FE simulation of rate-dependent behaviour of model geosynthetic-reinforced soil retaining wall

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1.Introduction

The deformation of geosynthetic-reinforced soil retaining walls (GRS-RW) is known to more-or-less rate-dependent stress-strain characteristic due to the viscosities of both geosynthetic reinforcement and soil as well as their interaction. To simulate this behaviour, any FE simulation should incorporate the material viscosity. In the present study, FE simulation was performed incorporating the non-linear three-component model[1, 2] to simulate results from a scaled-down GRS-RW model test vertically loaded with a rigid rough footing rested on the crest[3),]Fig. 1.

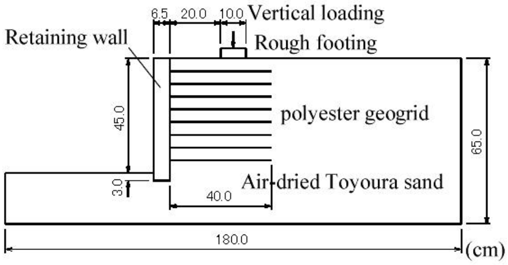

Fig.1 Physical model test

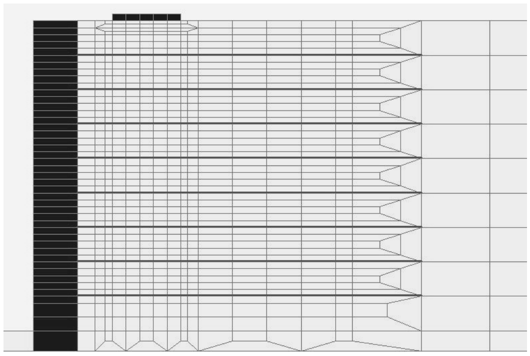

Fig.2 Finite element mesh for simulation

2.Layout of Model Test

A GRS-RW model with a 48 cm-high full-height rigid facing was constructed in a sand box (180 cm long, 40 cm wide & 80 cm high inside) by tamping air-dried Toyoura sand in eight layers to D_r=90 % (e= 0.65 & γ_d=1.60 g/cm^3) reinforced with a polyester geogrid. The model was loaded with a 10 cm-wide rigid rough footing with a wedge in order to eliminate any moment acting between the loading rod and the footing. The vertical settlement rate of the footing was stepwise changed in a range between 4.72E-3 and 4.72E-1mm/min with four times sustained loading[3)].

3.Numerical Analysis

The backfill and the facing were modelled by four-node quadrilateral plane elements and the geogrid layers by truss elements, Fig. 2. Vertical settlement vectors were given to the nodes at the footing bottom. According to the three-component model[1, 2)], the total strain rate, ε, is decomposed into the elastic and inelastic (or irreversible or visco-plastic) component, ε^e & ε^{ir} and the total component of the effective stress, σ, into the inviscid and viscous components, σ^f & σ^v. For the components for ε^e, σ^f, and σ^v, a cross-anisotropic elasticity model, a work-hardening model and the TESRA model, which is one specific three-component model for sand, were employed. The TESRA viscous model parameters employed are α=0.25, m=0.05, ε_0=10^{-8} s^{-1} for the backfill sand and α=0.55, m=0.12, ε_0=10^{-6} s^{-1} for the geogrid.

4.Test Result And Discussions

Fig. 3, 4 and 5 show the *q*-*s* relation, the time history of *q*, and the time history of *s*, respectively (*q* = average footing pressure & *s* = footing settlement). The settlement rate is 4.72E-3mm/min during stages b-c, d-e, f-g, j-k, i-m, n-o, p-q, t-u, v-w & z-A; and 4.72E-1mm/min during stages a-b, c-d, e-f, g-h, i-j, k-l, m-n, o-p, q-r, s-t, u-v, w-x, y-z & A-B loading stage. The period of sustained loading is four hours at stages h-i & x-y and six hours at stage B-C. The cyclic loading was performed at stage r-s and global unloading with one sustained loading staged started from point C.

