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ANALYTICAL MODEL FOR DESIGN OF GEOSYNTHETIC REINFORCED PAVEMENTS BASED ON PULLOUT TESTS

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ABSTRACT
The confined soil-geosynthetic interaction at low displacements is of main concern for design of geosynthetic reinforced pavements. Pullout tests have been used to understand the soil-geosynthetic interface under confinement using the limit equilibrium and analytical procedures. The limit equilibrium methods neither give sufficient information on the pullout force nor displacement and strains developed in the reinforcements prior to failure (Rowe and Mylleville, 1994). On the other hand, analytical methods can be used to predict displacement, strains and force generated in the reinforcement during the deformation as well as failure (Sugimoto and Alagiyawanna 2003). This paper presents a solution to the analytical model (solution to the governing differential equation for pullout test) to capture soil-geosynthetic interaction at small strains and its application to the geosynthetic reinforced pavement design.

1. INTRODUCTION

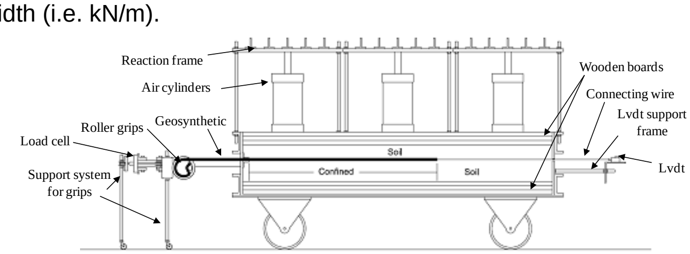
Analytical solutions to interpret and analyze data obtained by pullout test have been proposed by Juran and Chen (1988), Yuan and Chua (1991), Abramento and Whittle (1995), Sobhi and Wu (1996), Alobaidi et al. (1997), Madhav et al. (1998), Perkins and Cuelho (1999), Palmeira (2004), Teixeira et al. (2007). These models vary in their assumptions with respect to the constitutive material properties, the load transfer mechanism at the interface, and the shape of the load-strain curve during pullout (Gupta, 2009). In general, these analytical models are used to predict the load-displacement curve of soil-geosynthetic system under confinement.

The analytical models for pullout test interpretation were developed for MSE wall design and focus on predicting the maximum pullout force magnitudes. Since, the focus of current analytical solutions is prediction of failure conditions; the displacement profile from frontal linear variable differential transducer (LVDT) is the only displacement value used to predict the response of the geosynthetic for given load magnitude. However, for the geosynthetic reinforced pavements the initial stiffness of the soil geosynthetic interface is important which requires a model that can capture small displacement behavior. This paper describes the differential equation governing the behavior of soil-geosynthetic interaction in the pullout test. Then, the method is proposed to solve this equation using new boundary conditions which incorporate information from all the LVDT's used in a pullout test. Finally, the application of this solution to reinforced pavement design is discussed.

2. ANALYTICAL MODEL FOR PULLOUT TEST

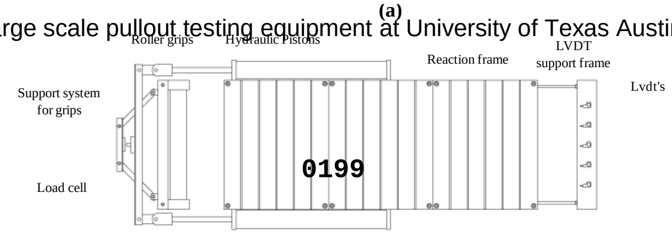
2.1 Governing Differential Equation

A pullout test is conducted by sandwiching a geosynthetic of known length L and width W between two soil layers inside the pullout box (Figure 1). Normal pressure is then applied on the top of the soil-geosynthetic interface to represent the field conditions under which geosynthetic is expected to perform. Finally, the geosynthetic is clamped at the loading grips and is pulled out of the box assembly at a constant rate of displacement and the required force is measured. The pullout force F measured during the pullout test is generally reported as a normalized value per unit width of the specimen and has units of force per unit width (i.e. kN/m).



(a)

Figure 1. Large scale pullout testing equipment at University of Texas Austin (Gupta, 2009)



Geosynthetics are categorized as extensible and inextensible reinforcements depending on strain magnitude required in mobilizing the maximum tensile strength. For inextensible geosynthetics the peak strain values range between 2%-5% whereas for extensible geosynthetics they are greater than 10%. McGown et al. (1978) reported different load-deformation response for these reinforcements as shown in Figure 2. In this study, the initial displacement behavior of geosynthetics was analyzed and geosynthetics were assumed to be inextensible in the range of strain mobilized due to these movements.

