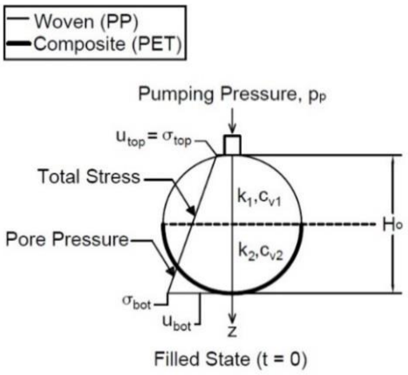
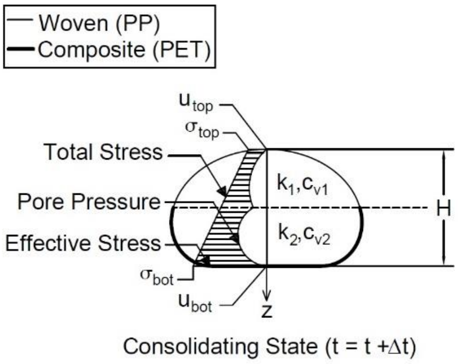


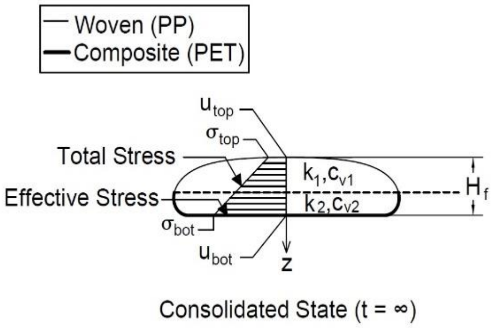
$$\sigma_{top} = u_{top} = p_p$$
$$\sigma_{bot} = u_{bot} = p_p + \gamma'_o H_o$$
$$\sigma'_{top} = \sigma_{top} - u_{top} = 0$$
$$\sigma'_{bot} = \sigma_{bot} - u_{bot} = 0$$

Fig. 4 Boundary condition of filled state



$$\sigma'_{top} = \sigma_{top} = p_p$$
$$\sigma'_{bot} = \sigma_{bot} = p_p + \gamma'_o H_o$$
$$u_{top} = u_{bot} = 0$$

Fig. 5 Boundary condition of consolidating state



$$\sigma'_{top} = \sigma_{top} = p_p$$
$$\sigma'_{bot} = \sigma_{bot} = p_p + \gamma'_o H_o$$
$$u_{top} = u_{bot} = 0$$

Fig. 6 Boundary condition of consolidated state

3. NUMERICAL SIMULATION

Two modified tubes, are shown in Figs. 7 and 8. The ratios used for the simulations are 50% woven (PP) and 50% composite (PET). Modified tube 1 has the woven (PP) in the bottom layer while modified tube 2 has the composite (PET) in the bottom layer. The numerical procedure proceeded by applying the multilayer consolidation theory proposed by Gray (1945) and the areal strain method proposed by Kim et al. (2015b, 2016) in conjunction with the analytical procedure proposed by Plaut and Suherman (1998) in modeling geotextile tubes. Consolidation parameters used in the calculations are obtained from the seepage induced hanging bag test performed by Kim et al. (2015c).

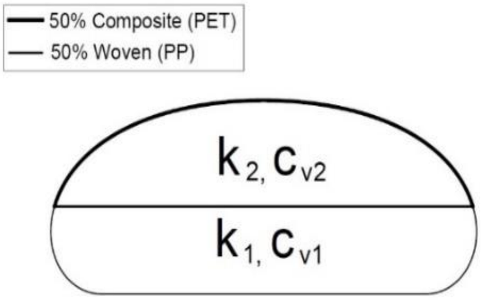


Fig. 7 Modified Tube 1 (MGT1)

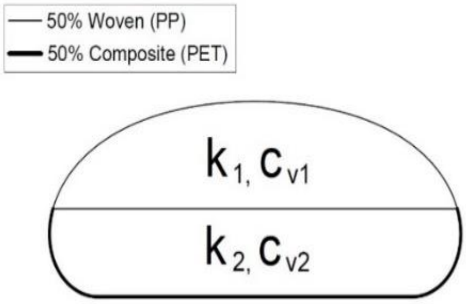


Fig. 8 Modified Tube (MGT2)

Both modified tubes have diameters of 0.55 m and lengths of 4 m. The initial properties of the tube are as follows: H_o = 0.417 m, w_o = 90.73%, and A_o = 0.219 m^2. The specific gravity G_s of the fill material is 2.687. Figs. 9 and 10 show the excess pore water isochrones of MGT1 and MGT2. Although the same ratios of fabric were used, results show that the dissipation of excess pore water pressure was faster in the MGT 1. This is because high excess pore water pressure values are located at the bottom of the tube. And because the woven (PP) fabric has a higher permeability than the composite (PET) fabric, these high excess pore water pressure values were easily dissipated in MGT1. Due to the composite (PET) fabric's low permeability, water could not easily flow out of the bottom portion of the MGT2, thus delaying the consolidation the tube.

