



January 18, 2006

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 14, 27, 28, 29, and 31
Geotechnical Recommendations

Introduction

This memorandum presents geotechnical recommendations for the design of Retaining Walls 14, 27, 28, 29, and 31 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 bridges. Walls 14, 27, 28, 29, and 31 will be constructed within the Bellevue Way Interchange between the East Channel Bridge and Mercer Slough. Wall Recommendations for other retaining walls associated with this project will be provided under separate cover.

Retaining Wall Descriptions

Retaining Wall 14 will provide for a shoulder widening of the eastbound HOV connection from Bellevue Way to I90. The wall will be approximately 230 feet in length and have a maximum exposed height of 11 feet.

Retaining Wall 27 will be a barrier wall between the westbound and eastbound HOV lanes near the termination of the HOV ramps from Bellevue Way. The wall will be approximately 750 feet in length and have a maximum exposed height of less than 3 feet. For a portion of its length, Wall 27 will support a grade separation between the traffic lanes.

Retaining Wall 28 will provide for shoulder widening of the eastbound HOV connection from Bellevue where the ramp merges with the eastbound connection to the reversible lanes. The wall will be approximately 300 feet in length and have a maximum exposed height of 6 feet. Wall 28 will be constructed in an existing embankment below an existing concrete cantilever wall.

Retaining Wall 29 will be a barrier wall along the westbound HOV lane shoulder on the ramp from Bellevue Way to I90. The wall will be approximately 1200 feet in length and have a maximum exposed height of less than 3 feet.

Wall 31 will be a barrier wall providing a grade separation between the westbound mainline HOV lane and the westbound HOV ramp from Bellevue Way. The wall will be approximately 125 feet in length and have a maximum exposed height of approximately 3 feet.

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, borings conducted for the foundation design of the W-80th Ramp Bridge (specifically BH-3-05), and our site visits, we believe Walls 14, 27, 28, 29, and 31 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.

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

Geotechnical Recommendations

We have evaluated allowable bearing capacity, settlement, and global stability for several wall types. Where specified, footing elevations are necessary to provide an adequate factor of safety for global stability and/or minimize settlement. We anticipate post construction settlements to be negligible.

Wall 14

Based on the subsurface conditions and wall geometry, several wall types are suitable for Wall 14. A Standard Plan concrete cantilever wall, a Standard Plan geosynthetic wall, and a structural earth (SE) wall are suitable wall types. Final wall type should be selected by your office based on cost, architectural requirements, construction sequencing, or other factors. Multiple wall types can be included in the Contract Plans as alternatives if the decision can be left up to the Contractor.

Standard Plans D-1a and D-1b (concrete cantilever walls) may be used for Wall 14 if a concrete cantilever wall is the preferred wall alternative. Walls 21 and 22 should be backfilled in accordance with Standard Plan D-4.

A Type 1 permanent geosynthetic wall as shown in Standard Plan D-3 may also be used for Wall 14.

Pre-approved, proprietary structural earth walls are also suitable for Wall 14. We have evaluated overall stability for SE walls. Overturning, sliding, and bearing capacity will be evaluated by the manufacturer's designer. Design parameters for inclusion in General

Special Provision, titled *Structural Earth Walls*, (GSP 13030201.FB6), are provided as follows:

<u>Soil Parameters</u>	<u>Wall Backfill</u>	<u>Retained Soil</u>	<u>Foundation Soil</u>
Unit Weight (pcf)	125	125	125
Friction Angle (deg)	36	36	32
Cohesion (psf)	0	0	0

<u>Foundation Soil</u>	<u>AASHTO Load Group I</u>	<u>AASHTO Load Group VII</u>
Allowable Bearing Capacity (tsf)	4	6
Acceleration Coefficient (g)	0	0.39

A traffic surcharge of 250 psf should be added when designing the walls.

The SE wall system should meet the following requirements.

1. The wall should be placed on a level (in direction perpendicular to the wall face) and firm foundation. Walls can be allowed to slope along their length up to 6H:1V (horizontal:vertical) as a continuous sloped footing. Stepped wall footings can step up more steeply.
2. Wall face batter should be no steeper than 1H:48V.
3. The base width of the wall should be greater than or equal to 70 percent.
4. The top reinforcing layer should be placed no lower than 2 feet below the top of the wall.
5. Wall embedment should be at least 2 feet or 10 percent of the wall height, whichever is greater.
6. Provisions for permanent control of subsurface water behind the wall should consist of a slotted drain pipe embedded in Gravel Backfill for Drains (Section 9-03.12(4)).
7. Drainage structures should be located outside the reinforced zone where possible. If drainage structures are planned within the reinforced zone, they must be shown on the plans and profile sheets provided to the wall proprietor so they can account for the structures in their design. If drainage structures are located behind the face of a MSE wall, the outfall pipe should run perpendicular to the wall face.

