Washington State Department of Transportation

Memorandum

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, XL-2423
Two Way Transit & HOV Operations, Stage 1
Retaining Walls 6, 7, 8, 9, and 10
Geotechnical Recommendations

Introduction

This memorandum presents geotechnical recommendations for the design of Retaining Walls 6, 7, 8, 9, and 10 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 6, 7, 8, 9, and 10 will be constructed along the westbound, outside shoulder on Mercer Island. The exposed face of each of these walls will form the traffic barrier on the outside shoulder. These walls replace existing barrier walls. Recommendations for other retaining walls associated with this project will be provided under separate cover.

Retaining Wall Descriptions

Each of these walls will form a traffic barrier at the edge of the westbound shoulder on I90. The exposed height of the walls will be no more than traffic barrier height. The walls will generally support a 3:1 (Horizontal:Vertical) slope. The slopes behind the walls will generally end at the face or back of existing cast-in-place concrete cantilever walls or counterfort walls. The location of each of the proposed walls are shown on Figure 2.

Retaining Wall 6 will be approximately 530 feet in length and will be located on the westbound shoulder of I90 between the 76th Ave. SE and 77th Ave. SE undercrossings. There is an existing cast-in-place counterfort wall located behind the proposed alignment of Wall 6. As proposed, Wall 6 will be cast against the toe of the existing wall's footing.

Retaining Wall 7 will be approximately 480 feet in length and will be located on the westbound shoulder of I90 between the 77th Ave. SE and 80th Ave. SE undercrossings.

There is an existing cast-in-place counterfort wall located behind the proposed alignment of Wall 7.

Retaining Wall 8 will be approximately 800 feet in length and will be located on the westbound shoulder of I90 between the Island Crest Way undercrossing and the Luther Burbank Lid. There is an existing cast-in-place counterfort wall located behind a portion of the proposed alignment of Wall 8.

Retaining Wall 9 will be approximately 780 feet in length and will be located on the westbound shoulder of I90 immediately east of the Luther Burbank Lid. Wall 9 will be constructed in the backfill of an existing concrete cantilever wall.

Retaining Wall 10 will be approximately 500 feet in length and will be located on the westbound shoulder of I90 immediately west of the Shorewood Drive undercrossing. Wall 10 will transition from being constructed in the backfill of an existing concrete cantilever wall to being constructed at the toe of an existing concrete cantilever wall.

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 6, 7, 8, 9, and 10 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

We understand Walls 6, 7, 8, 9, and 10 will be designed as cantilever walls. We understand the intent is to use a pre-cast wall section that will be set in an excavation and backfilled. These walls can also be supported on spread footings. 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 both the cantilever and spread footing supported 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.

Based on the cross-sections we have been provided, the footing elevations of the proposed walls will be at or above the footing elevations of the existing concrete cantilever and counterfort walls. We understand the existing footing elevation were determined from as-built drawings. We recommend the Project Office pothole the existing footings in several locations and field survey the location and elevation of the footings to confirm the location of the wall footings.

Spread Footing Supported Barrier Walls

If the structural design of the walls requires the bottom of the wall to be below the 1:1 line shown on Figure 4, structural shoring will be required. The need for structural shoring will significantly increase the cost of using the cantilever wall section. The use of spread footings may limit the excavation necessary to construct the walls. This may keep the base of the walls out of the influence zone of the existing walls (see Figure 4). 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

Analysis of Existing Retaining Walls

We understand Walls 6, 7, 8, and 10 will be constructed at the toe of the existing retaining walls at these locations. Construction of the new walls will necessitate the removal of some or all of the soil at the toe of the existing walls. This section presents design information so the structural designer can evaluate the sliding and overturning stability of the existing walls.

AASHTO seismic design criteria has been updated since the original design of the existing walls. We recommend using the design response spectra presented in the current AASHTO LRFD Bridge Design Specifications for seismic design of these walls. A peak bedrock acceleration of 0.39 is recommended based on the WSDOT Geotechnical Design

Manual (DM46-03). The recommended acceleration coefficient is based on expected ground motion at the project site that has a 10 percent probability of exceedence in a 50-year period (475-year return period).

Based on information contained on the as-built drawings, we recommend using the soil parameters in the following tables to evaluate sliding and overturning of the existing retaining wall above the proposed Walls. It is our opinion that the original design was conducted using Allowable Stress Design (ASD) and that appropriate factors of safety for ASD should be applied as part of the design review. This includes using a factor of safety of 1.5 to evaluate sliding under static conditions, a factor of safety of 1.1 to evaluate sliding under seismic conditions, and a factor of safety of 2.0 to evaluate overturning. The following table should be used to evaluate the existing wall above the proposed Wall 6.

