NCDOT's Experience with Approving MSE Wall Systems

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NCDOT MSE Wall System Reviews

- What is the goal of the MSE wall system reviews?

"It is a tool for operations to make the post-bid design reviews easier. It avoids disagreements with the wall vendors so everybody is on the same page with what we are using for design. Also, the approved design case calculations and submittal information provide a reference for operation engineers during design review and construction."

NCDOT's Challenges with Approving MSE Wall Systems

- AASHTO vs. FHWA
- MSEW vs. Vendor (Proprietary) Software
- Different Terminology
- Component Variation
- Inconsistencies
- Passionate Industry
- Past Success
- Fair Competitive Market

NCDOT's History with Approving MSE Wall Systems

- MSE Wall Policy/Provision first developed in 2007 – required HITEC Evaluation or grandfathered in existing systems
- Major policy/provision revision in 2010 – allowed for either HITEC or Consultant Evaluation, required renewals every 3 years and converted standard MSE wall provision to LRFD
- Policy/provision revised again in 2011 – added fine aggregate and FHWA traffic impact analysis
- Another revision expected in a few months – will add approved geogrids and "geostrips"

NCDOT's Experience with Approving MSE Wall Systems

- Traffic Surcharge Load Factor
- Fine Aggregate
- Traffic Impact Analysis
- Geogrid Evaluation Program

Traffic Surcharge Load Factor

- MSE wall provision requires the use of the simplified method for determining the maximum reinforcement loads (FHWA strongly recommends in GEC 11)
- AASHTO is not consistent for traffic surcharge load factor

$T_{max} = \sigma_H S_v$ (Eq. 11.10.6.2.1-2, Pg. 11-52)

$\sigma_H = \gamma_P (\sigma_v k_r + \Delta\sigma_H)$ (Eq. 11.10.6.2.1-1, Pg. 11-49)

$\gamma_P = 1.35$ for EV (Table 3.4.1-2, Pg. 3-14) and

σ_v includes "any surcharge load present"; however,

Figure C11.5.5-3b, Pg. 11-10 and Table 3.4.1-1, Pg. 3-13 say use 1.75 for LL,

Which one is right, 1.35 or 1.75?

Traffic Surcharge Load Factor

- FHWA (Sec. 4.4.7.e, Pg. 4-40) says –

"……a live load traffic surcharge that is represented by an equivalent uniform soil surcharge of height h_{eq} is assumed as load type "EV." This is in contrast to the external stability analysis where the live load traffic surcharge is assumed as load type "LS" because in external stability analysis the MSE wall is assumed to be a rigid block. For internal stability analysis, the assumption of load type "EV" is used so that the amount of soil reinforcement within the reinforced soil zone is approximately the same as obtained using past working stress design approach (i.e., calibration by fitting)."

- MSE wall provision requires 1.75 for AASHTO analysis
- Can not use different traffic surcharge load factors for internal and external stability in MSEW

Fine Aggregate

- We have received multiple requests to use fine aggregate instead of coarse aggregate for MSE walls on design-build and turnpike projects
- Goal was to make it a business decision based on electrochemical requirements and corrosion rates for steel reinforcement
- Looked at NCHRP Report 675 LRFD Metal Loss and Service-Life Strength Reduction Factors for Metal-Reinforced Systems (March, 2011)

Fine Aggregate

- NCHRP Report 675 (Table 12, Pg. 25) shows that coarse (high quality) and fine (good quality) aggregate do not provide that same probability of failure (p_f) with the AASHTO corrosion rates – "not comparing apples to apples"

Table 12. Occurrence of sacrificial steel consumption for galvanized reinforcements.

Fill Quality	t_{design} (years)	X (µm)	$p_f = 0.01$ (years)	$p_f = 0.05$ (years)	p_f @ t_{design}
Good	75	708	54	69	0.075
	100	1,008	65	84	0.116
High	75	708	75	102	0.010
	100	1,008	86	118	0.022

Corrosion Loss Rates

- For MSE wall internal stability, reinforcement is checked for pullout and strength – corrosion rates affect strength
- AASHTO resistance factors for strength are 0.65 for grids and 0.75 for strips (Table 11.5.6-1, Pg. 11-11)
- NCHRP Report 675 (Table 27, Pg. 43) recommends different strength resistance factors based on backfill quality and a 1% p_f (consistent with pile groups, redundant geotechnical systems)

Corrosion Loss Rates

- Hired Ken Fishman (one of the NCHRP Report 675 authors) to develop an alternate corrosion rate for fine aggregate based on AASHTO resistance factors
- Based on Ken Fishman's report for NCDOT, decided to use the AASHTO corrosion rate for galvanization (Sec. 11.10.6.4.2a, Pg. 11-60) for both fine and coarse aggregate and the AASHTO corrosion rate for carbon steel (Sec. 11.10.6.4.2a, Pg. 11-60) for coarse aggregate (p_f = 0.4%)