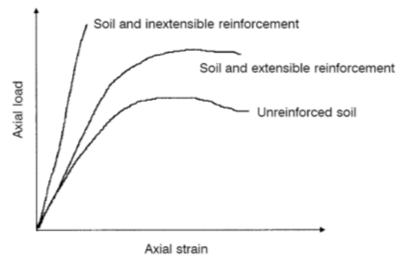


Figure 2. Axial load-strain relationship for various reinforcements with soil (McGown et al., 1978)

2.1.1 Shear stress-confined force relationship

Consider a geosynthetic element of length dx, confined inside the pullout box and subjected to force F in the pullout direction. Then the shear stress $\tau(x)$ is mobilized along its surface, such that the force is dissipated along its length. Assuming no extensibility of reinforcement, the free body diagram for points A and B on the either side of the element can be given as shown in Figure 3 below.

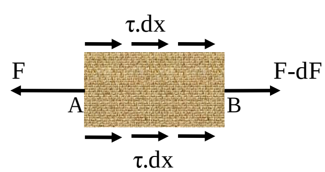


Figure 3. Free body diagram for geosynthetic element of length ∂x in pullout test

The force equilibrium can then be written in differential form as follows:

$$F(x) - (F(x) - dF(x)) = 2.\tau(x).dx \tag{1}$$

$$\tau(x) = \frac{1}{2}.\frac{dF(x)}{dx} \tag{2}$$

2.1.2 Confined force-strain relationship

Let us assume that strain $\varepsilon(x)$ develops in the element of length dx due to the change in confined force (dF) between two points. Then, the confined force and strain are related through confined stiffness J_c of the geosynthetic and is given as,

$$F(x) = J_c.\varepsilon(x) \tag{3}$$

2.1.3 Strain-displacement relationship

The strain developed in the geosynthetic element of length dx can then be related to the displacement in the reinforcement, dw_r as:

$$\varepsilon(x) = \frac{dw_r(x)}{dx} \tag{4}$$

By substituting Equation 4 into Equation 3,

$$F(x) = J_c . \frac{dw_r(x)}{dx} \tag{5}$$

Differentiating above equation with respect to x, gives

$$\frac{dF(x)}{dx} = J_c . \frac{d^2 w_r(x)}{dx^2} \tag{6}$$

Substituting Equation 6 into Equation 2 gives,

$$\tau(x) = \frac{1}{2} J_c . \frac{d^2 w_r(x)}{dx^2} \tag{7}$$

$$\frac{d^2 w_r(x)}{dx^2} = \frac{2.\tau(x)}{J_c} \tag{8}$$

The above expression is a second-order differential equation governing the soil-geosynthetic interface behavior during the pullout test. The equation relates the displacement $w_r(x)$ with the shear stress $\tau(x)$ developed at the soil-geosynthetic interface in terms of confined stiffness J_c, for geosynthetic element of length dx in the pullout test.

2.2 Assumptions involved

The expression derived in equation 8 was used to predict the behavior of the soil-geosynthetic interface in a pullout test is a second-order differential equation. The solution to the governing equation requires defining three relationships. Perkins and Cuelho (1999) developed the solution for the governing equation of geosynthetic element in a pullout test using assumptions related to each of the above relationships. The three assumptions were related to:

- Geosynthetic load-strain relationship
- Absolute movement of soil surrounding the geosynthetic
- Relationship to describe shear stress-displacement response

2.2.1 Geosynthetic load-strain relationship

An assumption is required for predicting the confined stiffness of the geosynthetic during the pullout test. It has been modeled as linear (Wilson-Fahmy et al., 1994), non-linear (Perkins and Cuelho, 1999) or equal to unconfined stiffness of the geosynthetic obtained from the wide-width in air tensile test (Ochiai et al. 1996, Sierra et al. 2009). In the solution proposed in this study, the force-strain relationship for a given geosynthetic was assumed linear and proportional to the confined stiffness of the soil-geosynthetic system. It differs from the current models which assume a linear relation based on the stiffness of the geosynthetic obtained from the unconfined tensile test to predict the behavior under confinement. Due to interlocking in geogrids or impregnation of geotextiles with the surrounding soil, the transverse ribs or fibers are mobilized leading to additional components which help in load dissipation throughout the length of the geosynthetic. This is not captured by the stiffness value of the geosynthetic obtained from isolated unconfined tensile tests in uniaxial direction. This assumption better represents the response of geosynthetics under pullout test conditions as shown in Figure 4.