Parameter	Value
Backfill Soil Unit Weight, γ (pcf)	130
Backfill Soil Friction Angle, ϕ_b (degrees)	35
Foundation Soil Friction Angle, ϕ_f (degrees)	32
Active Earth Pressure Coefficient, K_a	0.27
Seismic Earth Pressure Coefficient, K_{ae}	0.39
Coefficient of Sliding, $Tan\phi_f$	0.62

The following table should be used to evaluate the existing walls above the proposed walls 7, 8 and 10.

Parameter	Value
Backfill Soil Unit Weight, γ (pcf)	125
Backfill Soil Friction Angle, ϕ_b (degrees)	38
Foundation Soil Friction Angle, ϕ_f (degrees)	32
Active Earth Pressure Coefficient, K_a	0.24
Seismic Earth Pressure Coefficient, K_{ae}	0.35
Coefficient of Sliding, $Tan\phi_f$	0.62

We also recommend using a traffic surcharge load of 250 psf for evaluating the existing walls above proposed Wall 6 (this value was used in the original design).

The tables above do not include a passive earth pressure or equivalent fluid weight, since it is our opinion that the existing walls did not account for passive earth pressure. Furthermore, as currently planned, the new walls will provide little passive resistance to the existing structures. Examining bearing capacity and global stability, it is our opinion that removal of the soil at the toe of the existing walls will have negligible affect on either of these failure modes.

Construction Considerations

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 elevation of the existing wall footings should be limited to no more than 25 linear feet at a time.

Wall backfill should be concurrent 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.

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

11/22/07

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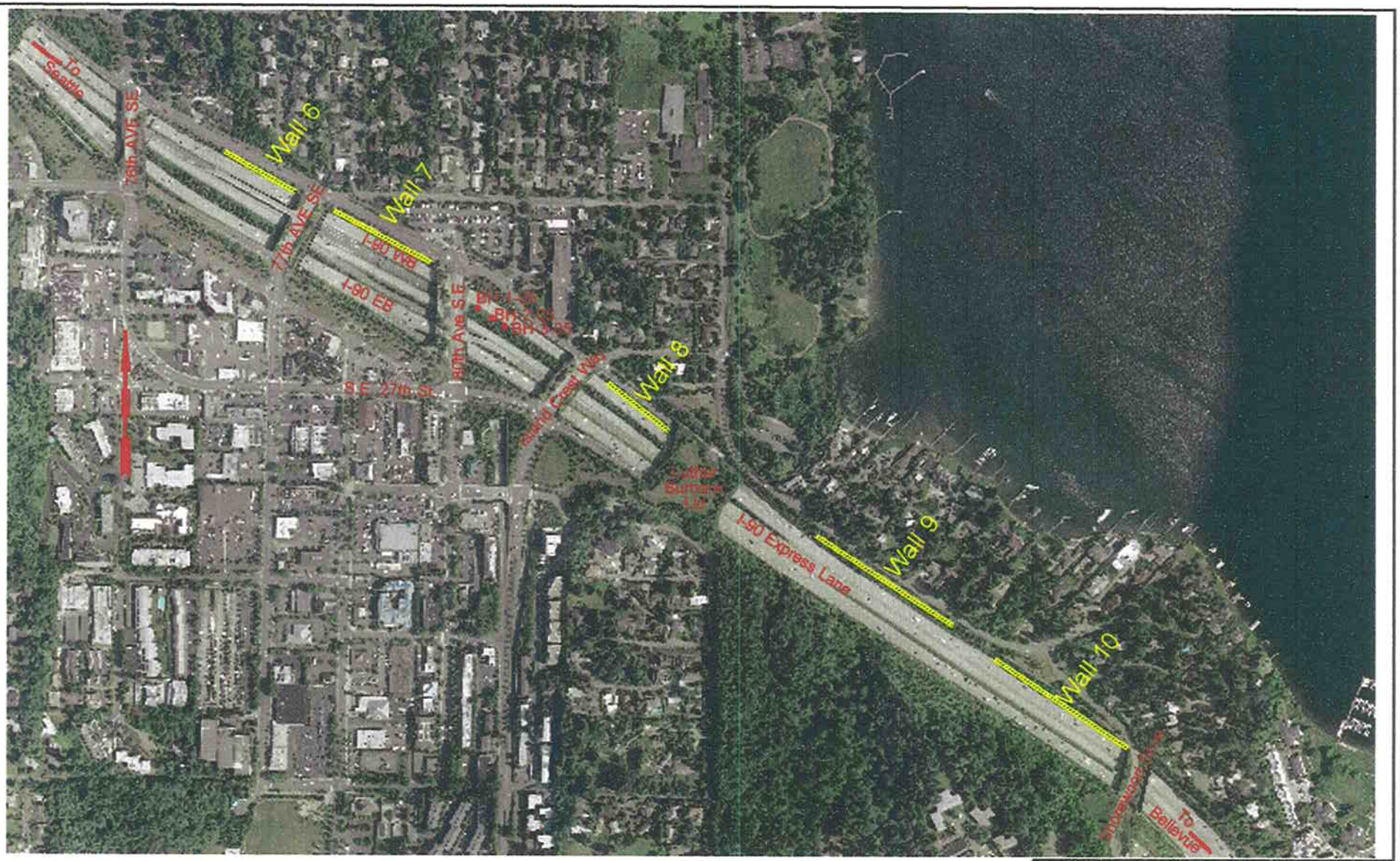

