



November 22, 2005

TO: Rosario Revilla/Adam Brown
Northwest Region, MS NB 82-75

FROM: T. M. Allen/M. A. Frye
E&EP Geotechnical Division, 47365

SUBJECT: SR-90, MP 6.22 to 7.24, XL2423
Two Way Transit & HOV Operations, Stage 1
Retaining Walls 5 and 30
Geotechnical Recommendations

Introduction

This memorandum presents geotechnical recommendations for the design of Retaining Walls 5 and 30 associated with the subject project. This project will provide two-way transit and HOV lanes between Seattle and Bellevue. HOV lanes will be added to the left of the general purpose lanes on the eastbound and westbound mainline roadways. Where existing reversible lanes exist, they will be maintained in their current configuration.

Throughout the length of the project, the addition of new HOV lanes will require widening of the existing outside shoulders. Across Mercer Island, the widening will generally only take place between the existing bridge structures. Walls 5 and 30 will be constructed between the WM-W ramp and westbound I90 between the East Anchorage of the I90 floating bridge and the First Hill Lid. Recommendations for other retaining walls associated with this project will be provided under separate cover.

Retaining Wall Descriptions

Retaining Wall 5 will be approximately 380 feet in length and will be between the WM-W ramp and westbound I90 just west of the First Hill Lid. Wall 5 will have a maximum exposed height of 10 feet.

Retaining Wall 30 will be approximately 290 feet in length and will be located on the westbound shoulder of I90 just west of the First Hill Lid. Wall 30 will be a "barrier wall" with a maximum exposed height of approximately 3 feet. Wall 30 will support a 3:1 (Horizontal:Vertical) slope.

Subsurface Conditions

A report titled *Geotechnical and Geologic Type, Size, and Location Report, I-90 Two-Way Transit and High-Occupancy Vehicle Operations, I-5 to Bellevue Way, King County, Washington*, July 2, 2004, prepared by Shannon & Wilson, Inc. provides a detailed description of site geology and soil conditions. This report also contains site maps and copies of boring logs from previous geotechnical studies throughout the project corridor.

Based on our study of the above report, our files, contract documents, and our site visits, we believe Walls 5 and 30 will be founded on either glacially consolidated soils or fill placed during the construction of I-90. Soils at the foundation level of these walls will likely transition between native soils and fills several times along the length of the walls depending on how the existing walls were constructed (i.e. shoring or open excavation).

Groundwater is not expected to be encountered during construction of these walls.

Geotechnical Recommendations

Wall 5

We understand a Standard Plan Concrete Cantilever wall is the preferred wall type for Wall 5. Based on the subsurface conditions, Reinforced Concrete Retaining Wall Types 1 through 4 (Standard Plans D-1a through D-1d) are suitable for Wall 5. Where Wall 5 will be above the biofiltration swale, we recommend the swale be considered an adjacent ditch section. The top of the wall footing should be a minimum of 1-foot below the bottom of the biofiltration swale in accordance with the Standard Plans. Wall 30 should be backfilled in accordance with Standard Plan D-4.

Wall 30

We understand Wall 30 will be designed as cantilever wall. We understand the intent is to use a pre-cast wall section that will be set in an excavation and backfilled. This wall can also be supported on a spread footing. A spread footing supported barrier could be designed similar to a Standard Plan Concrete Cantilever Wall or as an "L" shaped wall (similar to a moment slab barrier section). The following sections provide design recommendations for the two wall alternatives.

Cantilever Barrier Walls

Earth pressure diagrams are presented on Figures 2 and 3 for design of these walls. We recommend a resistance factor of 0.75 be used for the passive earth pressure. The passive resistance of the roadway surfacing materials may be used to design the walls. However, we recommend the structural designer analyze the temporary construction case with the wall constructed and backfilled, prior to placement of the roadway surfacing.

Spread Footing Supported Barrier Walls

The following tables provide design parameters for spread footings.

Bearing Capacity vs. Footing Width

Footing Width (ft)	Ultimate Bearing Capacity (ksf)	Service Bearing Capacity (ksf) Based on 1" of Settlement
2	7.0	6.0
3	8.8	4.2
4	10.5	3.2
5	12.3	2.7
6	14.0	2.5
7	15.7	2.2

Lateral Earth Pressure Coefficients and Soil Parameters

Parameter	Value
Backfill Unit Weight (γ)	125pcf
Backfill Soil Friction Angle (ϕ_f)	32°
Active Earth Pressure (K_a)	0.39
At Rest Earth Pressure (K_0)	0.62
Bearing Soil Friction Angle (ϕ_f)	32°
Passive Earth Pressure (K_p) - Unfactored	3.85*
Coefficient of Sliding	0.6
Seismic Coefficient (K_{ae})	0.67

* The passive earth pressure for roadway surfacing materials can be taken as 7.55.
 We recommend the following resistance factors be used when evaluating the different limit states.