2.2.2 Absolute movement of soil surrounding the geosynthetic

The differential movement dw at a point along the reinforcement is sum of two components dw_s and dw_r. According to Sobhi and Wu (1996), "The component dw_s is defined as the displacement due to shear strain at the soil-geosynthetic reinforcement and dwr is defined as the displacement due to tensile elongation of reinforcement." For the present analysis dw_s was considered to have zero magnitude and dw_r was considered equal to the total displacement measured during the test. The above assumption can be expressed in the mathematical form using the following equations:

$$dw(x) = dw_s(x) + dw_r(x) \tag{9}$$

$$dw_s(x) = 0 \tag{10}$$

$$dw(x) = dw_r(x) \tag{11}$$

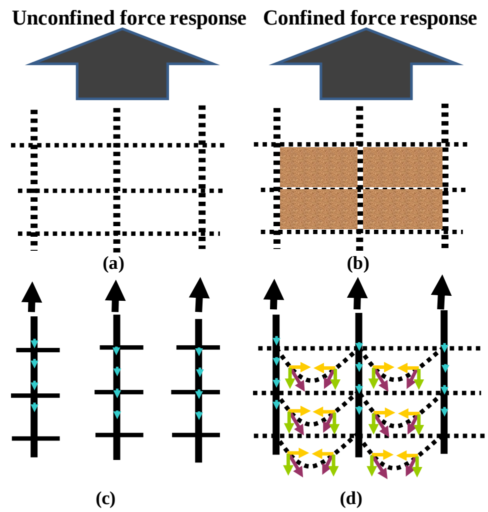


Figure 4. Response of geosynthetic: (a) Unconfined force (b) Confined force (c) Longitudinal ribs mobilized under unconfined loads (d) Both longitudinal and transverse ribs mobilized under confined loading conditions

2.2.3 Shear stress- relative displacement relationship at the interface

Juran and Chen (1988) indicate that modeling of the load transfer mechanism generated in a pullout test requires an appropriate interaction law to relate the shear stress mobilized at any point of the interface to the reinforcement displacement. In previous studies, the distribution of shear stress has been assumed constant (Sobhi and Wu, 1996), linear (Abdelouhab et al., 2008), bi-linear (Juran and Chen 1988, Madhav et al. 1998), non-linear (Perkins and Cuelho, 1999) or hyperbolic (Gurung and Iwao, 1998) with increasing geosynthetic displacement magnitude. Sobhi and Wu (1996) defined limit shear stress for pullout test which was lower than the maximum shear stress and a function of overburden pressure applied to the soil-geosynthetic interface. They showed results from finite element analyses indicating development of uniform shear stress independent of the frontal pullout force magnitude and length of the geosynthetic.

The analyses in this study assumes a parameter called as yield shear stress (τ_y), which is assumed to be uniform over the active length of the reinforcement. The yield shear stress is a key parameter for a given soil-geosynthetic system subjected to normal pressure and is independent of the displacement at a point along the confined length of geosynthetic. It is computed based on the movement of LVDT's used in the test and has lower magnitude than that obtained from maximum pullout conditions (τ_{max}). In principal, the yield shear stress is a parameter which accounts for shear, bearing and passive mechanisms experienced by the geosynthetic in the pullout box at small displacements.

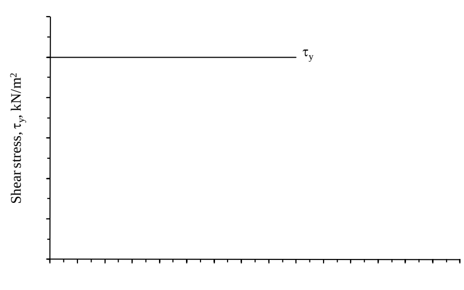


Figure 6. Shear stress distribution as a function of displacement at a given point