JOB XL-2423 S.R. 90 C.S. LAYOUT

I-90 Two Way Transit & HOV Operations

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 10/2005
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Figure 1

Vicinity Map
Wall Locations Shown Are Approximate

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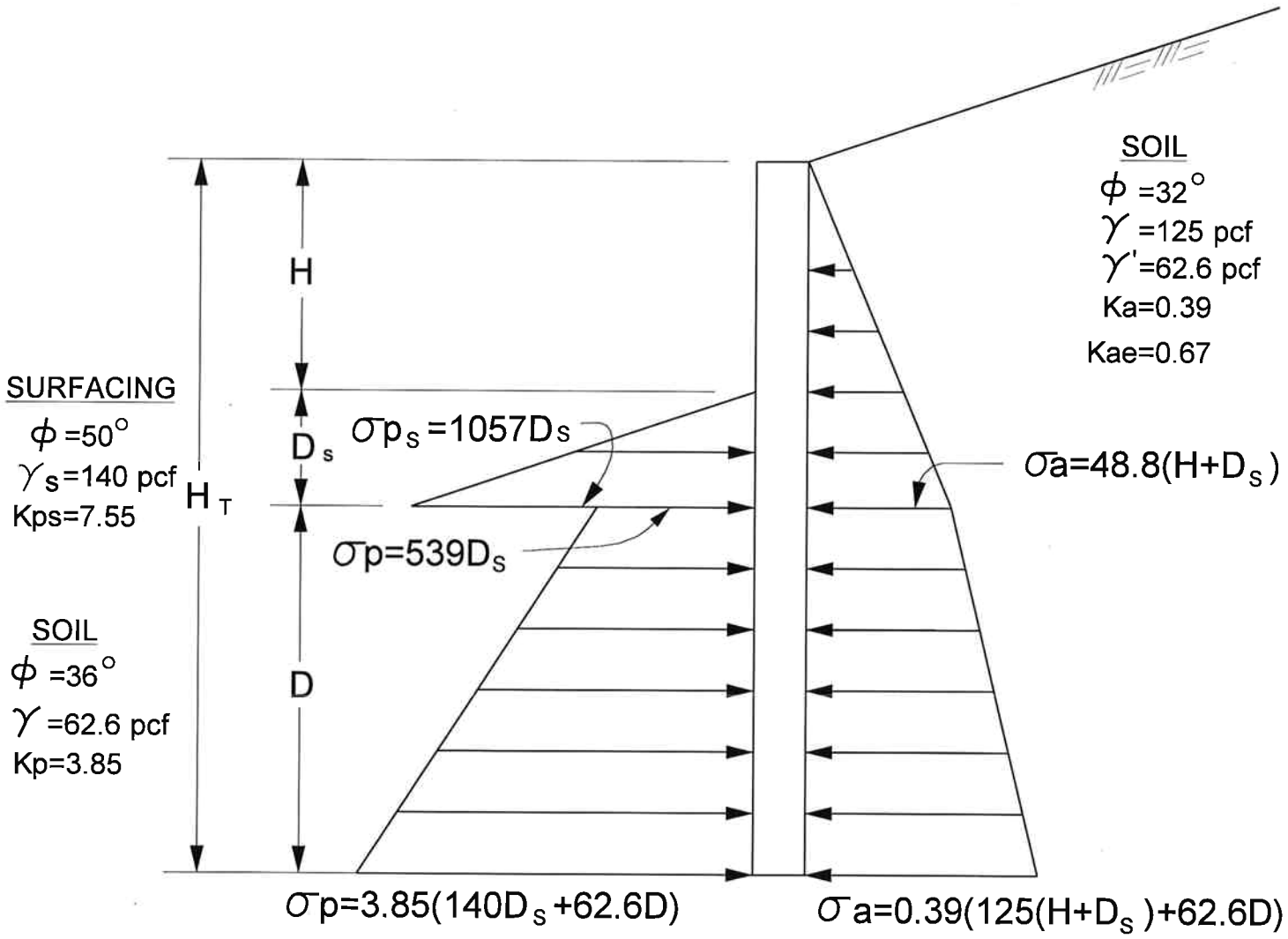
Strength Limit State