Spread Footing Resistance Factors

Limit State	Resistance Factor ϕ		
	Shear Resistance to Sliding	Passive Pressure Resistance to Sliding	Bearing
Strength	0.80	0.50	0.45
Service	N/A	N/A	1.00
Extreme	0.90	0.90	0.90

Construction Considerations

If Wall 5 is constructed prior to Wall 30, open excavation should not be allowed below the 1:1 line from the toe of the existing wall footings as shown on Figure 4. Shoring, if necessary, will need to be designed to account for the horizontal pressures in accordance with Section 3.11.6 of the 2005 *AAHSTO LRFD Bridge Design Specifications*. Any open excavation steeper than 4:1 below the footing elevation of the Wall 5 should be limited to no more than 25 linear feet at a time.

Backfill for Wall 30 should be placed concurrently on both sides of the wall up to the subgrade elevation on the roadway side the walls. Failure to backfill concurrently may result in wall rotation.

Recommended Additional Services

Because the future performance and integrity of the geotechnical elements of this project will depend largely on proper PS&E preparation and diligent construction procedures, we recommend that the Geotechnical Division (GD) in conjunction with the Regional Materials Engineer (RME) provide the following post-report services:

The GD should prepare the Summary of Geotechnical Conditions to be included in the PS&E as an appendix. The summary should be prepared as part of the PS&E review process.

The GD/RME should review all construction plans and specifications to verify that the design criteria presented in this report have been interpreted correctly and properly integrated into the design.

The GD/RME should attend pre-construction conferences with the Construction Project Engineer and Contractor to discuss important geotechnical related construction issues.

The GD/RME should review Contractor submittals for all shoring walls and other geotechnical elements of this project.

The RME should observe all exposed subgrades after completion of stripping and excavation to contract elevations. The RME should confirm that suitable soil conditions have been reached and determine appropriate subgrade compaction methods.

In addition to the aforementioned services, the Geotechnical Division can provide inspector training for construction personnel, assist in change of condition claims, and review cost reduction incentive proposals (CRIPs).

Intended Report Use and Limitations

This report has been prepared to assist the Washington State Department of Transportation in the engineering design and construction of the subject project. It should not be used, in part or in whole for other purposes without contacting the EEP Geotechnical Division for a review of the applicability of such reuse. This report should be made available to prospective contractors for their information or factual data only and not as a warranty of ground conditions.

The conclusions and recommendations contained in this report are based on the Geotechnical Division's understanding of the project at the time that the report was written and on site conditions that existed at the time of the field exploration. If significant changes to the nature, configuration, or scope of the project occur during the design process, the Geotechnical Branch should be consulted to determine the impact of such changes on the recommendations and conclusions presented in this report.

Site exploration and testing describes subsurface conditions only at the sites of subsurface exploration and at the intervals where samples are collected. These data are interpreted by members of the Geotechnical Division who then render an opinion regarding the general subsurface conditions. The distribution, continuity, thickness, and characteristics of identified (and unidentified) subsurface materials may vary considerably from that indicated by the subsurface data. While nothing can be done to prevent such variability, the Geotechnical Division is prepared to work with the Design Team to reduce the impacts of variability on project design, construction, and performance. Periodic geotechnical observation during construction may be beneficial in this respect. This ongoing involvement of the Geotechnical Division throughout the design and project development process will also help to avoid costly mistakes associated with misinterpretation of the contents of this report and resulting shortcomings of project design or contract documents.

The conclusions and recommendations presented in this report assume that surface and subsurface conditions, as observed during field exploration activities are representative of the site conditions throughout the project area. Because of this assumption, these recommendations should be considered subject to change depending on the actual subsurface conditions encountered. Actual subsurface conditions can be discovered only during earthwork and construction operations. Accordingly, the Geotechnical Division should be involved in the construction of the project in order to make appropriate observations and recommendations for alteration in design, as appropriate.

Rosario Revilla/Adam Brown
November 22, 2005
Page 6

If you have questions or require further information, please contact Tony Allen at (360) 709-5450 or Mark Frye at (360) 709-5469.



