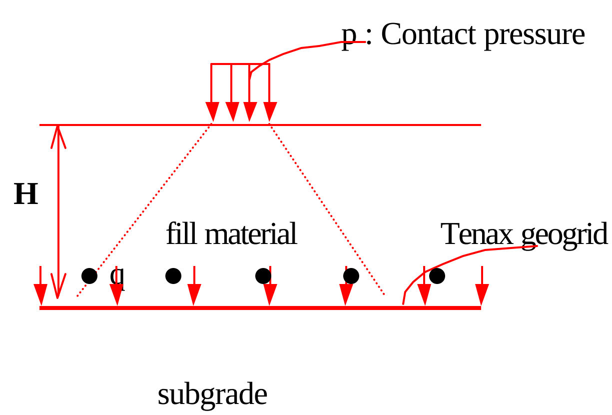
$$q_u = \pi \cdot c_u \qquad (1)$$

where c_u is the undrained shear strength of the subgrade. An empirical relation between CBR value and the undrained shear strength can be used if subgrade CBR value is provided

$$c_u = 30 * CBR \ \ (kPa) \qquad (2)$$

When localized shear failure of the subgrade can be prevented (i.e., a general shear failure can be reached), the bearing capacity of the subgrade can be increased to

$$q_g = 6.2 \cdot c_u \qquad (3)$$



Tenax geogrids have high tensile strength, high tensile modulus and great soil interlocking capacity. Large scale pull-out testing demonstrated that Tenax geogrids retained great soil interlocking capacity when the soil type changes from gravel to sand. Testing and project experience have proven that Tenax geogrids are capable of preventing localized shear failure of the soft subgrade. Tenax geogrid prevents local movement of the material through the mechanism of interlocking the fill material in the aperture of the geogrid and also by a separation function (when Tenax multilayered geogrids are used) to a certain degree.

2. Types of Dynamic Loading

Three types of dynamic loading are considered in this design manual and software:

- single axle (single wheel)
- single axle (dual wheel)
- tandem axle

3. Contact Pressure and contact area

The design dynamic loading, Q, for rubber tired vehicles (single, dual, or tandem wheel) is equal to half of the axis load

$$Q = \frac{P_{axis}}{2} \tag{4}$$

The contact pressure, p, under dynamic loading is determined as follows:

- for single wheel and dual wheel loading, the contact pressure is equal to their tire inflation pressure, the typical tire inflation pressure is around 100 psi.

- for tandem axis loads, the contact pressure is calculated by

$$p = \frac{Q}{a * b} \tag{5}$$

where **a** is the spacing of tandem axles, **b** is the total width of dual wheels.

The contact area is assumed to be a circular area, and its radius is calculated by

$$R = \sqrt{\frac{Q}{\pi * p}} \tag{6}$$

4. Determination of the Fill Thickness

Boussinesq equations are used here to calculate the required fill thickness. The criterion for calculating the fill thickness is that the thickness of the fill must be large enough to allow the stress transferred to the subgrade surface is within the bearing capacity of the subgrade as determined by equation (1) and (2).

For rubber tired traffic loading, the contact area of the wheel is assumed to be a circular one, in this case, the vertical stress q transferred from uniform loading p under a circular area can be calculated by

$$q = p\{1 - [\frac{1}{1 + (R/H)^2}]^{3/2}\} \tag{7}$$

where R is the radius of the circular loading area, and H is the thickness of the fill. Substituting eq. (1) and eq. (6) into the above equation, the required thickness for an unreinforced section is

$$H_u = \sqrt{\frac{\frac{Q}{\pi \cdot p}}{(1 - \frac{\pi \cdot c_u}{p})^{-2/3} - 1}} \tag{8}$$

similarly, the required thickness for a section reinforced with Tenax geogrid is

$$H_r = \sqrt{\frac{\frac{Q}{\pi \cdot p}}{(1 - \frac{6.2 \cdot c_u}{p})^{-2/3} - 1}} \tag{9}$$

5. Design Example

Input data:

subgrade CBR value = 0.5
single axle load = 20 kips
tire inflation pressure = 100 psi

Calculations:

The wheel load: Q = 20/2 = 10 kips = 10,000 1b

The subgrade undrained shear strength can be calculated by eq. (2)

Cu = 30*0.5 = 15 kPa = 2.16 psi

For unreinforced section, the required thickness, H_u, is calculated from eq. (8)

$$H_u = \sqrt{\frac{\frac{10,000}{3.14 \cdot 100}}{(1 - \frac{3.14 * 2.16}{100})^{-2/3} - 1}} = 25.8 \text{ in}$$

and the required thickness with Tenax geogrid

$$H_g = \sqrt{\frac{\frac{10000}{3.14 \cdot 100}}{(1 - \frac{6.2 * 2.16}{100})^{-2/3} - 1}} = 17.8 \text{ in}$$

6. Design Worksheet SoilStable

The above described set of design calculations are simplified in a Microsoft Excel® worksheet called **SoilStable** to assist in designing of soft soil stabilization with and without the use of Tenax's Geogrids. Enclosed is a diskette/ CD with a copy of **SoilStable** worksheet.

Using the worksheet is straight forward; by inserting the input data in the corresponding cells, and hitting the button "CALCULATE", the designed cross section with and without using geogrid will be displayed on the output cells. The worksheet contains a background information on Tenax MS geogrid series and the specification sheets of MS220, MS330, and MS500 geogrids. Micrsoft Office ® 97 (or more recent version) is required to open this worksheet, with "Enabling Macro" option

7. Comments

(1) Comparison of the bearing capacity formulas in different design methods.

- Giroud and Noiray "Design of geotextile reinforced unpaved road"

$q_u = 3.14 * c_u$ for unreinforced section

$q_r = 5.14 * c_u$ for reinforced section

- Barenberg "Subgrade stabilization"

$q_u = 3 * c_u$ for unreinforced section

$q_r = 6 * c_u$ for reinforced section

- Philip's "Stabilization Design Guide"

$q_u = 2.8 * c_u$ for unreinforced section

$q_r = 5 * c_u$ for reinforced section

- Tensar's "Construction Over Soft Soils"

$q_u = 3.1 * c_u$ for unreinforced section

$q_r = 6.2 * c_u$ for reinforced section

(2). The bearing capacity of the fill must also be checked by eq. (1) against the contact pressure from the wheel.

(3). This design method can be used in conjunction with other design methods (such as AASHTO method for flexible pavements etc.) to design pavement system.

References

Giroud, J.P. and Noiray, L. (1981). Design of geotextile reinforced unpaved road, Journal of Geotechnical Engineering, ASCE, 107, 1233-1254

Barenberg, E.J. (1992), Subgrade stabilization, in A Design Primer: Geotextiles and Related Materials, IFAI, 10-20.

Phillips Fibers Corporation. (1987). Stabilization design guide.

Rodin, S. (1965). Ability of a clay fill to support construction plant, Journal of Terramchanics, 2, 51-68.

Tensar Corporation. (1987). Design guidline for subgrade improvement under dynamic loading with Tensar geogrids.