2.4 Displacement distribution along geosynthetic length

Assuming that the shear stress is constant and equal to the yield shear stress τ_y, and substituting dw for dwr as derived in Equation 11, the governing differential Equation 8 at any given time t for a given frontal pullout force, can be written as,

$$\frac{d^2w(x)}{dx^2} = \frac{2.\tau_y}{J_c} \tag{12}$$

The two model parameters are τ_y and J_c. Since both these parameters are assumed to have a unique value for a given pullout test, the right hand side of Equation 12 can be replaced by another constant β, such that

$$\beta = \frac{2.\tau_y}{J_c} \tag{13}$$

Substituting Equation 13 into Equation 12,

$$\frac{d^2w(x)}{dx^2} = \beta \tag{14}$$

Integrating both sides, we obtain

$$\frac{dw(x)}{dx} = \beta.x + C_1 \tag{15}$$

Then, the strain at any confined point x can be expressed as shown in Equation 15 and can be written as:

$$\varepsilon(x) = \beta.x + C_1 \tag{16}$$

Then, the force at any point x can be given by substituting the Equation 16 in Equation 3,

$$F(x) = J_c.\varepsilon(x) = J_c.(\beta.x + C_1) \tag{17}$$

Further integrating both sides of Equation 15, leads to

$$w(x) = \frac{1}{2}\beta.x^2 + C_1.x + C_2 \tag{18}$$

where C_1 and C_2 are constants whose values can be estimated using boundary conditions. The expressions derived in Equations 16, 17 and 18 above can be used to predict the strain, force and displacement profile at any point x within the pullout box in terms of model parameters τ_y and J_c provided C_1 and C_2 are known.

2.5 Boundary conditions

The coefficient values are computed based on the boundary conditions adopted by a given model while proposing a solution to the governing equation. The boundary conditions involve knowing two quantities at a given instant of time. These are generally force at pullout end and displacement at other end of the specimen. Therefore, a known force value at one boundary and known displacement value at other boundary at any given instant of time can be used to solve for both the coefficients.

For the force boundary condition, the force at pullout end of the specimen is known at any given time and can be used to solve for one coefficient (C_1 in this case). Since the analytical solutions for pullout test were developed in previous studies to assess the collapse of MSE walls, the focus was modeling of the failure conditions. Therefore, the displacement boundary condition in these solutions was based on the mobilization of the entire length of the geosynthetic. It was assumed that when maximum pullout force was reached in a given test, the entire length of the geosynthetic is mobilized and displacement at the embedded end is zero. This condition was then used to solve for second coefficient (C_2 in this case). The magnitudes of these coefficients were finally used for predicting the displacement distribution for the entire geosynthetic length at failure.

However, the applicability of pullout tests to reinforced pavement design involves understanding of the soil-geosynthetic interface stiffness developed at low displacement magnitudes. The solution is thus required to model the entire frontal force and displacement curve for a pullout test with emphasis on capturing the initial displacement mobilized at the interface. In other words, the solution requires a displacement boundary condition such that it can be solved for increments of frontal pullout force value throughout the test and not the maximum pullout force alone. The displacement values for a given frontal force can be obtained by integrating the strain profile over the entire length of the geosynthetic. Consequently, solutions for second coefficient have involved assuming a strain distribution and solving it to predict the subsequent displacement profile for the entire geosynthetic length. Two methods have been proposed in the literature to solve the coefficient for second boundary condition in regards with strain distribution. The first approach involves solving the displacement boundary by assuming constant strain distribution over the entire length of the geosynthetic. The second approach involves assuming a linear distribution of strain and substituting the value for the coefficient from another test like wide width tensile test or direct shear test. This solution is then used to predict displacement profile along the length of the geosynthetic.

2.5.1 Constant strain distribution

A constant strain distribution assumes the uniform strain between two measurement points. Then the average strain between these points is calculated based on the displacement measurements made using LVDT's during the test. This approach was proposed by Ochiai et al., (1996) and the strain throughout the entire length of the geosynthetic was assumed as a step function. The above assumption is illustrated in Figure 5. Consider a geosynthetic of confined length L subjected to pullout force Fp at a given time t, as shown in Figure 5a. Then let x_1, x_2 and x_3 be three points on the geosynthetic such that the distance between 1 and 2 is L_1 and 2 and 3 is L_2. Also, the displacements for given force are d_1, d_2 and d_3 at these three points. Then using the above assumption of constant strain, its value can be calculated. The resulting strain and displacement profile predicted based on above assumption is shown in Figures 5b and 5c respectively.