Prior to contract advertisement, the Project office should contact each of the wall proprietors listed in the General Special Provisions to confirm that they want to be included in the contract.

Wall 28

We recommend using a cantilever soldier pile wall for Wall 28. Earth pressure diagrams for design of Wall 28 are provided on Figures 6 and 7. We recommend a resistance factor of 0.75 be used for the passive earth pressure. If the back face of Wall 28 falls below the 1:2 (Horizontal:Vertical) line shown on Figure 8, the lateral pressure from the existing wall footing should be included in the design of Wall 28. We recommend the surcharge pressure from the existing wall be distributed in accordance with Figures 3.11.6.3-1 and 3.11.6.3-2b in the 2005 *AASHTO LRFD Bridge Design Specifications*.

Walls 27, 29 and 31

We understand Walls 27, 29, and 31 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 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 where the walls will support a slope. Figures 4 and 5 present earth pressure diagrams for design of these walls where the walls will support traffic. 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 (3:1 sloping backfill), 0.31 (level backfill)
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_{ac})	0.67 (3:1 sloping backfill) 0.44 (level backfill)

* The passive earth pressure for roadway surfacing materials can be taken as 7.55.

A traffic surcharge of 250 psf should be applied where these walls will support a roadway. The traffic surcharge should be applied as a rectangular distribution to the back of the wall equal to the 250 psf times the active earth pressure, or 77.5 psf.

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

Backfill for Walls 27, 29, and 31 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 Division should be consulted to determine the impact of such changes on the recommendations and conclusions presented in this report.

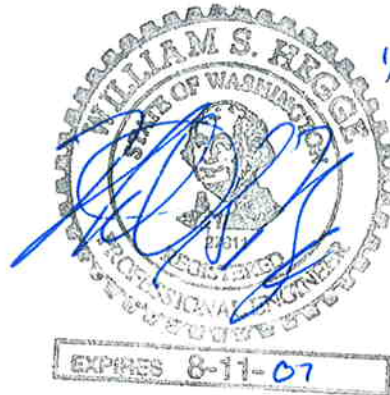
Site exploration and testing describes subsurface conditions only at the sites of subsurface exploration and at the intervals where samples are collected. These data are interpreted by members of the Geotechnical Division who then render an opinion regarding the general subsurface conditions. The distribution, 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.



Prepared By:
Mark A. Frye
Geotechnical Designer



Reviewed By:
William S. Hegge
Senior Foundation Engineer



Agency Approval Authority:
Tony M. Allen
State Geotechnical Engineer

TMA/maf
Attachment: Figures
Boring Logs

cc: Chris Johnson, Northwest Region Materials Engineer, MS NB 82-29
Munindra Talukdar, Bridge and Structures Office, MS 47340
Theresa D. McAuliffe, HNTB Corporation



