DRAFT

MEMORANDUM

Anchorage

DATE: August 21, 2000

TO: Jim Thomson, HNTB

Boston

FROM: Jamie Beaver, Mike Bailey, P.E., and Barry Chen, P.E., Hart Crowser, Inc.

RE: Geotechnical Input to MSE Wall and Reinforced Slope Design
Third Runway Embankment
J-4978-30

Chicago

Denver

This memorandum contains geotechnical design information for use by RECo for the design of MSE walls and reinforced embankment fill below walls. Information included in this memorandum should be considered as the basis-of-design, based on consensus of the design team, and may be subject to changes or amendment based on additional review and input from the design team (Hart Crowser, HNTB, and RECo). Other structural criteria needed for wall design are not addressed herein, but will be controlled by the 1996 AASHTO code unless specific variations are approved by the design team.

Fairbanks

Geotechnical Input into Slope Stability Analysis

Jersey City

Geotechnical design information is summarized herein for input into the internal reinforcement design analysis. Note that the reinforcement strip lengths may need to be increased to satisfy the compound and global slope stability requirements or to reduce calculated soil deformation based on FLAC analyses. We anticipate that Hart Crowser will work with RECo to accomplish these analyses after RECo performs the internal reinforcement design.

Juneau

Minimum Factors of Safety

Long Beach

Design shall be based on 1996 AASHTO criteria except where RECo can provide performance data to support alternative criteria. Where an update to the AASHTO code has occurred in an interim version, the existing standard of design will be accepted, if approved by the design team. Tables 1 and 2 compare AASHTO and FHWA factors of safety and other criteria to the RECo design manual for static and seismic stability, respectively. Where discrepancies exist, the design team will need to agree upon values before proceeding with the design.

Portland

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Table 1 - Static Stability Analysis

	FHWA, 1997 (Min. F.S. or Other)	**AASHTO, 1996 (Min. F.S. or Other)**	**RECo Design Manual, 1999 (Min. F.S. or Other)**
External Stability			
Sliding	≥1.5 MSEW[1]; ≥1.3 RSS[2]	≥1.5	≥1.5
Overturning	Not explicitly stated (expressed as maximum eccentricity)	≥2.0	≥2.0
Eccentricity at Base	≤B[3]/6	Not specifically stated	Not specifically stated
Bearing Capacity (for sliding and overturning)	≥2.5; ≥1.3 RSS local bearing failure	≥2.0 (if justified by geotech analysis); ≥2.5 otherwise	≥2.0 (if detailed geotech info.); ≥2.5 (if general geotech info.)
Deep-Seated Stability (i.e., Global and Compound Stability)	≥1.3	≥1.3 (if soil param. based on lab tests); ≥1.5 otherwise	Not specifically stated
Internal Stability			
Pullout Resistance	≥1.5 (MSEW and RSS); ≥1.3 (Internal Slope Stability for RSS)	≥1.5, where maximum friction angle of 34 deg. is used to calculate the horizontal force (if without the benefit of triaxial or direct shear testing to provide soil shear strength data)	Defaults to AASHTO, Interim 1998
Pullout Resistance[5]	(Same as AASHTO 1997)	T_{max} ≤0.55 F_y	T_{max} ≤0.55 F_y

1. Mechanically Stabilized Earth Wall.
2. Reinforced Soil Slopes.
3. Dimension B equals the reinforced zone length plus the facing panel width.
4. Dimension L equals the reinforced zone length.
5. T equals "tension" and F_y equals "yield strength."

Table 2 - Seismic Stability Analysis

	FHWA, 1997 (Min. F.S. or Other)	AASHTO, 1996 (Min. F.S. or Other)	RECo Design Manual, 1999 (Min. F.S. or Other)
External Stability			
Sliding	≥1.1; same approach as AASHTO, 1996	≥1.1; include 100% of inertial force and 50% of dynamic thrust[1]	≥1.1
Overturning	Not specifically stated	≥1.5; include 100% of inertial force and 50% of dynamic thrust	≥1.5
Eccentricity at Base	≤L/3	Not specifically stated	Not specifically stated
Bearing Capacity (for sliding and overturning)	75% static (i.e., ≥1.87); same approach as AASHTO, 1996	75% static (i.e., ≥1.5 or ≥1.87 for MSE and RSS, respectively); include 100% inertial force and 50% of dynamic thrust	Not specifically stated
Deep-Seated Stability (i.e., Global and Compound Stability)	≥1.1	≥1.1	Not specifically stated
Internal Stability			
Pullout Resistance	75% static; reduce F*[2] to 80% static value	75% static; reduce F* to 80% static value; include internal inertial force	Not specifically stated
Pullout Resistance	(Same as AASHTO, 1996)	T_{max} ≤0.55 F_y	T_{max} ≤0.55 F_y

1. Dynamic thrust determined by the pseudo-static Mononobe-Okabe analysis.
2. F* is the friction factor variable, which is part of the reinforcement pullout analysis.
3. Other parameters as defined for Table 1.

Other MSE Wall Design and Reinforced Slope Parameters

Table 3 provides a comparison of various aspects of MSE wall design that were identified to resolve potential discrepancies or omissions of specific design information. The design team accepted use of these AASHTO criteria without exception.

Table 3 - Comparison of Other Aspects of MSE Wall and Reinforced Slope Design

	FHWA, 1997 (Min. F.S. or Other)	AASHTO, 1996 (Min. F.S. or Other)	RECo Design Manual, 1999 (Min. F.S. or Other)
MSEW Embedment[1]	H/7 (H same as AASHTO, 1996)	H/7 for 2H:1V slope in front of wall, where H is from top of wall at wall face to top of leveling pad	Same as AASHTO, 1996
Horizontal Bench in Front of Walls Founded on Slopes	4 feet minimum width	4 feet minimum width	3 feet minimum width
Calculation of Sliding for External Stability	(Same as AASHTO, 1996)	Neglect passive resistance; include width and weight of wall facing in calculation of sliding/overturning	Not specifically stated
Leveling Pad Width	Not specifically stated	Designed to meet local bearing capacity needs and differential settlement between wall facing and backfill	Not specifically stated
Maximum particle size for reinforced backfill (see text for detailed discussion)	4 inches	4 inches	6 inches
Friction Factor for Internal Reinforcement Design (backfill on ribbed steel strips)	(Same as AASHTO, 1996)	F^*_{max}<2.0; F^*_{max}<1.2 + log C_u, where C_u equals backfill uniformity coefficient. C_u = 4 for ribbed steel strips if tests are not available	Based on extensive pullout tests, but no values are specifically stated

1. MSEW embedment is not a specific requirement of AASHTO or FHWA, but is provided as guidance for MSEW constructed on fill.
2. Shaded items (AASHTO criteria) accepted as basis of design.