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Attachment: Figures

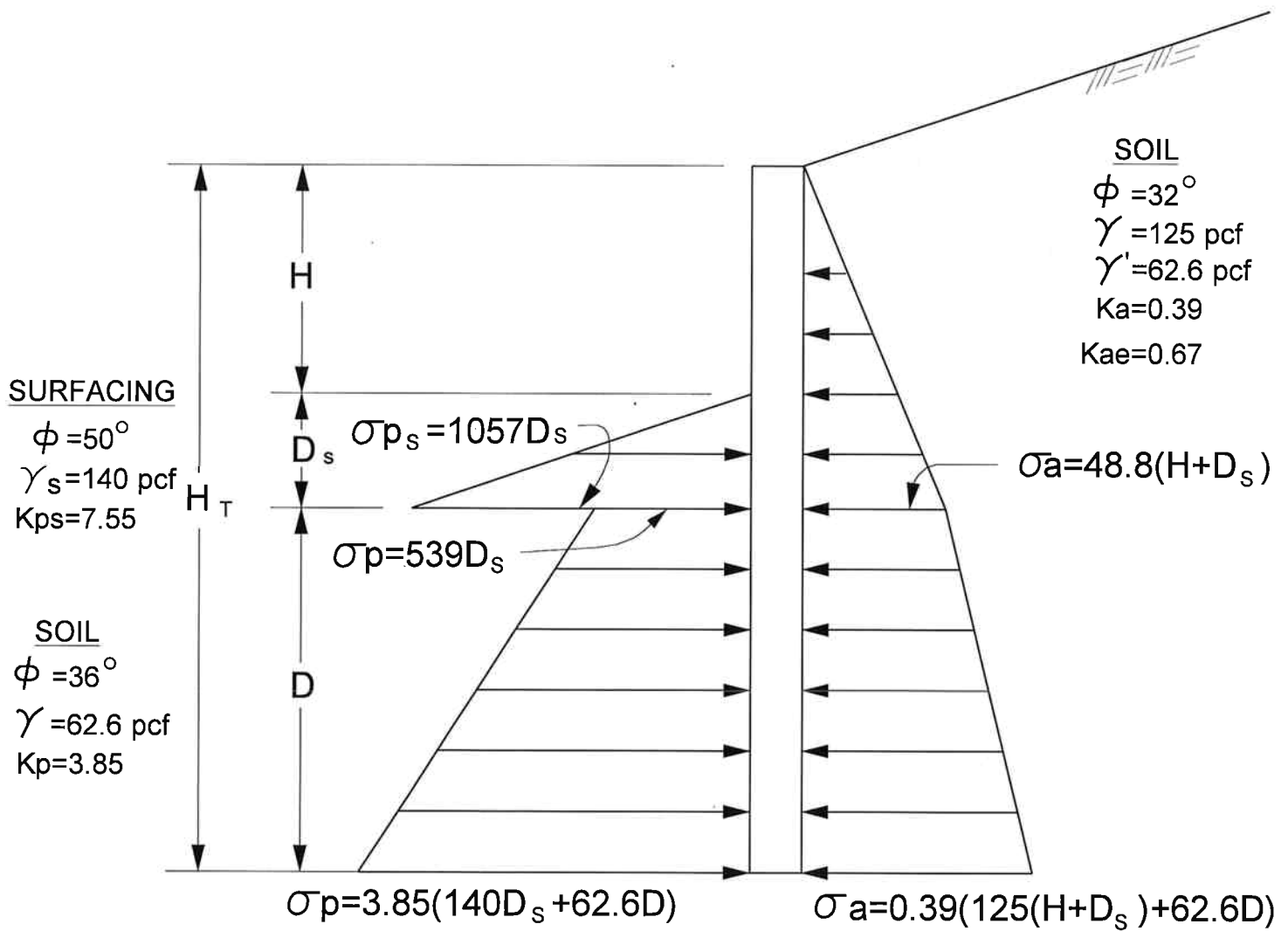
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Theresa D. McAuliffe, HNTB Corporation



JOB XL-2423 S.P. 90 C.S. LAYOUT	
I-90 Two Way Transit & HOV Operations	
WASHINGTON STATE DEPARTMENT OF TRANSPORTATION MATERIALS BRANCH	DATE 10/2005 SCALE VERT. _____ HORIZ. _____
T.E. BAKER MATERIALS ENGINEER	SHEET _____ OF _____ DRAWN BY DWG