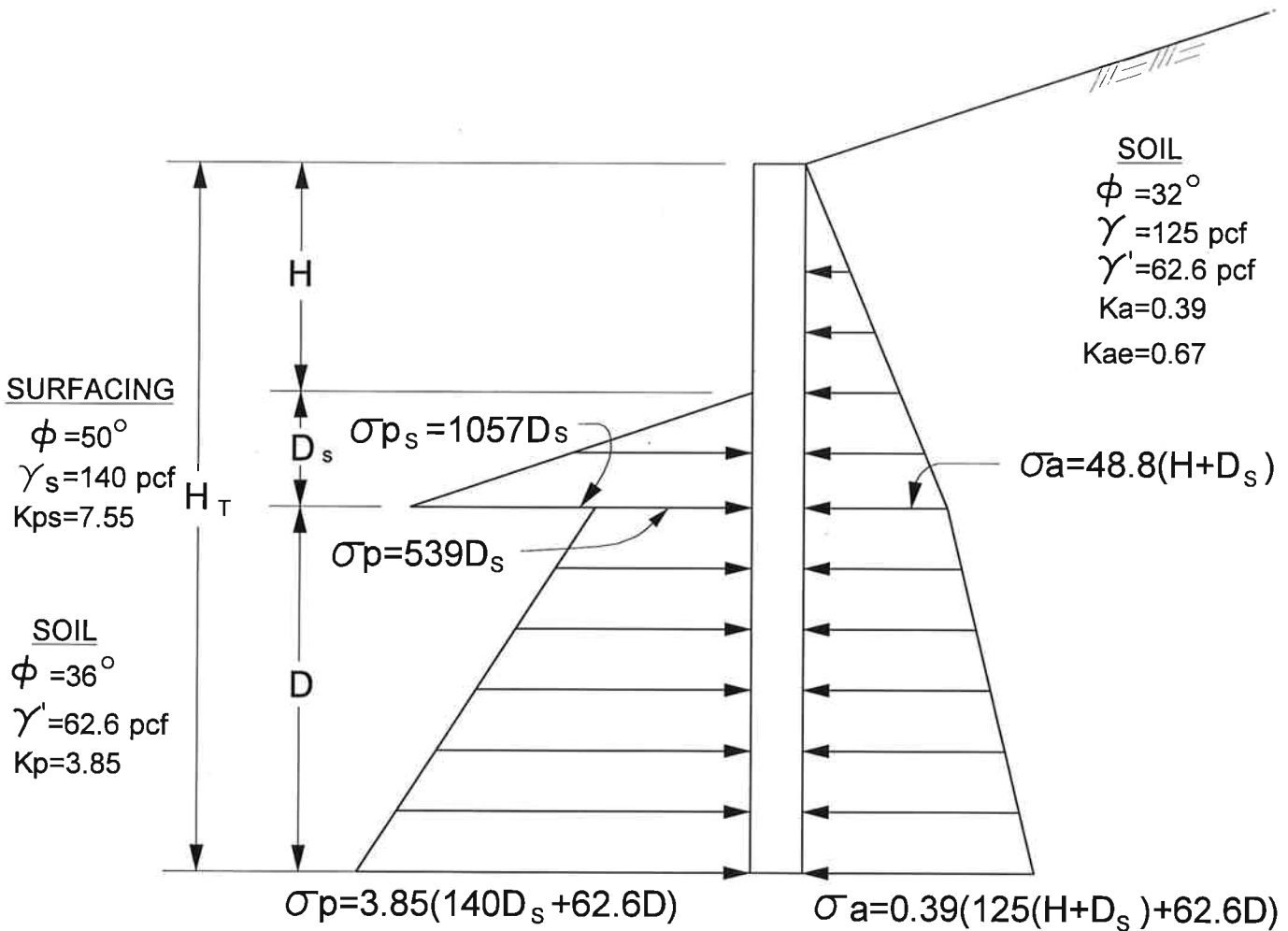
JOB XL-2423 S.P. 90 C.S. LAYOUT

I-90 Two Way Transit & HOV Operations

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION MATERIALS BRANCH T. E. BAKER MATERIALS ENGINEER	DATE 10/2005 SCALE VERT. _____ HORIZ. _____ SHEET _____ OF _____ DRAWN BY DWG
--	--