NOTES

① If the wall is backfilled prior to construction of the roadway surfacing, the temporary construction stage where Ds=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.

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I-90 Two Way Transit & HOV Operations

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

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Figure 2: Earth Pressure Diagram
Walls 6, 7, 8, 9, and 10

Extreme Limit State

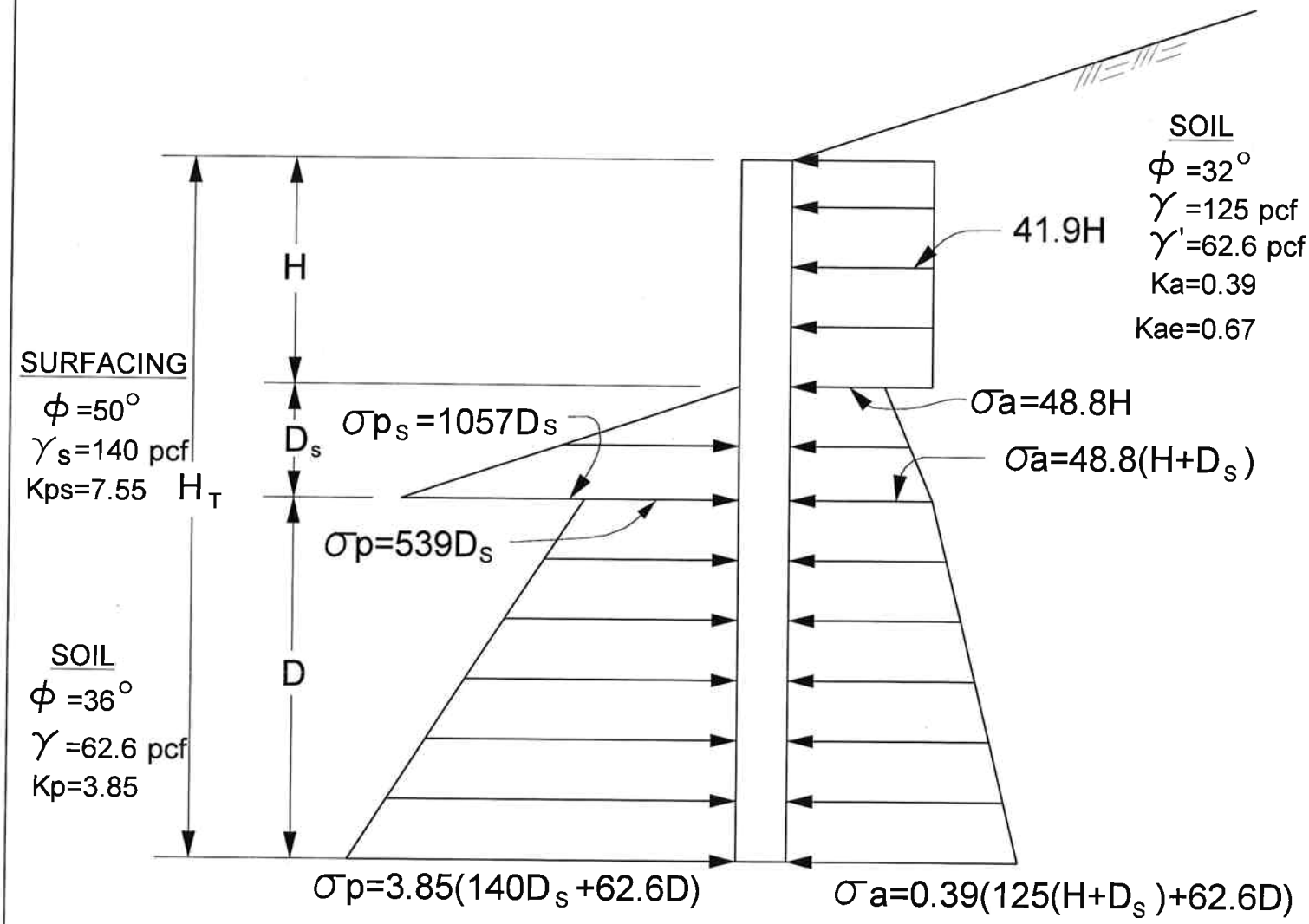

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Figure 3: Earth Pressure Diagram
Walls 6, 7, 8, 9, and 10