Keywords: FEM, Deformation characteristics, Time-dependency, Bearing capacity, Creep, Settlement rate
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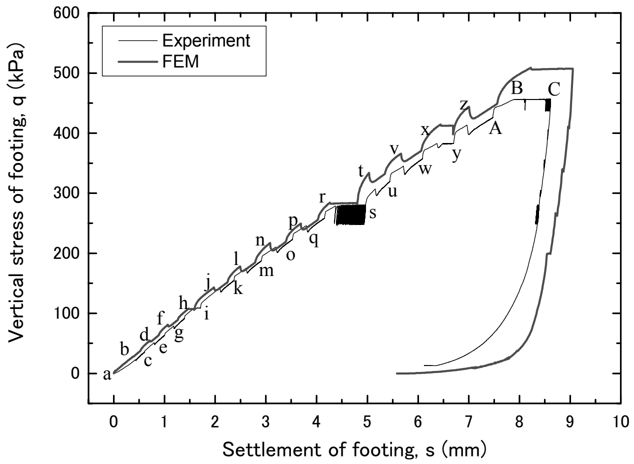

Fig.3 Observed and computed footing pressure-settlement relations

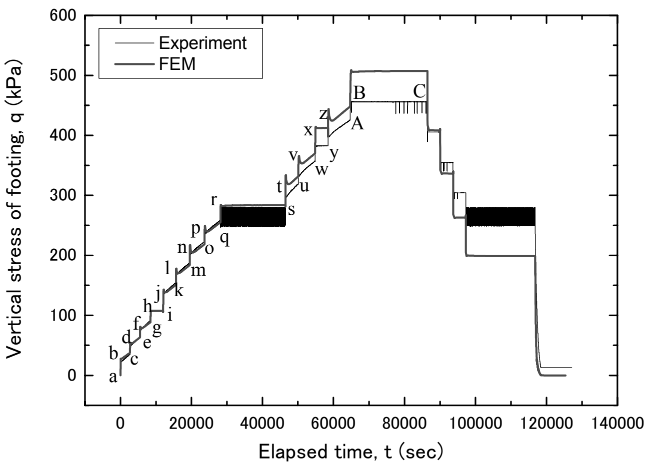

Fig.4 Observed and computed time histories of footing pressure

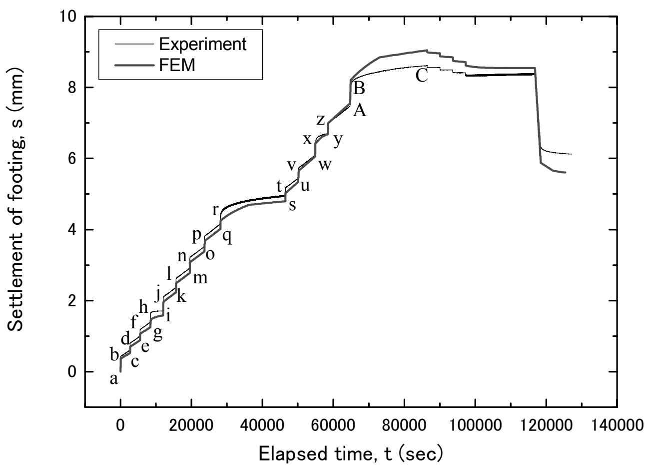

Fig.5 Observed and computed time histories of footing settlement

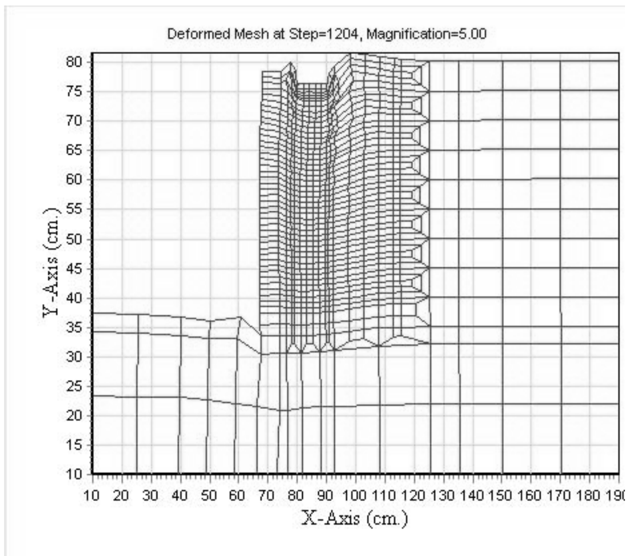

Fig.6 Computed ground deformation

The *q-s* relation is well simulated by FEM, in particular jumps in the *q* value upon sudden changes by a factor of 100 or 1/100 in the settlement rate and creep behaviour. Fig. 6 shows deformation of whole model at analysis step 1204. This result shows that realistic FEM simulation of rate-dependent bahviour of GRS-RW can be performed based on the non-linear three-component model. It should be noted, however, that cyclic loading and unloading cannot be simulated by the present scheme.

5.Conclusions

FEM analysis incorporating the non-linear three-component model for the viscous properties of backfill and geogird simulated well the rate-dependent deformation characteristic of a geogrid-reinforced soil retaining wall model vertically loaded with a strip footing rested on the crest. 4)

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