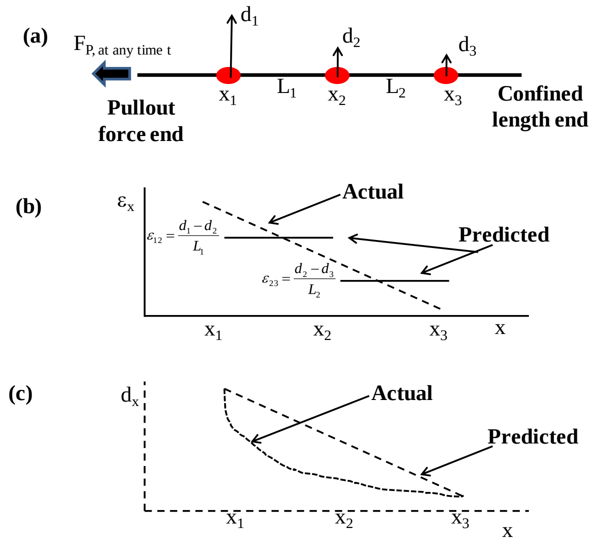


Figure 5. Predictions based on constant strain distribution: (a) Schematic of displacement profile for given pullout force (b) actual vs. predicted strain distribution (c) actual vs. predicted displacement

Based on model assumptions it can be seen that strain is a linear function whereas displacement is a quadratic function over the length of the geosynthetic for given frontal pullout force. However, the assumption of constant strain leads to linear distribution of displacement along the length of the geosynthetic. i.e., value for second coefficient is assumed zero. This approach under predicts the strain magnitude at points closer to the pullout end and over predicts the strain at point closer to the embedded end of the geosynthetic.

2.5.2 Linear strain distribution

This assumption involves modeling the strain distribution as a continuous function over the mobilized length of the geosynthetic. The solutions incorporating boundary condition based on this hypothesis represent the model conditions realistically. Two approaches have been reported in the literature to model this behavior.

The first approach involves assuming the strain distribution under confined conditions in the reinforcement equals that under unconfined conditions. Then knowing the frontal force, the strain magnitude is calculated as shown in Equation 17. Once the strain magnitude is known, the displacement value can be calculated by integrating Equation 16. Sierra et al. (2009) proposed a load transfer model to predict force-displacement relationship of the geogrid under pullout conditions by subdividing it into rheological units but used load–elongation curves from tensile tests on the geogrids. The other approach involves developing the entire solution and then calibrating the second coefficient from a test other than the pullout test. Sobhi and Wu (1996) proposed a model to predict pullout force and displacement at a point under confined conditions but it required another test as proposed by Ling et al. (1992) to calibrate the model. The drawback of this approach is that the strain levels used to calibrate the parameter are different from one observed in the pullout test. This leads to test results which are sensitive to small changes in value of the assumed parameter.

2.6 Discussion

The current analytical solutions either incorporate the limited data obtained from the pullout test or use other tests to predict the model parameters. The assumptions made in the current models with regards to second boundary condition leads to errors which are critical when predicting behavior of soil-geosynthetic interface at regime of low displacements.

3. SOIL-GEOSYNTHETIC INTERACTION MODEL

The solution for governing differential equation of the pullout test involves two coefficients. The first coefficient can be computed by using the force boundary condition at the pullout end of the geosynthetic. The second coefficient is computed using assumption regarding strain distribution within the geosynthetic for a given force level. A new model called soil-geosynthetic interaction (SGI) model is proposed as part of this paper which involves a different approach in terms of displacement rather than strain values to compute the second boundary condition for the pullout test.

Specifically, rather than assuming the strain distribution for a given geosynthetic, the incremental distance travelled by increase in frontal pullout force through the confined geosynthetic specimen length during the test is monitored. In other words, the length of geosynthetic mobilized for a given frontal pullout force value is computed. This concept was proposed by Sobhi and Wu (1996) and called active length of reinforcement where the force is zero within the embedded geosynthetic for a given magnitude of frontal pullout force. The similar definition for active length (L’) of the geosynthetic was adopted in the present model. However, it is different from the total length (L) of geosynthetic specimen used in the pullout test which is a fixed quantity and does not vary with frontal pullout force during the test. The active length increases with increasing frontal pullout force and becomes equal to the total length only when the entire geosynthetic is mobilized.