Embankment Soil Input Parameters

Figure 1 is a "typical" cross section through a MSE wall showing the conceptual fill soil zonation within the embankment for two representative cases. As suggested by the figure, each zone has a different function, which affects the requirements of the engineering properties within a given zone.

For Third Runway embankment construction to date, several fill categories (i.e., soil "Groups") have been defined to meet the needs of various zones, to give the contractor maximum flexibility in selecting fill material. The fill groups are defined by grain size distribution, which cover a broad spectrum of material types that range from well-graded soils with few fines to soils with higher fines content that can only be placed in specific "non-structural" areas of the embankment.

Hart Crowser recommended modifying the existing embankment fill specifications for MSE wall/slope backfill to provide consistent strength and density of the completed fill, while still providing maximum flexibility to the contractor. Specific design criteria include controlling the fines content to enable wet weather construction and eliminating coarser material that may damage reinforcing elements.

Table 4 provides soil gradations recommended by FHWA and AASHTO for the reinforced zones that incorporate either steel or geosynthetics. RECo has indicated they can design reinforcement for wall backfill with a much wider gradation range than recommended by FHWA or AASHTO. However, the design team decided to constrain the wall backfill gradation to provide a high degree of confidence in strength and deformation of the compacted backfill. Also, geosynthetic reinforced fills, which might be used for embankment reinforcing below the wall reinforcing zone, would require limiting the maximum particle size to avoid/reduce damage to the reinforcement. Table 5 provides soil gradations agreed to by the design team for the various fill categories.

Figures 2 through 4 provide the grain size distributions for the embankment fill Groups 1A, 1B, and 2, which are the basis for defining acceptable wall backfill soils. Figures 5 through 7 provide grain size distributions agreed to by the design team for the MSE wall/slope backfill zones, based on the fill material groups shown in Table 5 and WSDOT criteria.

Table 6 provides electrochemical soil property limits recommended by FHWA, AASHTO, and RECo for reinforced fill zones. The design team concurred on use of the AASHTO criteria as the basis for design and specifications.

The design team anticipates that fill material for the reinforced wall and slope zones will be controlled in the constructions specifications based on design considerations of strength, stiffness, fill placement criteria such as moisture sensitivity for compaction, risk of damage to the reinforcing, and cost-effectiveness, which are still being evaluated.

Table 4 - Soil Gradations for Reinforced Walls and Slopes

Sieve Size	Percent Passing	
	Steel Strip Reinforced Zones	**Geosynthetic Reinforced Zones Below Walls**
AASHTO, 1996		
4-inch	100	-
3-inch	-	-
¾-inch	-	100[1]
No. 40	0 to 60	0 to 60
No. 200[4]	0 to 15	0 to 15
FHWA, 1997		
4-inch	100	100
0.8-inch (20 mm.)	-	75 to 100[2]
No. 4	-	20 to 100
No. 40	0 to 60	0 to 60
No. 200	0 to 15	0 to 15
RECo[3]		
6-inch	100	-
U.S. No. 200[4]	0 to 15	-

1. Maximum particle size for geosynthetic reinforcement is ¾ inch unless full-scale installation damage tests are conducted, or if epoxy coatings are used for steel reinforcement.
2. Maximum particle size for geosynthetic reinforcement can be increased from ¾ to 4 inches (100 mm) if field tests are performed to evaluate strength reduction due to construction damage. P.I. < 6 for fine-grained fraction for steel reinforcement; P.I. < 20 for fine-grained fraction for geosynthetic reinforcement.
3. The RECo design manual does not provide a specific backfill gradation; rather, the manual states specific requirements for maximum particle size, fines content, etc.
4. The plasticity index should be less than or equal to 6 for fine-grained fraction.

Table 5 - Soil Gradations for Fill Material "Groups"

Sieve Size	Percent Passing		
	Embankment Fill (Not Reinforced)	**Steel Strip Reinforced Zones**	**Geosynthetic Reinforced Zones Below Walls**
Group 1A			
6-inch	100	-	-
4-inch	-	100	-
3-inch	70 to 100	70 to 100	-
1¼-inch	-	-	100
¾-inch	50 to 77	50 to 77	50 to 77
U.S. No. 4	30 to 50	30 to 50	30 to 50
U.S. No. 40	3 to 15	3 to 15	3 to 15
U.S. No. 200[1]	0 to 5	0 to 5	0 to 5
Group 1B			
6-inch	100	-	-
4-inch	-	100	-
3-inch	70 to 100	70 to 100	-
1¼-inch	-	-	100
¾-inch	35 to 80	35 to 80	35 to 80
U.S. No. 4	20 to 55	20 to 55	20 to 60
U.S. No. 40	3 to 30	3 to 30	3 to 30
U.S. No. 200[1]	0 to 8	0 to 8	0 to 8
Group 2			
6-inch	100	-	-
4-inch	-	100	-
3-inch	70 to 100	70 to 100	-
1¼-inch	-	-	100
¾-inch	50 to 85	50 to 85	50 to 85
U.S. No. 4	30 to 65	30 to 65	30 to 65
U.S. No. 40	5 to 30	5 to 30	5 to 30
U.S. No. 200[1]	0 to 12	0 to 12	0 to 12
Group 3			
6-inch	100	-	-
U.S. No. 4	50 to 100	-	-
U.S. No. 40	20 to 60	-	-
U.S. No. 200[1]	0 to 35	-	-
Group 4			
6-inch	100	-	-
¾-inch	75 to 100	-	-
U.S. No. 4	50 to 100	-	-
U.S. No. 40	20 to 70	-	-
U.S. No. 200[1, 2]	0 to 50	-	-

1. The fine-grained soil percentage passing the U.S. No. 200 is based on the fraction of the soil passing the ¾-inch sieve
2. P.I. < 4 for fine-grained fraction.

Table 6 - Comparison of Recommended Backfill Electrochemical Properties, Primarily for Steel Reinforcement Unless Indicated

	FHWA, 1997	AASHTO, 1996	RECo Design Manual, 1999
Soil pH[1]	5 to 10	5 to 10	5 to 10
Soil resistivity (at 100% saturation)	>3000 ohm-cm	>3000 ohm-cm[2]	>3000 ohm-cm
Water soluble chloride content	<100 ppm	<100 ppm	<100 ppm
Water soluble sulfate content	<200 ppm	<200 ppm	<200 ppm
Organic content	1% max.	1% max. (for material finer than No. 10 sieve)	Free of organics and other deleterious materials

1. For geosynthetic reinforcement, FHWA recommends pH is 3 to 9 for polyesters and pH greater than 3 for polyolefins. AASHTO recommends pH of 4.5 to 9 for all geosynthetics.
2. If soil resistivity is greater than or equal to 5,000 ohm-cm, the chlorides and sulfates requirement may be waived.
3. Shaded parameters (AASHTO criteria) accepted as basis of design.