Figure 1
Vicinity Map
Wall Locations Shown Are Approximate


Strength Limit State



NOTES

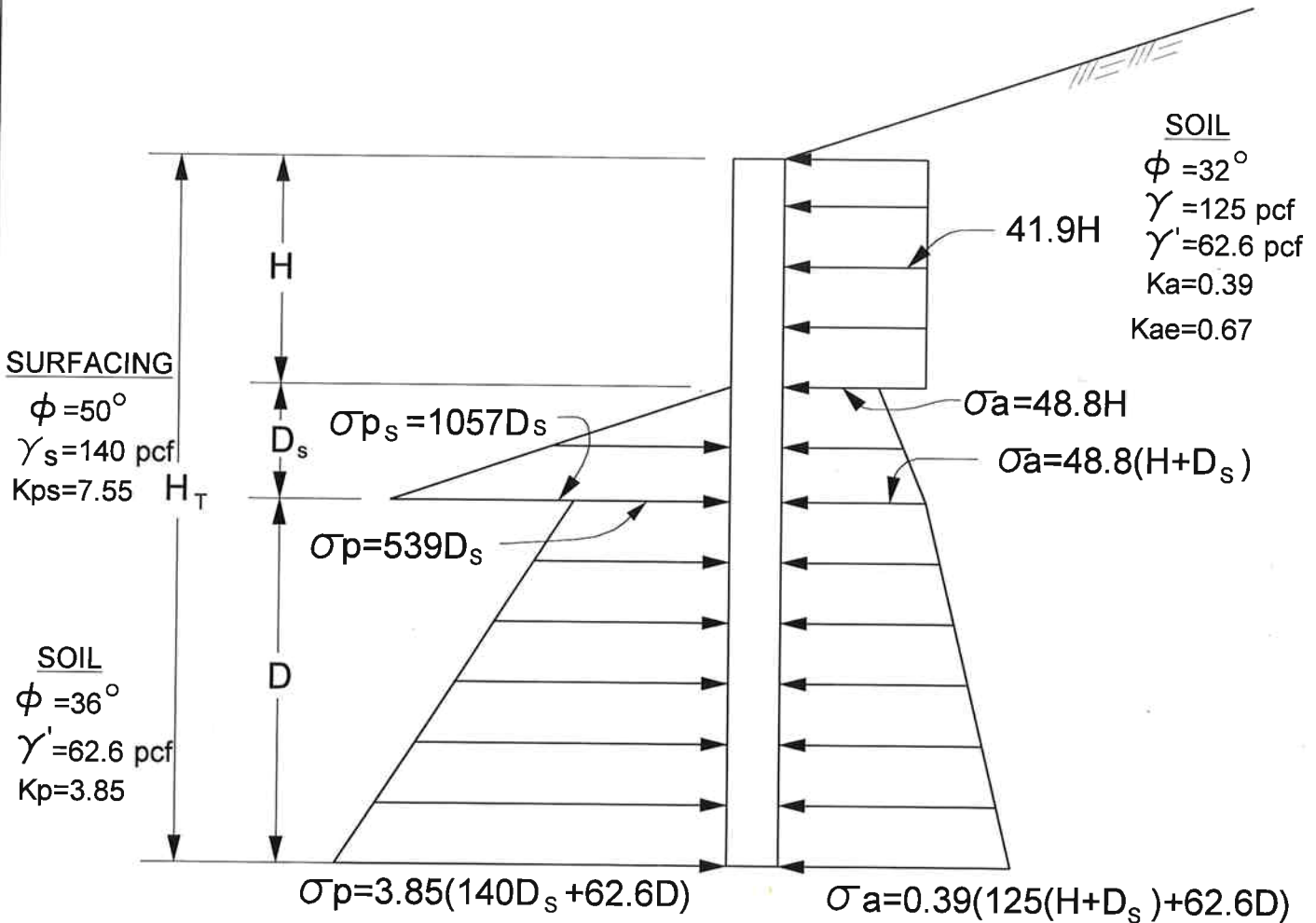
- ① If the wall is backfilled prior to construction of the roadway surfacing, the temporary construction stage where $D_s = 0$ should be evaluated.
- ② All pressures in psf.
- ③ D_s is the total depth of roadway surfacing including Portland Cement Concrete Pavement, Hot mix Asphalt Pavement, and Crushed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

Figure 2: Earth Pressure Diagram
 Walls 27 and 29

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
	SCALE NOT TO SCALE
	SHEET ___ OF ___
	DRAWN BY DWG