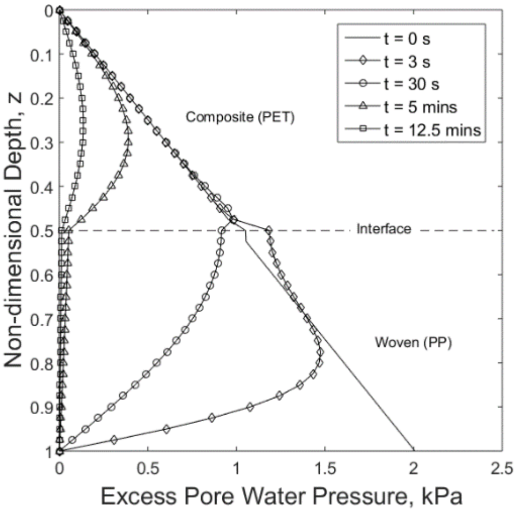


Fig. 9 Excess pore water pressure isochrones (MGT1)

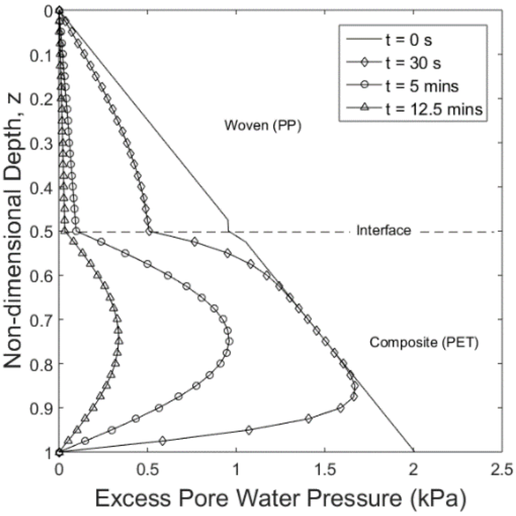


Fig. 10 Excess pore water pressure isochrones (MGT2)

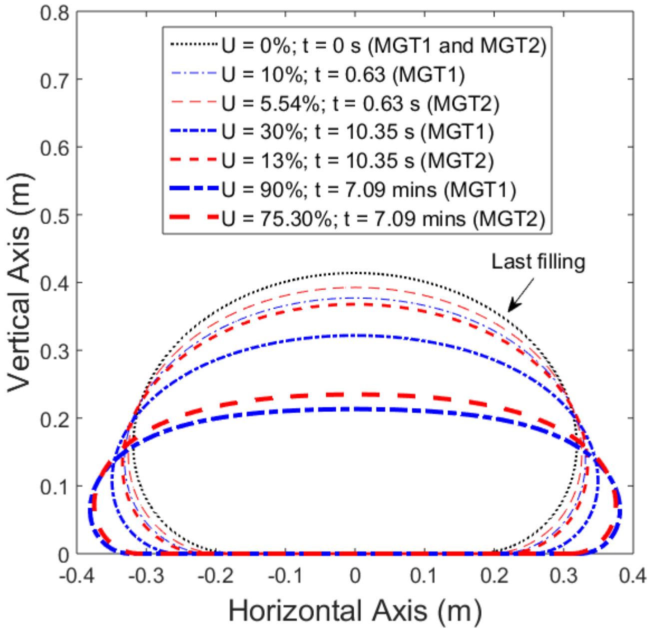


Fig. 11 Geotextile tube deformation of MGT1 and MGT2 during consolidaiton

Fig. 11 shows the deformation of the MGT1 and MGT2 during consolidation. The consolidated properties of the MGTs are: $H_f = 0.201$ m, $w_f = 41.67\%$, and $A_f = 0.135$ m^2. The MGT1 has a degree of consolidation U of 90% in 7.09 mins as compared to the MGT2 which has a degree of consolidation U of 75.30% in 7.09 mins. This shows that the fabric placement can affect the consolidation speed. This also shows that geotextile tubes can be modified and optimized to improve either retaining efficiency or dewatering efficiency by changing the fabric's ratio or location.

4. CONCLUSION

In order to optimize retaining efficiency, dewatering efficiency, and tensile strength, a modified geotextile tube is proposed in this study. The consolidation analysis of the present invention was performed by applying the areal strain method and Terzaghi's consolidation theory in conjunction with an analytical procedure to model the tubes. The analyses follow the concept of multilayer consolidation and were performed to understand the deformation mechanism of the MGT. The consolidation constants were determined from the void ratio-effective stress-permeability relationship of the woven and composite fabric, which was obtained from the seepage induced hanging bag test. Although the same ratios of fabric were used in the numerical calculations, results show that the dissipation of excess pore water pressure was faster in the MGT1. This is because high excess pore water pressure values are located at the bottom of the tube. And because the woven (PP) fabric has a higher permeability than the composite (PET) fabric, these high excess pore water pressure values were easily dissipated in MGT1. Due to the composite (PET) fabric's low permeability, water could not easily flow out of the bottom portion of the MGT2, thus delaying the consolidation the tube. This shows that the fabric placement can affect the consolidation speed. This also shows that geotextile tubes can be modified and optimized to improve either retaining efficiency or dewatering efficiency by changing the fabric's ratio or location.

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