The remainder of this section provides preliminary design information for those fill material groups the contractor would use to construct the embankment zones relevant to the MSE and reinforced fill design. Depending on the results of the RECo analysis and input from HNTB, some of the fill material groups may need to be excluded from consideration for specific zones, or need to have strength values modified based on laboratory testing.

Zone B_2. This zone includes both the reinforced fill zone behind the MSE wall and the reinforced fill zone below the MSE wall. These respective zones may be independent with respect to the type of reinforcement selected for design, but backfill for both zones should have similar shear strength, drainage, and compaction characteristics. Table 7 presents proposed specification requirements and recommended design parameters for Zone B_2 fill.

Results of preliminary global stability analyses for the pseudo-static case show that the soil shear strength must be greater than an effective friction angle of 37 degrees below the MSE wall for stability. This implies that reinforcement is needed to increase the overall shear strength of the zone. The depth and length defining the zone geometry, as well as the degree and type of reinforcing needed, will need to be determined by additional global and compound stability analyses.

Table 7 - Zone B_2 Fill

Zone B_2	Proposed Specification Requirements			Recommended Design Parameters[1]		
	Minimum % Compaction ASTM D 1557[2]	**Moisture Range Relative to OMC[3]**	**Maximum Loose Lift Thickness in Inches[4]**	**γ in pcf**	**c' in psf**	**ϕ' in deg.**
Group 1A	92	±3	12	140	0	37
Group 1B	92	±3	12	140	0	37
Group 2[5]	95	±2	12	140	0	37
Group 3	-	-	-	-	-	-
Group 4	-	-	-	-	-	-

1. The soil shear strength values shown do not consider any contribution of the reinforcing elements.
2. Less compaction acceptable within 5 feet of wall to control panel displacement during construction.
3. Moisture content for compaction may be reduced to "dry side" of OMC per RECo recommendation.
4. Maximum 10-inch compacted lift thickness.
5. Fines content for Group 2 would preclude wet weather placement.

For compaction immediately adjacent to the MSE wall facing panels, only hand compaction equipment can be used to avoid the risk of damaging or causing deflection of the panels, which may result in a somewhat lower level of compaction being achieved in this zone. The distance affected is typically about 5 feet, but this would need to be confirmed based on the compaction equipment being used by the contractor.

If geosynthetic reinforcement is used in the B_2 zone below the MSE wall, we recommend that WSDOT's Test Method 925 be used to determine long-term strength values unless an appropriate geosynthetic is already rated (i.e., from the WSDOT QPL list of products).

Zone B_3. This is the high strength embankment fill zone, which provides a foundation for the MSE wall. Results of preliminary global slope stability analysis for the pseudo-static case indicate this zone requires a soil shear strength effective frictional angle of 35 degrees to satisfy global stability within the embankment fill below MSE walls. Table 8 presents proposed specification requirements and recommended design parameters for Zone B_3 fill.

Table 8 - Zone B_3 Fill

Zone B_3	Proposed Specification Requirements			Recommended Design Parameters		
	Minimum % Compaction ASTM D 1557[1]	**Moisture Range Relative to OMC**	**Maximum Loose Lift Thickness in Inches**[2]	γ **in pcf**	**c′ in psf**	ϕ' **in deg.**
Group 1A	90	±3	12	140	0	35
Group 1B	90	±3	12	140	0	35
Group 2	90	±2	12	140	0	35
Group 3	-	-	-	-	-	-
Group 4	-	-	-	-	-	-

1. Minimum percent compaction may be increased pending further analysis of potential settlements under wall load.
2. Maximum 10-inch compacted lift thickness.

Zone C_1. This is the common embankment fill behind the MSE wall reinforced zone which has been identified as zone "B" or zone "C" in the Phase I and Phase 2 embankment specifications (zone "C" was used to designate stockpiled soils in Phase 3). This zone is similar to the "random fill" designation in the RECo design manual for the fill behind the MSE wall reinforced zone. Here, the contractor will have the most flexibility in the fill material groups. Zone C_1 fill may contain fill material within some or all of the groups indicated below in no particular sequence or relative thickness. Note that restrictions may need be placed on the use of Group 4 soils in zone C_1, depending on performance observations during the current Phase 3 embankment construction. These will be specified at a later date. Table 9 presents proposed specification requirements and recommended design parameters for zone C_1 fill.

Table 9 - Zone C_1 Fill

Zone C_1	Proposed Specification Requirements			Recommended Design Parameters		
	Minimum % Compaction ASTM D 1557	**Moisture Range Relative to OMC**	**Maximum Loose Lift Thickness in Inches**	**γ in pcf**	**c' in psf**	**ϕ' in deg.**
Group 1A	90	±3	12	135	0	35
Group 1B	90	±3	12	135	0	35
Group 2	90	±2	12	135	0	35
Group 3	92	-2~+3	8	135	0	35(1)
Group 4	92	-2~+1	8	130	0	35(1)

(1) Soil strength value for Group 4 and Group 3 soils should be verified in the laboratory and/or field tests to demonstrate these materials have sufficient strength, or the recommended design parameters may need to be modified for the global stability analysis.

Zone A_2. This is the free-draining soil used in the embankment underdrain layer (i.e., nominally 3 feet thick). Table 10 presents the proposed specification requirements and recommended design parameters for Zone A_2 fill.

Table 10 - Zone A_2 Fill

Zone A_2	Proposed Specification Requirements			Recommended Design Parameters		
	Minimum % Compaction ASTM D 1557	**Moisture Range Relative to OMC**	**Maximum Loose Lift Thickness in Inches**	**γ in pcf**	**c' in psf**	**ϕ' in deg.**
Group 1A	90	±3	12	140	0	37
Group 1B	-	-	-	-	-	-
Group 2	-	-	-	-	-	-
Group 3	-	-	-	-	-	-
Group 4	-	-	-	-	-	-

Notes on Soil Fill Strength Values. Hart Crowser accomplished preliminary global stability analyses using a frictional strength value of $\phi' = 37$ degrees for embankment soil in the reinforced zone and $\phi' = 35$ degrees for the unreinforced embankment fill. These values were based largely on experience and published information results for comparable embankment fills that are well-compacted and constructed of relatively well-graded soils. A single boring that was advanced through the Phase 1 (1998) fill placed for the Third Runway, suggested these values were reasonable based on correlation with Standard Penetration Test blow counts in Group 2 and Group 3 soils that ranged from 29 to over 100. The Phase 1 fill was placed according to the compaction standards specified herein for zones B_3 and C_1, which are below that specified herein for the reinforced Zone B_2.

At the time RECo started design, we discussed the AASHTO criteria that suggest maximum values of ϕ' should be limited in the absence of specific data from tests on the backfill soils. In Section 5.8.2, AASHTO says a maximum value of $\phi' = 30$ degrees should be used (in the absence of tests) for calculating active earth pressure acting horizontally on the reinforced zone. In Section 5.8.4.1, AASHTO says a maximum value of $\phi' = 34$ degrees should be used (in the absence of tests) for calculating horizontal force within the reinforced zone. Generally these values apply to soils that may be poorly graded, with moderate compaction, and with fines contents up to 15 percent (based on the total backfill unit weight), which is the maximum allowed by AASHTO.