... \EarthPressure.dgn 12/8/2005 1:24:36 PM


Extreme Limit State



NOTES

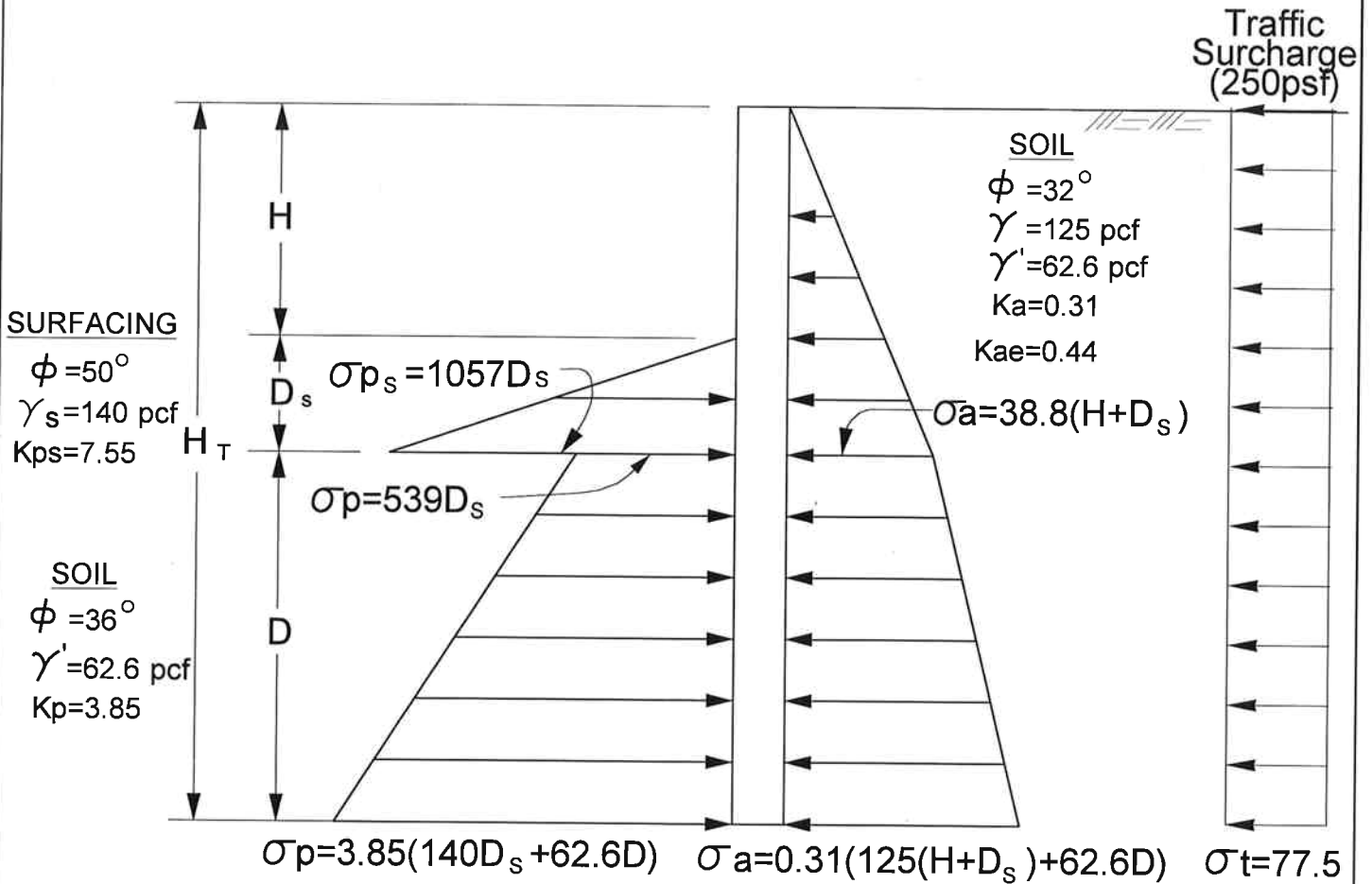
- ① If the wall is backfilled prior to construction of the roadway surfacing, the temporary construction stage where $D_s=0$ should be evaluated.
- ② All pressures in psf.
- ③ D_s is the total depth of roadway surfacing including Portland Cement Concrete Pavement, Hot mix Asphalt Pavement, and Crushed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