The SGI model uses this concept of active length to define the second boundary condition during the pullout test. The active length of the geosynthetic for a given frontal pullout force value is the point where the force front has just been reached. Since the geosynthetic is in equilibrium, the force and displacement at any location in the confined geosynthetic beyond this point beyond is zero. Thus, a boundary condition can be defined at this point where the displacement magnitude is known (zero for the given case). This boundary will move towards the embedded end of the geosynthetic from the pullout end as the frontal pullout force increases during the test. The boundary condition is based on evaluating the equilibrium of the mobilized geosynthetic length for a given pullout force magnitude. Rather than monitoring the conditions at the far end of the geosynthetic at maximum pullout force, the conditions at this moving boundary are analyzed at every increment of frontal pullout force during the test. This additional boundary condition in terms of known displacement magnitude is then utilized to obtain the solution for the governing differential equation of the pullout test for a geosynthetic.

3.1 Proposed solution

As described above, the active length of reinforcement L' is a boundary condition where the displacement equals zero. Then, the frontal boundary condition where frontal pullout force F_p is known along with displacement boundary condition at point L' can be used to solve for Equation 18 to obtain displacement distribution for the given geosynthetic as shown below.

Applying the boundary conditions to solve for coefficients C_1 and C_2 at a given frontal force magnitude as derived in Equation 18,

At x=0, $F(x=0) = F_P$ (Measured frontal pullout force) (19)

At x=-L’, $w(x=-L') = 0$ (Moving boundary condition) (20)

To obtain the value of C_1 Equation 17 can be solved by using boundary conditions as shown in Equation 19. Then,

$$C_1 = \frac{F_P}{J_c} \tag{21}$$

Furthermore, solving Equation 18, using boundary conditions as shown in Equation 20, and substituting C_1 from Equation 23, we get C_2 as follows;

$$C_2 = \frac{F_P}{J_c}.L' - \beta.\frac{L'^2}{2} \tag{22}$$

Now substituting the values of C_1, C_2 and β in the Equation 18 we obtain the expression for displacement w(x) at any confined point x for a given frontal pullout force Fp in terms of τ_y, J_c, and L' as,

$$w(x) = \frac{\tau_y}{J_c}.x^2 + \frac{F_P}{J_c}.x + \frac{F_P}{J_c}.L' - \frac{\tau_y}{J_c}.L'^2 \tag{23}$$

Rearranging,

$$w(x) = \frac{(L'+x)}{J_C}[F_P - \tau_y(L'-x)] \tag{24}$$

To obtain the strain distribution, the above equation can be differentiated with respect to x, the strain $\varepsilon(x)$ at any point can be given as,

$$\varepsilon(x) = \frac{\partial w(x)}{\partial x} = \frac{1}{J_C}[F_P + 2.\tau_y x] \tag{25}$$

Then the force at any point x can be given by substituting the expression above in Equation 4,

$$F(x) = J_c.\varepsilon(x) = F_P + 2.\tau_y x \tag{26}$$

Furthermore, for a given pullout force Fp, the force at point L' i.e. at the end of the boundary is zero, thus substituting for x = -L' in Equation 26, we obtain

$$F(x = -L') = F_P - 2.\tau_y.L' = 0 \tag{27}$$

$$L' = \frac{F_P}{2.\tau_y} \tag{28}$$

Thus the point L' where the force front has just been reached for a given frontal pullout force can be calculated knowing the yield shear stress parameter. Substituting the above expression for L' in Equation 24, the displacement distribution can be obtained in terms of model parameters τ_y and J_c as,

$$w(x) = \frac{\tau_y}{J_c}.x^2 + \frac{F_P}{J_c}.x + \frac{F_P^{\,2}}{4.\tau_y.J_c} \tag{29}$$

Thus, using the Equations 24, 25 and 29, strain $\varepsilon(x)$, force F(x) and the displacement w(x) at a point x can be calculated for a given frontal pullout force Fp in terms of yield shear stress, τ_y and confined stiffness J_c of the geosynthetic.

3.2 Parameter for geosynthetic reinforced pavement

The focus of conducting the pullout tests was to quantify the soil-geosynthetic interaction at low displacement magnitudes and there subsequent application to geosynthetic reinforced pavement design. Therefore, a parameter was defined based on the solution of the pullout test equations developed above, which is considered representative of the stiffness of the system. This parameter was used to quantify the governing mechanism of lateral restraint for reinforced pavement design.