During design team discussions, we agreed to accomplish initial design for the NSA wall using two values of ϕ' (37 and 34 degrees) for soil in the reinforced zone B_2, to enable comparison of the cost difference between specification of a select backfill compared to a less select material. We agreed that the $\phi' = 37$ degrees would represent a relatively well-graded backfill with less than 8 percent fines (corresponding to the embankment Group 1A and 1B soil types), and that $\phi' = 34$ degrees would correspond to backfill with up to 15 percent fines (which is slightly more silty than allowed under Group 2). Furthermore RECo used $\phi' = 34$ degrees for the embankment fill behind and below the reinforced fill, corresponding to zones C_1 and B_3.

No decision has been made at this time regarding selection of the backfill soil for the NSA and South MSE walls. The design team concurs that a select backfill (less than 5 percent fines, well-compacted, and relatively well-graded) will be used for the West wall backfill. Further tests will be needed to confirm compaction requirements to achieve minimum design strengths for the wall backfill and unreinforced portions of the embankment to conform to AASHTO criteria. This could be accomplished along with planned field tests to verify suitability of the Group 4 soils as part of Phase 3 construction, by a separate laboratory study during design, or as verification testing during the fill acceptance quality assurance process during MSE wall construction.

Foundation Soil Input Parameters

The foundation soils vary significantly from one wall location to another, as well as below the footprint of a given wall. This section provides the values used in preliminary global stability analysis, see Hart Crowser's June 2000 Report "Preliminary Stability and Settlement Analyses, Subgrade Improvements, MSE Wall Support, Third Runway Project." For the shear strength of clay soils, we considered both the short-term (i.e., undrained) end-of-construction case, and the longer-term (i.e., partially drained) end-of-construction case. For the latter, pore pressures were allowed to dissipate based on anticipated rates of consolidation determined from laboratory tests and piezocone dissipation test results.

Subgrade improvements are needed in some areas to improve shear strength and/or where mitigation of settlement and/or soil liquefaction are required. Feasible subgrade improvement techniques include overexcavation/backfill, vibro-compaction, and vibro-replacement stone columns. We assumed that peat underlying the wall zone would be removed.

The nature and extent of recommended subgrade improvements are provided in a separate document (refer to Hart Crowser's Report, Preliminary Stability and Settlement Analyses, Subgrade Improvements, MSE Wall Support, Third Runway Project dated June 2000). Table 11 presents foundation soil input parameters for various soil types.

Table 11 - Foundation Soil Input Parameters

		Effective (Drained)		**Total (Undrained)**
	γ in pcf	**c′ in psf**	**ϕ' in deg.**	**Su in psf**
Soft to Stiff Sandy Clay/Silt	115	0	32	1000
Very Stiff to Hard Clay/Silt	115	0	32	3500
Loose to Medium Dense Sand	125	0	32	-
Medium Dense to Dense Sand	130	0	35	-
Dense to Very Dense Sand	135	0	37	-
Glacial Till	130	250	40	-
Improved Subgrade	135	0	35	-

Seismic Stability Input Parameters

The 475-year return period seismic event has been selected for MSE wall design. This event would be expected to produce a horizontal peak ground acceleration (PGA) of 0.36 g based on site-specific evaluation (see Hart Crowser's memoranda dated October 8, 1999, and April 10, 2000). Hart Crowser will use a synthetic time history developed based on the results of a site-specific probabilistic seismic hazard analysis for deformation modeling using the finite difference model "FLAC."

Other Geotechnical Input Parameters

Coefficient of Friction for Sliding Analysis. This will depend on the specific embankment material zone being analyzed:

- For reinforced zones use tan 37 deg. = 0.75; and

- For the interface below reinforced zones (i.e., top of Zone B_3), use tan 35 deg. = 0.70.

These are ultimate values of friction, and allowable resistance to sliding should be based on a minimum Factor of Safety as noted in Tables 1 and 2.

Soil Allowable Bearing Capacity. No deep-seated bearing capacity failures below the extent of ground improvement are anticipated due to the presence of dense, glacial soils. For local punching shear analysis below the leveling pad, Hart Crowser recommended assuming an allowable bearing capacity of 6 ksf with a minimum of 2 feet of embedment and a 1-foot-wide leveling pad. The design team agreed to check bearing capacity and anticipated deformation after the wall geometry was developed.

Differential Settlement. The design team anticipates that the wall facing panels can tolerate the differential settlements that Hart Crowser initially estimated for the MSE wall foundation soils including subgrade improvements (up to 1/100). However, it may also be prudent to add vertical slip joints for the West MSE wall and possibly the North MSE wall. The design team agreed that RECo would propose location of wall joints based on change in wall height and subgrade.

Groundwater Conditions. Groundwater generally occurs at relatively shallow depth in the foundation soils. MSE wall backfill will typically need to be hydraulically connected to the embankment drainage layer. This precludes the use of Group 3 and Group 4 materials below Zone B_2 due to the high fines content of these fill materials. Note that the preliminary global stability analysis included the assumption that the foundation soils and embankment drainage layer were saturated (i.e., piezometric line at the top of the drainage layer), which is conservative. Further analysis, particularly of the South MSE wall may indicate less risk of long-term subgrade saturation, which would increase Factor of Safety.

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Attachments:
Figure 1 - Conceptual Zoned Embankment Cross Sections
Figures 2 through 4 – Phase 3 Group 1A, 1B, and 2 Fill Specifications
Figures 5 through 7 - Proposed Group 1A, 1B, and 2 MSE Wall/Slope Backfill Specification

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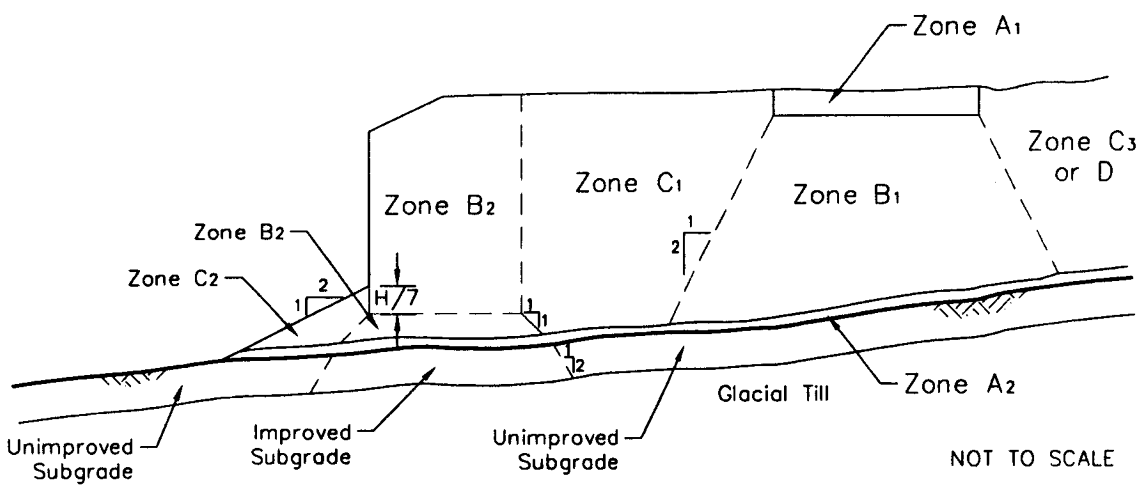
Conceptual Zoned Embankment Cross Sections