Figure 1
 Vicinity Map
 Wall Locations Shown Are Approximate


Strength Limit State



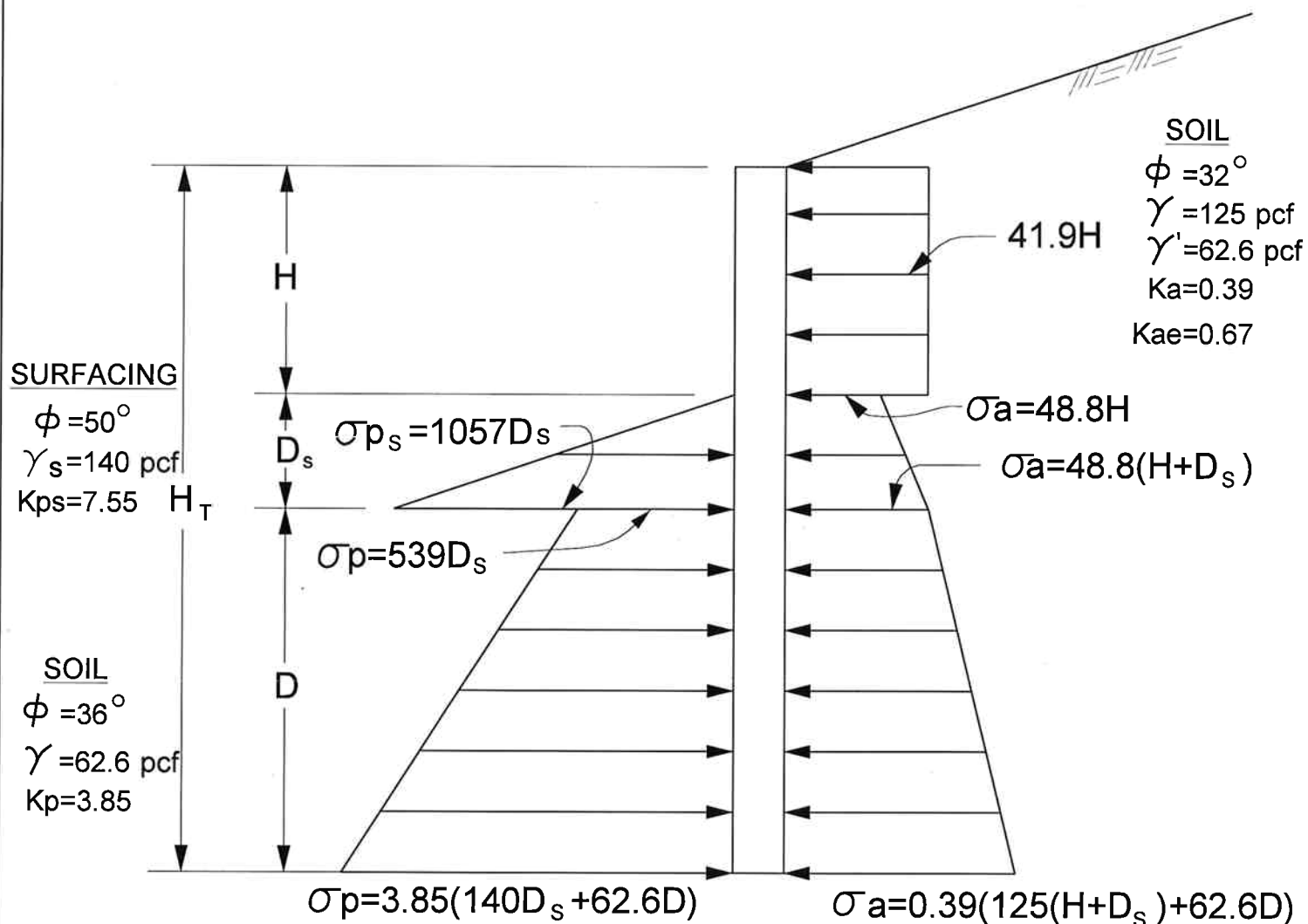
NOTES

- ① If the wall is backfilled prior to construction of the roadway surfacing, the temporary construction stage where $D_s = 0$ should be evaluated.
- ② All pressures in psf.
- ③ D_s is the total depth of roadway surfacing including Portland Cement Concrete Pavement, Hot mix Asphalt Pavement, and Crushed Surfacing Base Course.

Figure 2: Earth Pressure Diagram
Wall 30

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Extreme Limit State



NOTES

- ① If the wall is backfilled prior to construction of the roadway surfacing, the temporary construction stage where $D_s = 0$ should be evaluated.
- ② All pressures in psf.
- ③ D_s is the total depth of roadway surfacing including Portland Cement Concrete Pavement, Hot mix Asphalt Pavement, and Crushed Surfacing Base Course.