Figure 3: Earth Pressure Diagram
Walls 27 and 29

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 SCALE NOT VERT. TO SCALE HORIZ. SHEET ____ OF ____ DRAWN BY DWG

...EarthPressure.dgn 12/8/2005 1:24:44 PM

Strength Limit State




NOTES

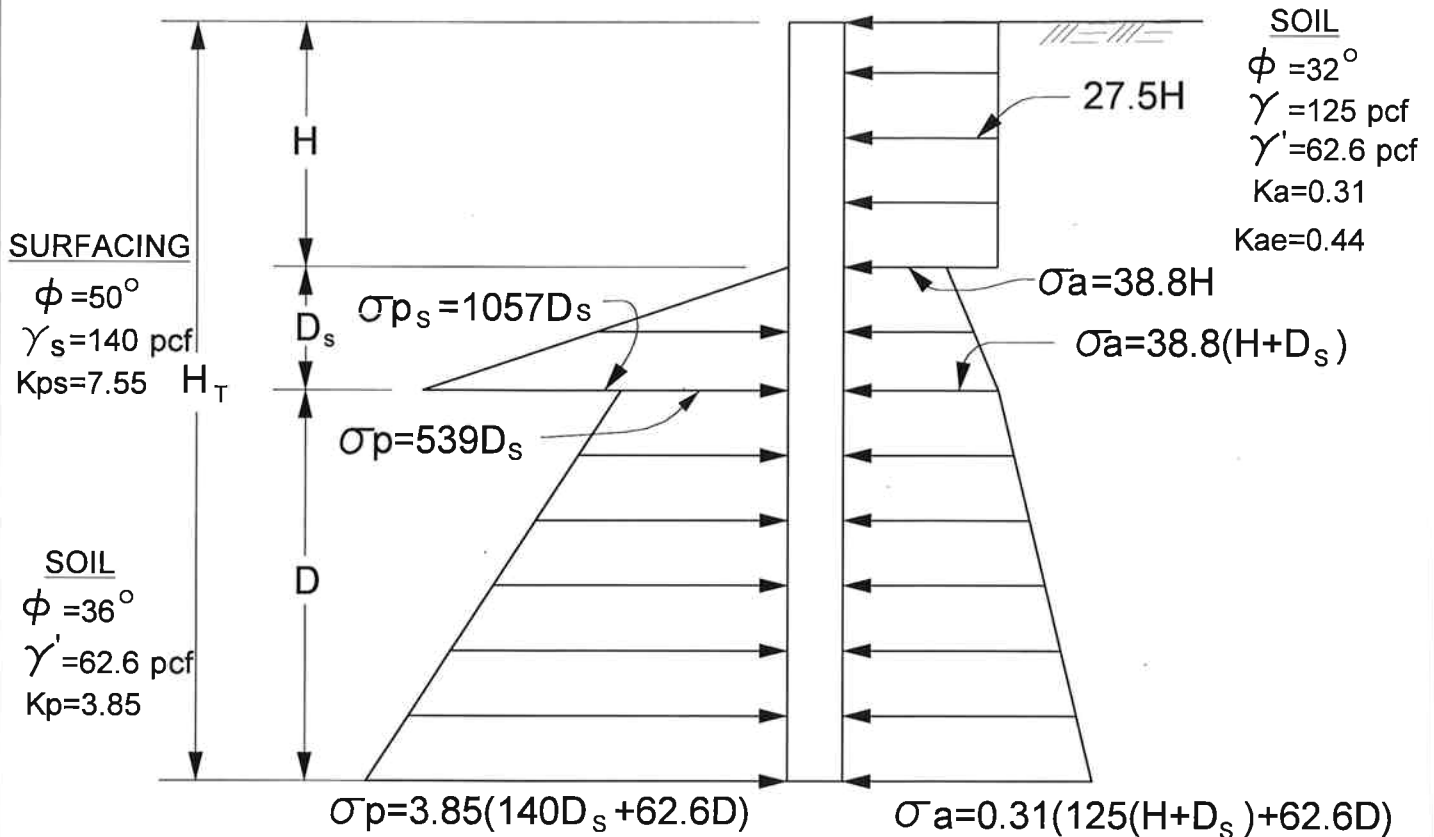
- ① If the wall is backfilled prior to construction of the roadway surfacing, the temporary construction stage where $D_s=0$ should be evaluated.
- ② All pressures in psf.
- ③ D_s is the total depth of roadway surfacing including Portland Cement Concrete Pavement, Hot mix Asphalt Pavement, and Crushed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

Figure 4: Earth Pressure Diagram

Walls 27 and 31

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
	SCALE NOT TO SCALE VERT. SCALE HORIZ.
	SHEET ___ OF ___
	DRAWN BY DWG

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.