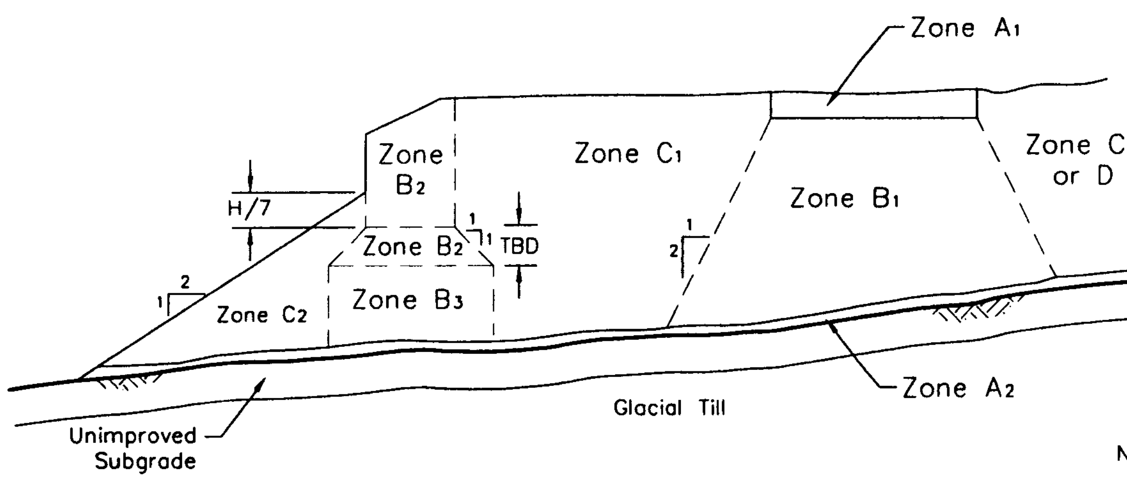
EMBANKMENT ZONES

- A_1 PAVEMENT SUBGRADE
- A_2 DRAINAGE
- B_1 PAVEMENT SUPPORT
- B_2 MSE REINFORCING
- B_3 MSE SUPPORT
- C_1 COMMON EMBANKMENT BEHIND WALLS
- C_2 COMMON EMBANKMENT, SLOPES
- C_3 COMMON EMBANKMENT, OTHER
- D NON-STRUCTURAL FILL



NOT TO SCALE

(i) MSE RETAINED EMBANKMENT



NOT TO SCALE

(ii) MSE RETAINED EMBANKMENT (Walls on Embankment Fill)