Figure 3: Earth Pressure Diagram
Wall 30

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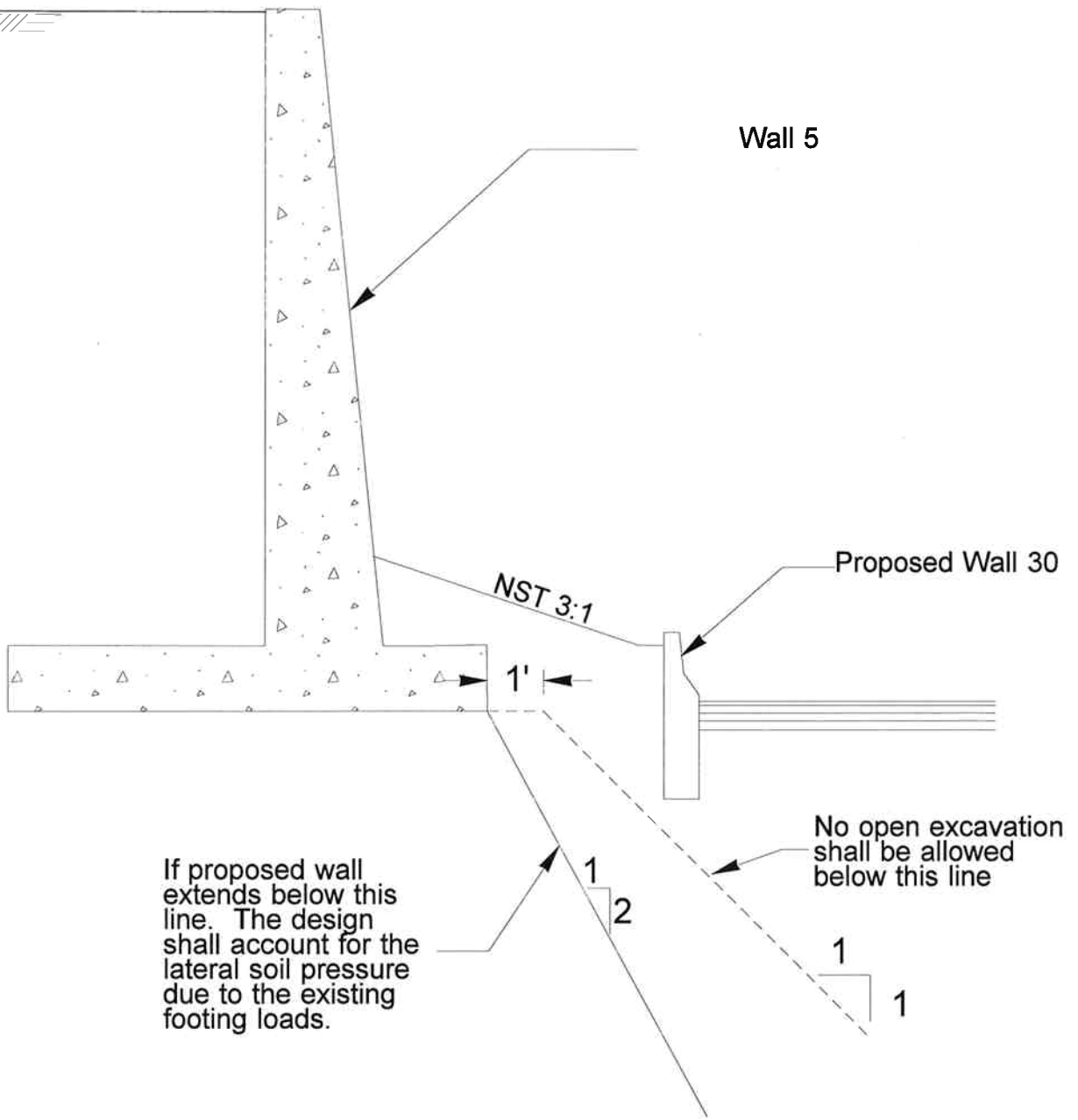



Figure 4
Typical Section
Wall 30

JOB <u>XL-2423</u> S.R. <u>90</u> C.S. _____ LAYOUT _____	
I-90 Two Way Transit & HOV Operations	
 WASHINGTON STATE DEPARTMENT OF TRANSPORTATION MATERIALS BRANCH T. E. BAKER MATERIALS ENGINEER	DATE <u>10/2005</u> SCALE <u>NOT TO SCALE</u> VERT. _____ HORIZ. _____ SHEET _____ OF _____ DRAWN BY <u>DWG</u>