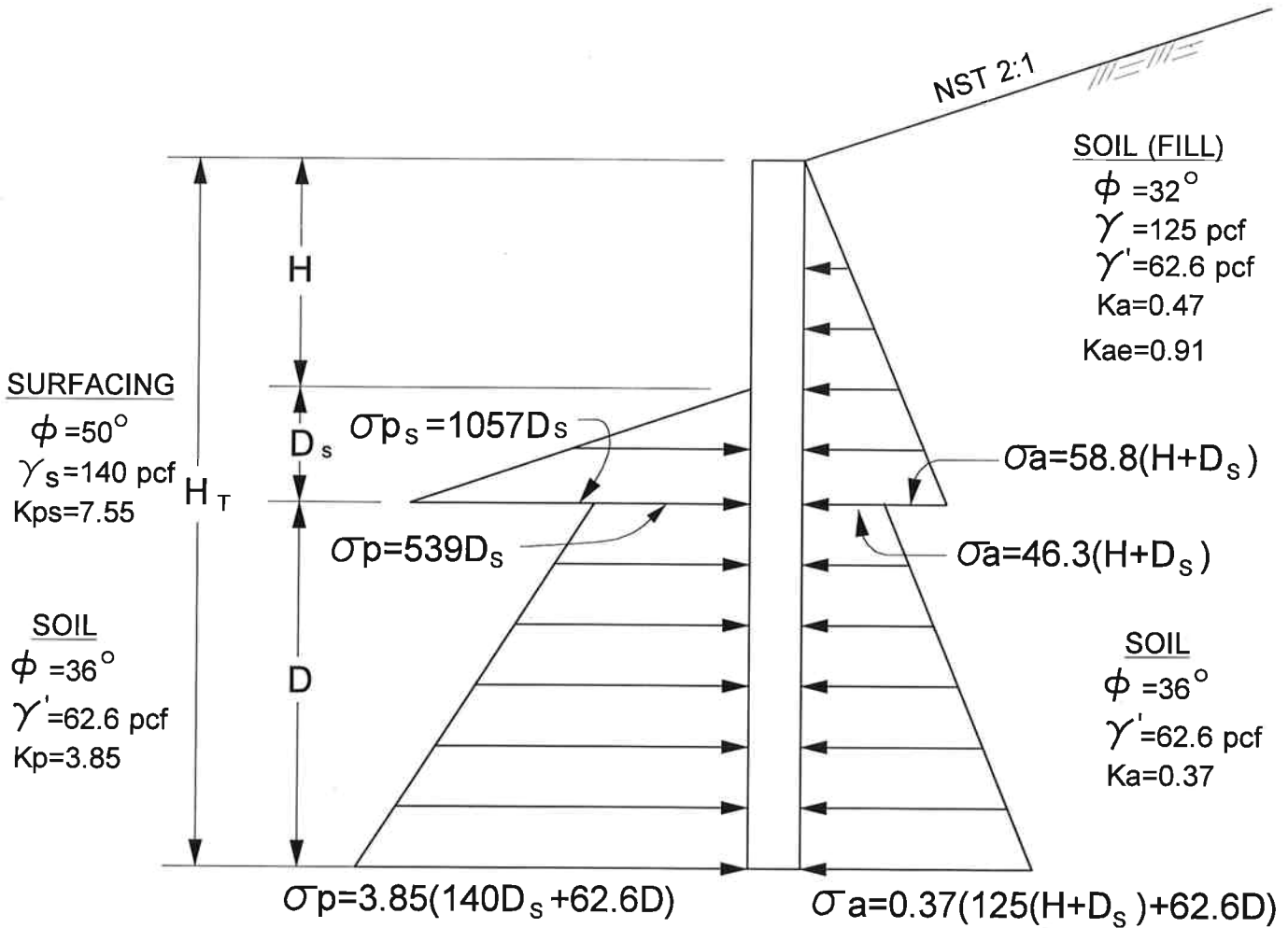
Figure 5: Earth Pressure Diagram

Walls 27 and 31

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 I. E. BAKER MATERIALS ENGINEER	DATE <u>10/2005</u> SCALE <u>NOT TO SCALE</u> VERT. _____ HORIZ. _____ SHEET _____ OF _____ DRAWN BY <u>DWG</u>