HARTCROWSER
J-4978-17 6/00
Figure 1

Phase 3 Group 1A Fill Specification

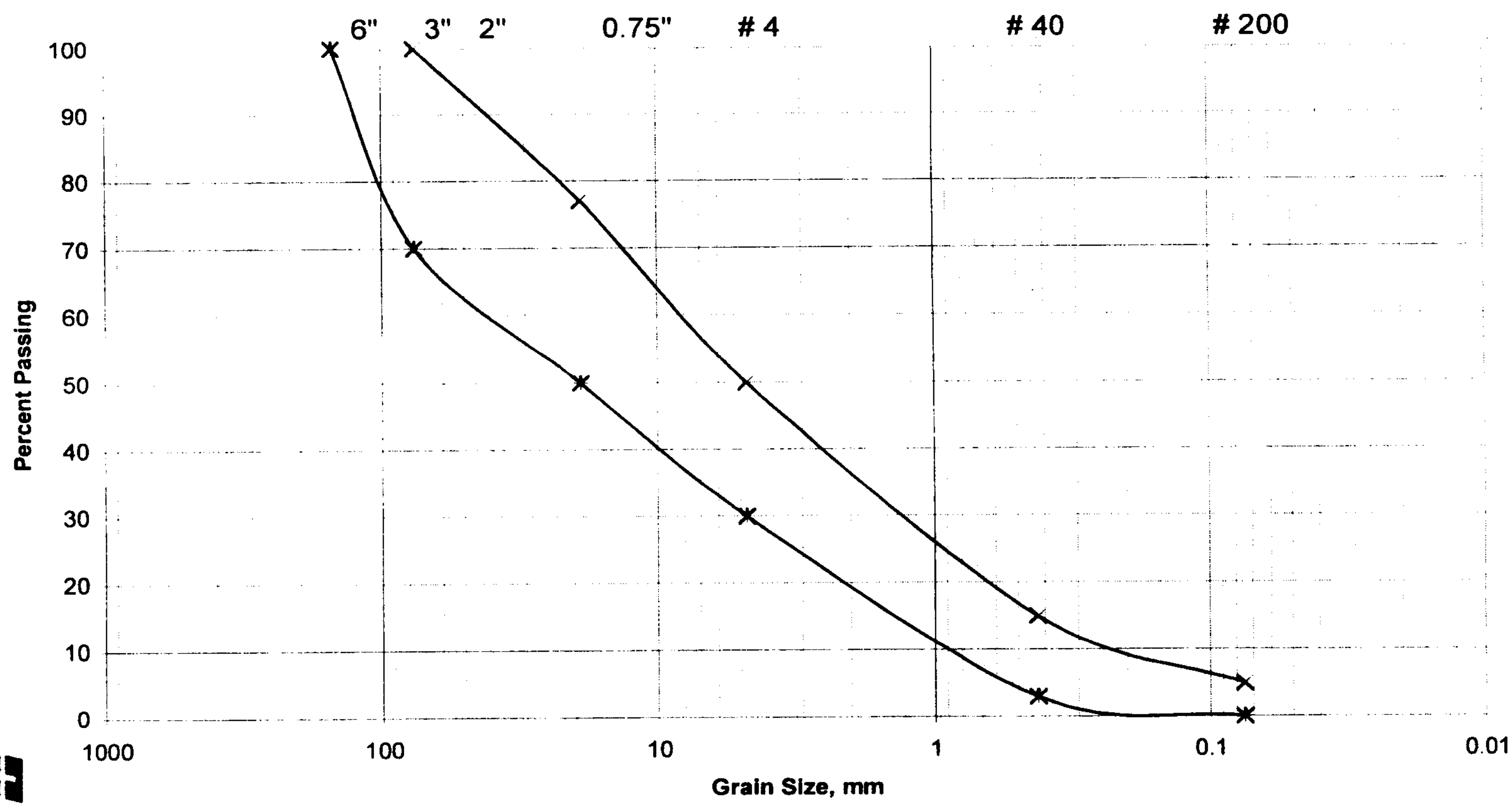


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Figure 2

Phase 3 Group 1B Fill Specification

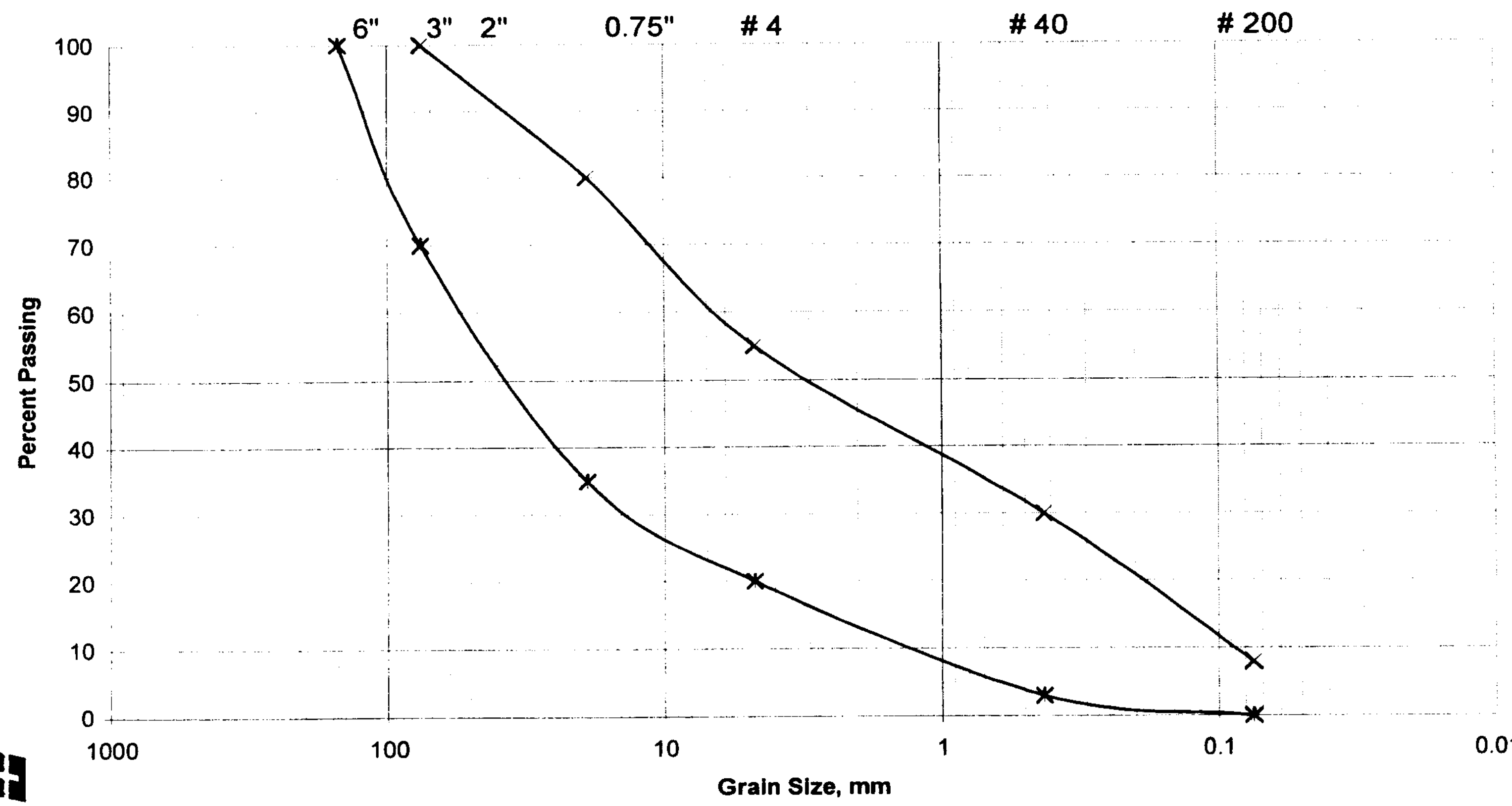

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Figure 3

AR 045663

Phase 3 Group 2 Fill Specification