Corrosion Loss Rates

CARBON STEEL CORROSION RATES	
Aggregate Type (in the reinforced zone)	**Corrosion Loss Rate (after zinc depletion)**
Coarse	0.47 mil/year
Fine (except abutment walls)	0.58 mil/year
Fine (abutment walls)	0.70 mil/year

- The p_f for MSE abutment walls with fine aggregate is 0.4% (about 20% more steel) and the p_f for all other MSE walls with fine aggregate is 1% (about 10% more steel)

Fine Aggregate

- Developed fine aggregate testing requirements with M&T and the NCAA – based on AASHTO (Sec. 11.10.6.4.2a, Pg. 11-60) and NCHRP Report 675 (Table 4, pg. 7)
- Different AASHTO test methods (Sec. C11.10.6.4.2a, Pg. 11-60) than what has been used for coarse aggregate
- M&T created *Mechanically Stabilized Earth Wall Fine Aggregate Sampling and Testing Manual* – referenced in the MSE wall provision and link on GEU website

Fine Aggregate

- NCHRP Report 675 recommends frequency of testing based on resistivity – since coarse aggregate consistently tests above 10,000 ohms-cm, no electrochemical testing is required for coarse aggregate
- NCHRP Report 675 recommends frequency of testing for 5,000 – 10,000 ohms-cm every 4,000/2,000 cubic yards – since fine aggregate consistently tests between 3,000 – 10,000 ohms-cm, electrochemical testing is required every 3,000 cubic yards for fine aggregate

Traffic Impact Analysis

- Require traffic impact analysis for guardrail with 8 ft posts (not for guardrail with standard posts) and barriers (with moment slabs) above walls in accordance with FHWA (Sec. 7.2, Pg. 7-14) instead of AASHTO – FHWA is newer and based on NCHRP Report 663 (July, 2010)
- Structure Design created standard concrete barrier rail with moment slab details based on NCHRP Report 663 – details are in the geotechnical design cell library
- FHWA does not change impact loads for guardrail or load factors for soil or impact loads

Traffic Impact Analysis

- What does FHWA impact analysis change from AASHTO?
  - Uses different impact loads for barrier (Sec. 7.2.1., Pgs. 7-16 & 7-17)
  - Sets load factor for traffic surcharge to 1.35 (Sec. 7.2.1., Pg. 7-15)
  - Defines new resistance factors for combined static/traffic barrier impact (Table 4-7, Pg. 4-48)
  - Does not make an exception for creep reduction factor for geosynthetic reinforcement for impact (Sec. 7.2.1, Pg. 7-16)
- MSE wall provision reverts back to AASHTO exception for creep reduction factor for geogrid reinforcement rupture

MSEW

- Update MSEW (free update) to get correct FHWA impact calculations (Technical Support beta tested it)
- MSE wall provision requires MSEW runs to verify wall designs – MSEW input files must be submitted
- MSEW verification is required because we know how it runs and to make the review easier
- For cases with impact, there will be 2 MSEW runs, one for AASHTO LRFD analysis and one for FHWA impact analysis

Geogrid Evaluation Program

- Why do we need a geogrid evaluation program?
  - Geogrids were being submitted through the product evaluation program – didn't know how to evaluate
  - Consistency was an issue – same geogrid in same material was assigned different values for same property for different projects/applications; laboratory data and NTPEP evaluations still need to be interpreted
  - Inspection/certification was an issue – field personnel and contractors did not know whether geogrids actually met contract requirements; take vendors word for it?
  - Needed for standards (e.g., temporary walls, RSS) and MSE wall system reviews
  - Tony Allen likes it (similar to WSDOT program)

Geogrid Evaluation Program

- How does Geogrid Evaluation Program work?
  - Like MSE walls, value management agreed to leave geogrids out of the product evaluation program
  - Program and website is administered by M&T
  - Technical working group consisting of GEU and M&T reviews submittals – renewal is required every 3 years
  - Geogrids with NTPEP evaluation are approved
  - Geogrids without NTPEP evaluation are either approved for provisional use or unapproved
  - Assigns values to geogrid properties – requires some properties while other more controversial properties (e.g., junction strength, aperture stability) are optional

Geogrid Evaluation Program

- Term definitions
- Tables with optional and required properties with acceptable sources
- Table to be submitted that includes tensile strengths (T_{ult} & T_{al}), reduction factors (RF_{ID}, RF_D and RF_{CR}), pullout resistance factors (F*), soil-geogrid friction angles (ρ), average junction strengths (Xj_{ave}) and aperture stability (*J*)
- Could provide up to 18 design strengths (T_{al}) and 6 pullout resistance factors (F*) and soil-geogrid friction angles (ρ) per geogrid

Vog!


CAUTION
VOLCANIC FUMES ARE
HAZARDOUS TO YOUR HEALTH
AND CAN BE LIFE-THREATENING
VISITORS WITH BREATHING AND
HEART PROBLEMS, PREGNANT WOMEN
AND YOUNG CHILDREN
SHOULD AVOID THIS AREA

Questions?