For capturing the interface behavior realistically, it is necessary to compute force values where the displacements are being measured during the pullout test. The relationship thus developed can be used to determine the response of geosynthetic for given displacement increment. This can then be translated to quantify the soil-geosynthetic response to obtain a measure for lateral restraint mechanism developed in the reinforced flexible pavements by using pullout test data. Thus, equations were solved to obtain the relation between confined force and displacement in terms of model parameters as shown below.

Replacing Fp in Equation 29 with Equation 16, we get

$$w(x) = \frac{\tau_y}{J_c}.x^2 + \frac{(F(x) - 2.\tau_y.x)}{J_c}.x + \frac{(F(x) - 2.\tau_y.x)^2}{4.\tau_y.J_c} \tag{30}$$

$$w(x) = \frac{F(x)^2}{4.\tau_y.J_c} \tag{31}$$

$$F(x)^2 = (4.\tau_y.J_c).w(x) \tag{32}$$

This is the governing equation for the soil-geosynthetic interaction in the pullout test at each point on the geosynthetic. It suggests that the displacement at a point is related to square of the force at that point through parabolic relation and the constant is given by Equation 32. The force and displacement at any given point x throughout the geosynthetic can be related by model parameters i.e., yield shear stress, τ_y and confined stiffness J_c of the soil-geosynthetic system. The solution proposed here is similar to one proposed by Bergado et al. (2008) which assumed the parabolic function between displacement w(x) and distance x.

The above model parameters can be lumped into a single constant, called coefficient of soil geosynthetic interaction (K_{SGI}) which can be directly estimated using the pullout test and is given as,

$$K_{SGI} = 4.\tau_y.J_c \tag{33}$$

Then Equation 32 can be written as:

$$F(x)^2 = K_{SGI}.w(x) \tag{34}$$

According to Bonaparte et al. (1987), “There are two important soil-reinforcement interaction characteristics for design: soil reinforcement interface shear behavior and the influence of soil confinement on tensile characteristics of the reinforcement.” Therefore, constant K_{SGI} allows for combing both these characteristics in a unified approach and evaluating them quantitatively. The parameter K_{SGI} can be used as an index for comparison of performance for various geosynthetic in the pullout test. For a geotextile, it is typically expected that the yield shear stress would be higher whereas the confined stiffness would be lower than that obtained for a geogrid using the same soil and confining pressure in a given pullout test. Since the above constant is function of both interface shear and confined stiffness of the system, it can be used to compare the performance of both geogrids and geotextiles using the same criteria. Moreover, it can be calibrated using the data obtained only from the pullout test as explained in Section 3.6.3 thereby eliminating the need to use other tests.

4. CONCLUSIONS

The performance of the geosynthetic reinforced pavement depends on the interaction between the soil matrix and the geosynthetic inclusions. The currently available analytical models were developed for MSE walls and focused on maximum pullout force conditions. Therefore, the soil-geosynthetic interface model (SGI) was proposed to quantify the low displacement interaction behavior of the soil-geosynthetic system. The model is based on two parameters: yield shear stress (τ_y) and confined stiffness (J_c) of the system.

Based on the model, the equilibrium of geosynthetic specimen was analyzed at each time step for known frontal pullout force. The concept of active length of reinforcement during pullout testing was introduced which helped in establishing the displacement boundary condition. The governing differential equation was then solved thereby providing a continuous function to predict displacement, strain and force at each point along the length of the geosynthetic. Unlike analytical models proposed in the literature, there were no additional tests involved while back calculating the magnitudes of these parameters. They were estimated exclusively from the data obtained by conducting the pullout test.

The coefficient of soil-geosynthetic interaction (K_{SGI}) was then computed which combined both the parameters in a single framework.

The proposed approach has advantages over available models as it uses only the pullout test data and makes realistic assumptions in solving the governing differential equation. Further it allows for calculating a single value which can be used as the basis for comparing performance of two different types of geosynthetics i.e., geogrids and geotextiles or similar products placed under same working conditions in the field. It can be applied to reinforced pavement design as it better characterizes the low displacement interaction behavior of soil-geosynthetic interface.

The research presented above deals with the qualitative assessment of the applicability of the pullout tests to geosynthetic reinforced pavements. Future research involves conducting the laboratory pullout tests and performing finite element simulations to validate the proposed model.

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