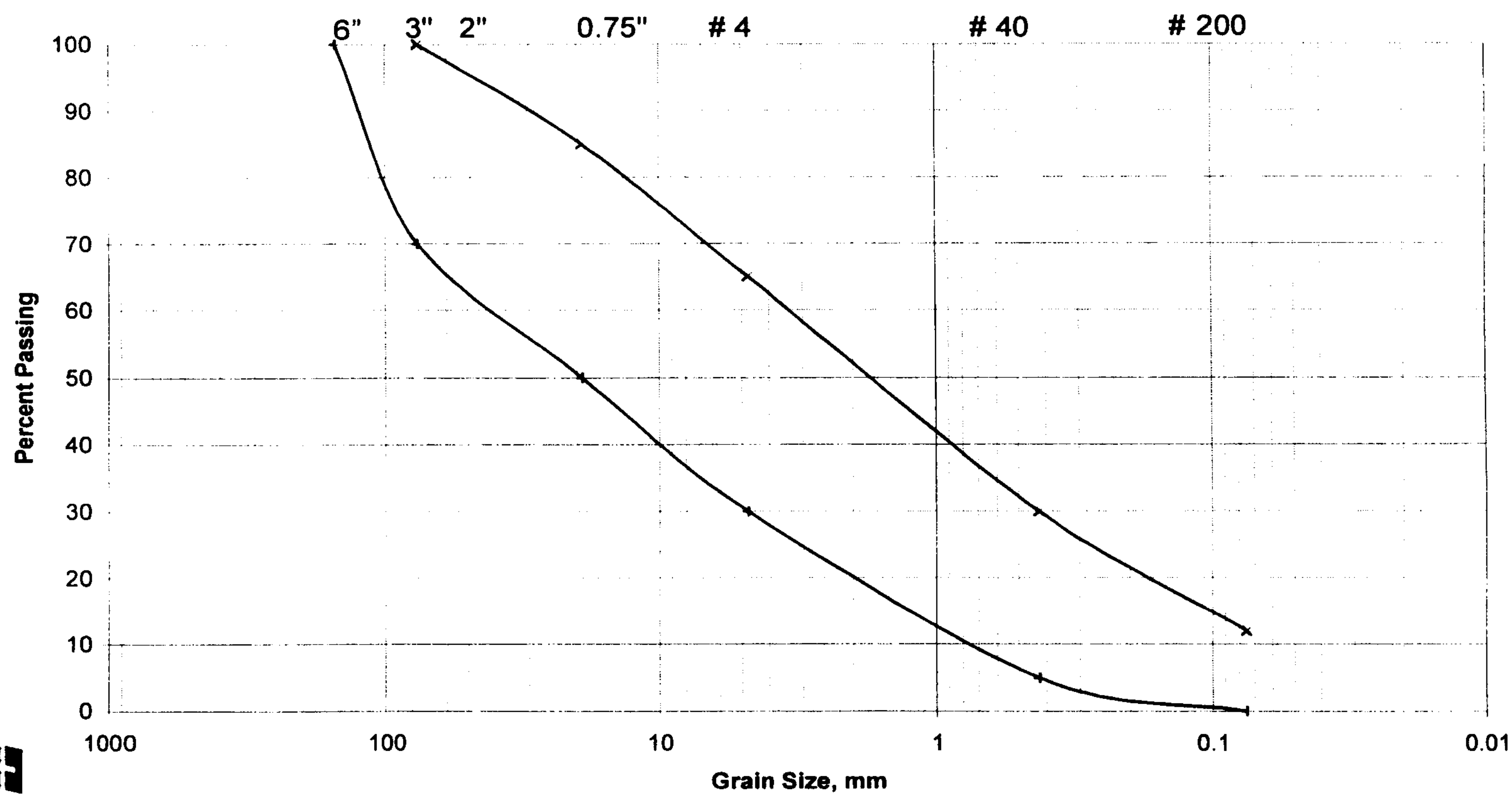

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Figure 4

DTN 6/22/00 49781702.cdr

Proposed Group 1A MSE Wall/Slope Backfill Specification

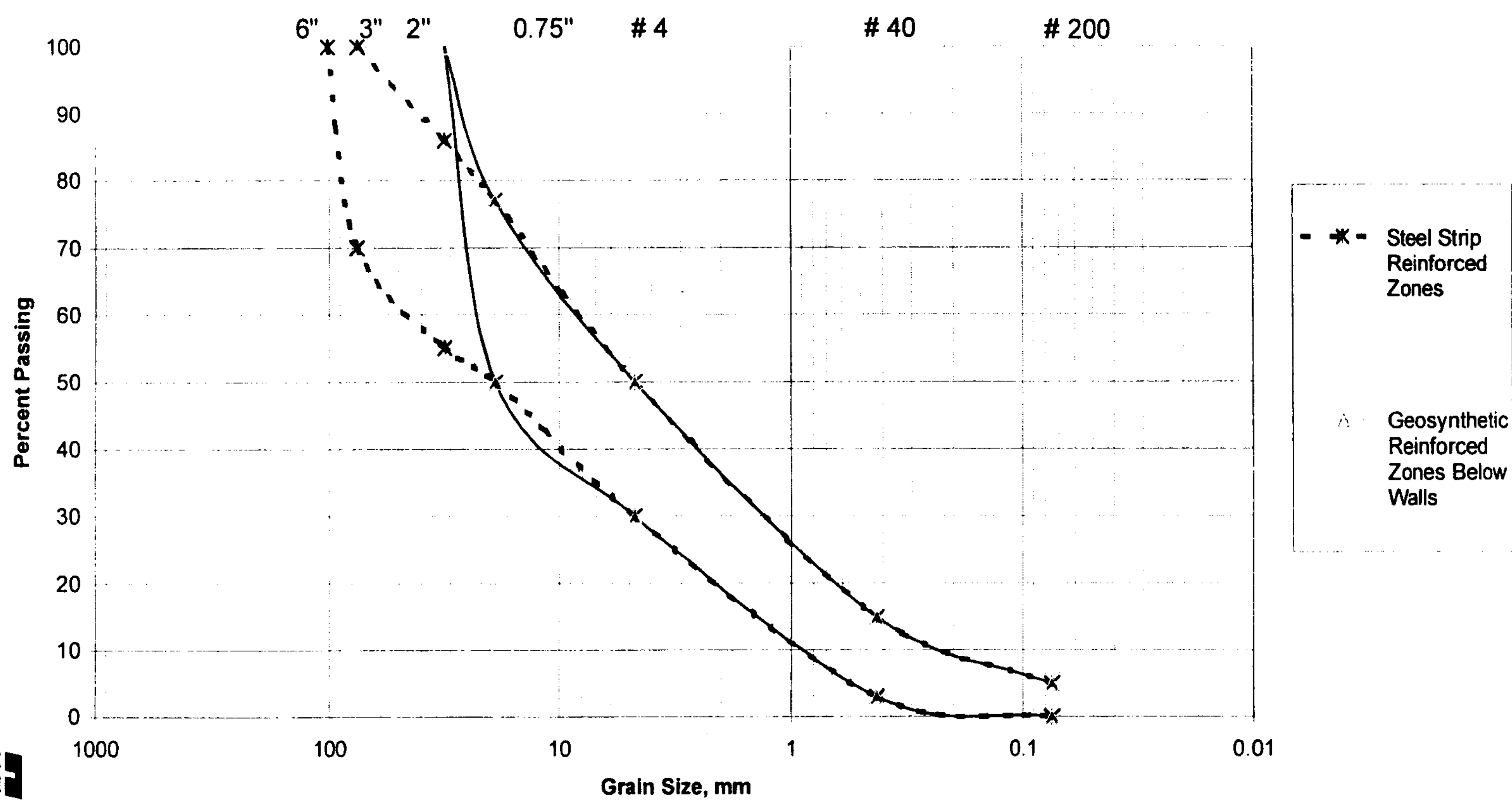

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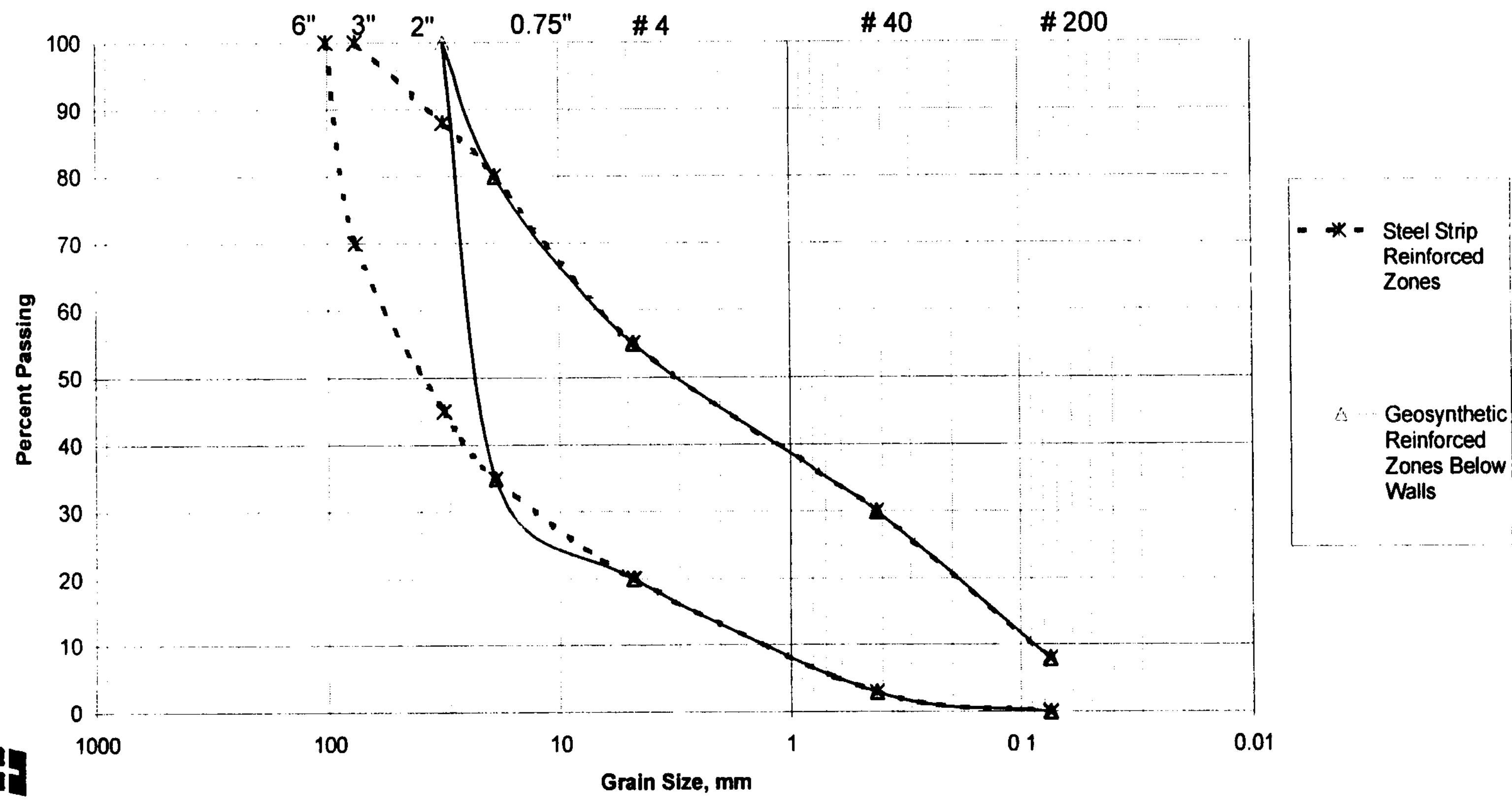
Figure 5

DTN 6/22/00 49781703.cdr

