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Reinforcement loads in geosynthetic walls and the case for a new working stress design method ☆

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Abstract

The paper provides a synthesis of work by the writers that has the objective of developing a new working stress method for the calculation of reinforcement loads in geosynthetic reinforced soil walls. As a precursor to this objective, careful back-analyses of a database of instrumented and monitored full-scale field and laboratory walls are used to demonstrate that the current American Association of State Highway and Transportation Officials (AASHTO) Simplified Method used in North America results in excessively conservative estimates of the volume of reinforcement required to generate satisfactory long-term wall performance. The new design method captures the essential contributions of the different wall components and properties to reinforcement loads. The method is calibrated against measured in situ wall reinforcement loads using a careful interpretation of reinforcement strains and the conversion of strain to load using a suitably selected reinforcement stiffness value. A novel feature of the method is to design the wall reinforcement so that the soil within the wall

Abbreviations: AASHTO, American Association of State Highway and Transportation Officials; ASTM, American Society for Testing and Materials; CRS, constant-rate-of-strain tensile test; HDPE, high-density polyethylene; PET, polyester; PP, polypropylene; RMC, Royal Military College

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Nomenclature

a	local stiffness constant coefficient (dimensionless)
CF	calibration factor (ratio of global reinforcement strain to strain gauge strain) (dimensionless)
COV	coefficient of variation (standard deviation/mean) (dimensionless)
COV_ε	coefficient of variation of strain measurements (dimensionless)
COV_J	coefficient of variation of reinforcement stiffness (dimensionless)
COV_T	total coefficient of variation of reinforcement load $= \sqrt{\mathrm{COV}_\varepsilon^2 + \mathrm{COV}_J^2}$ (dimensionless)
d	facing batter constant coefficient (dimensionless)
D	reinforcement demand (total horizontal earth load) (N)
$D_{t\mathrm{max}}$	reinforcement load distribution factor ($= T_{\mathrm{max}}/T_{\mathrm{mxmx}}$) (dimensionless)
FS	overall factor of safety (dimensionless)
H	height of wall (m)
i	counter $(1, 2, 3, \ldots, n)$
J	tensile stiffness of reinforcement (N/m)
J_{ave}	average tensile stiffness for all "n" reinforcement layers (N/m)
J_{c}	creep (tensile) stiffness of reinforcement (N/m)
J_{CRS}	tensile stiffness of reinforcement from CRS test (N/m)
$J_{\mathrm{D\ 4595}}$	reinforcement stiffness from in-isolation wide-width strip tensile test carried out according to ASTM D 4595 (N/m)
J_i	tensile stiffness of reinforcement layer "i" (N/m)
J_{r}	stress relaxation (tensile) stiffness of reinforcement (N/m)
$J_{1\%}$	reinforcement stiffness at 1% strain (N/m)
$J_{1000\,\mathrm{h}}$	reinforcement stiffness at 1000 h (N/m)
K	coefficient of lateral earth pressure (dimensionless)
K_{a}	coefficient of active earth pressure (dimensionless)
K_{abh}	horizontal component of active earth pressure coefficient accounting for wall face batter (dimensionless)
K_{ah}	horizontal component of active earth pressure coefficient (dimensionless)
K_{avh}	horizontal component of active earth pressure coefficient for vertical wall (dimensionless)
K_0	coefficient of lateral earth pressure at rest (dimensionless)
n	total number of reinforcement layers in wall section (dimensionless)
p_{a}	101 kPa (atmospheric pressure)
q	surcharge pressure (Pa)
R	resistance (sum of reinforcement load capacities) (N)
RD, $\mathrm{RD}_{\mathrm{actual}}$, $\mathrm{RD}_{\mathrm{design}}$	resistance–demand ratio (dimensionless)
$\mathrm{RF}_{\mathrm{actual}}$, $\mathrm{RF}_{\mathrm{design}}$	reinforcement strength reduction factor ($= \mathrm{RF}_{\mathrm{ID}}\,\mathrm{RF}_{\mathrm{CR}}\,\mathrm{RF}_{\mathrm{D}}$) (dimensionless)
$\mathrm{RF}_{\mathrm{CR}}$	reinforcement strength reduction factor for creep rupture (dimensionless)