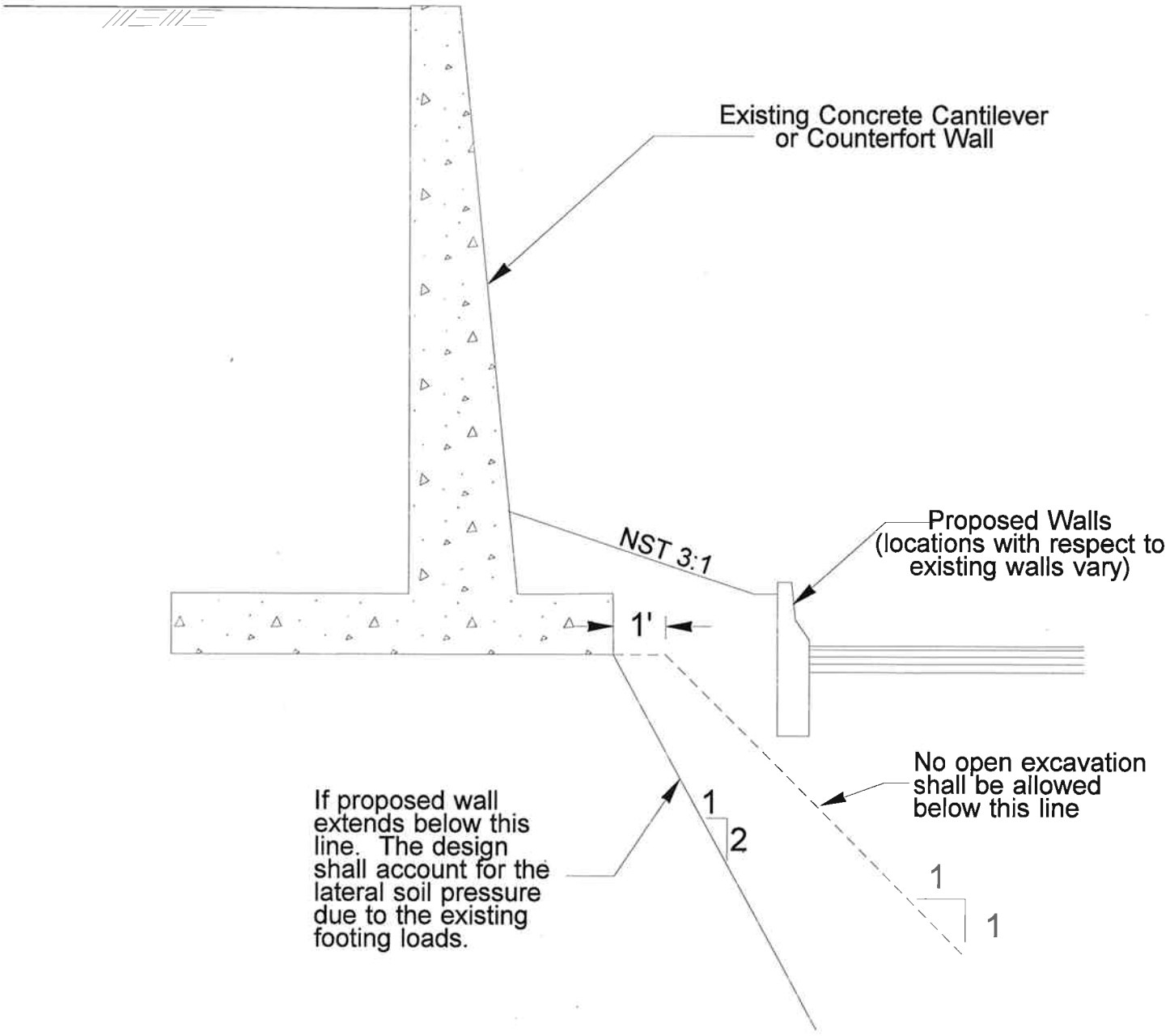

Figure 4
Typical Section
Walls 6, 7, 8, 9, and 10

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I-90 Two Way Transit & HOV Operations

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