Proposed Group 1B MSE Wall/Slope Backfill Specification



AR 045666

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Figure 6

DTN 6/22/00 49781704.cdr

Proposed Group 2 MSE Wall/Slope Backfill Specification

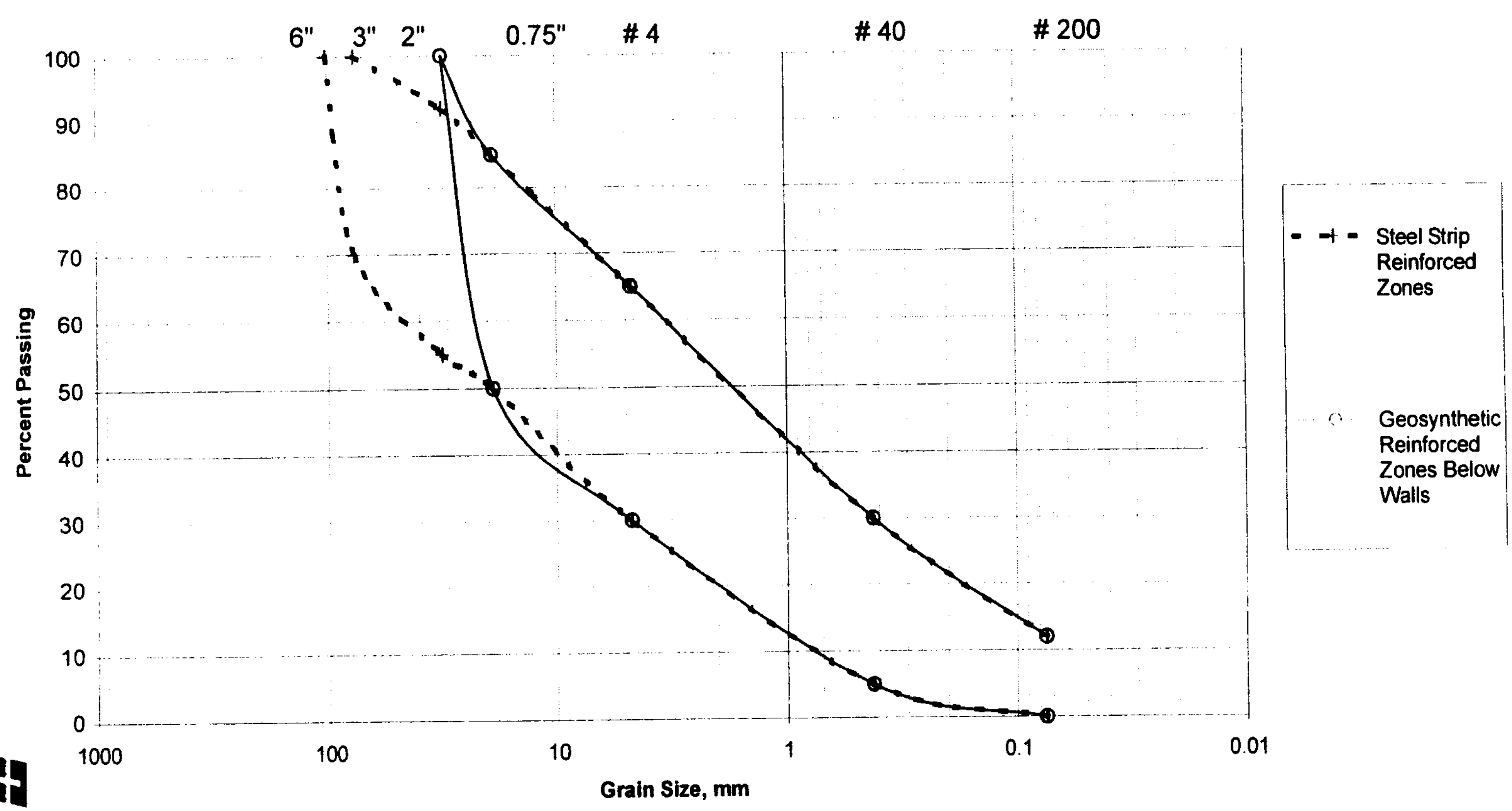

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Figure 7

DTN 6/22/00 49781705.cdr

AR 045667