...EarthPressure.dgn 12/8/2005 1:25:00 PM


Strength Limit State



NOTES

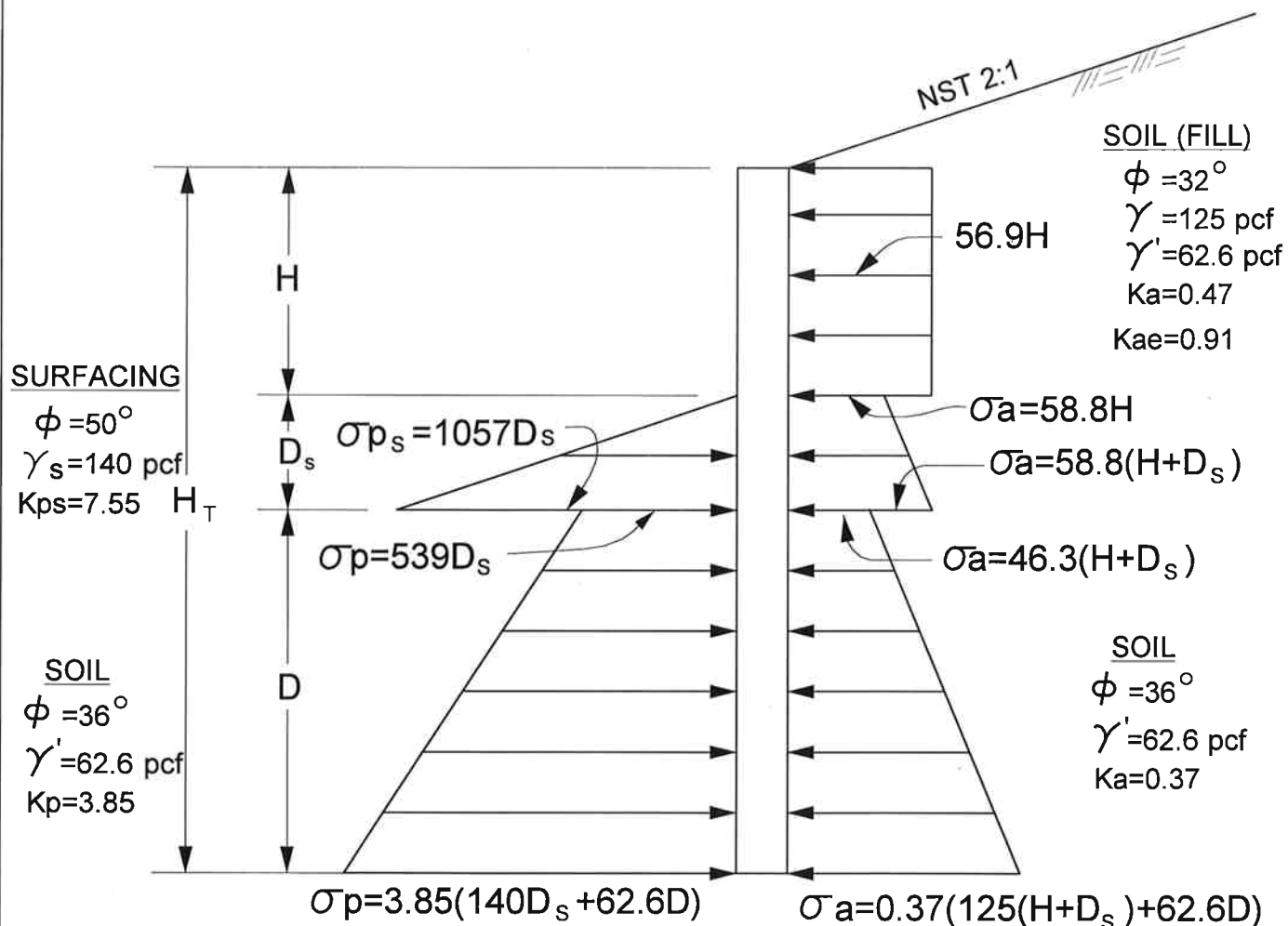
- ① The temporary construction stage where $D_s = 0$ should be evaluated.
- ② All pressures in psf.
- ③ D_s is the total depth of roadway surfacing including Portland Cement Concrete Pavement, Hot mix Asphalt Pavement, and Crushed Surfacing Base Course.
- ④ Passive pressures shown are unfactored.
- ⑤ Passive pressures should be applied over 3 pile diameters below the lagging.
- ⑥ Active pressures shown should be applied over 1 pile diameter below the lagging.

Figure 6: Earth Pressure Diagram
Walls 28

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 10/2005
	SCALE NOT VERT. TO SCALE HORIZ.
	SHEET _____ OF _____
	DRAWN BY DWG

... \EarthPressure.dgn 12/8/2005 1:25:06 PM

Extreme Limit State



NOTES

- ① 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.
- ④ Passive pressures shown are unfactored.
- ⑤ Passive pressures should be applied over 3 pile diameters below the lagging.
- ⑥ Active pressures shown should be applied over 1 pile diameter below the lagging.

Figure 7: Earth Pressure Diagram
Walls 28

JOB <u>XL-2423</u> S.R. <u>90</u> C.S. _____ LAYOUT _____	DATE <u>10/2005</u> SCALE <u>NOT TO SCALE</u> VERT. _____ HORIZ. _____ SHEET _____ OF _____ DRAWN BY <u>DWG</u>
<h2 style="margin: 0;">I-90 Two Way Transit & HOV Operations</h2>	
 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>

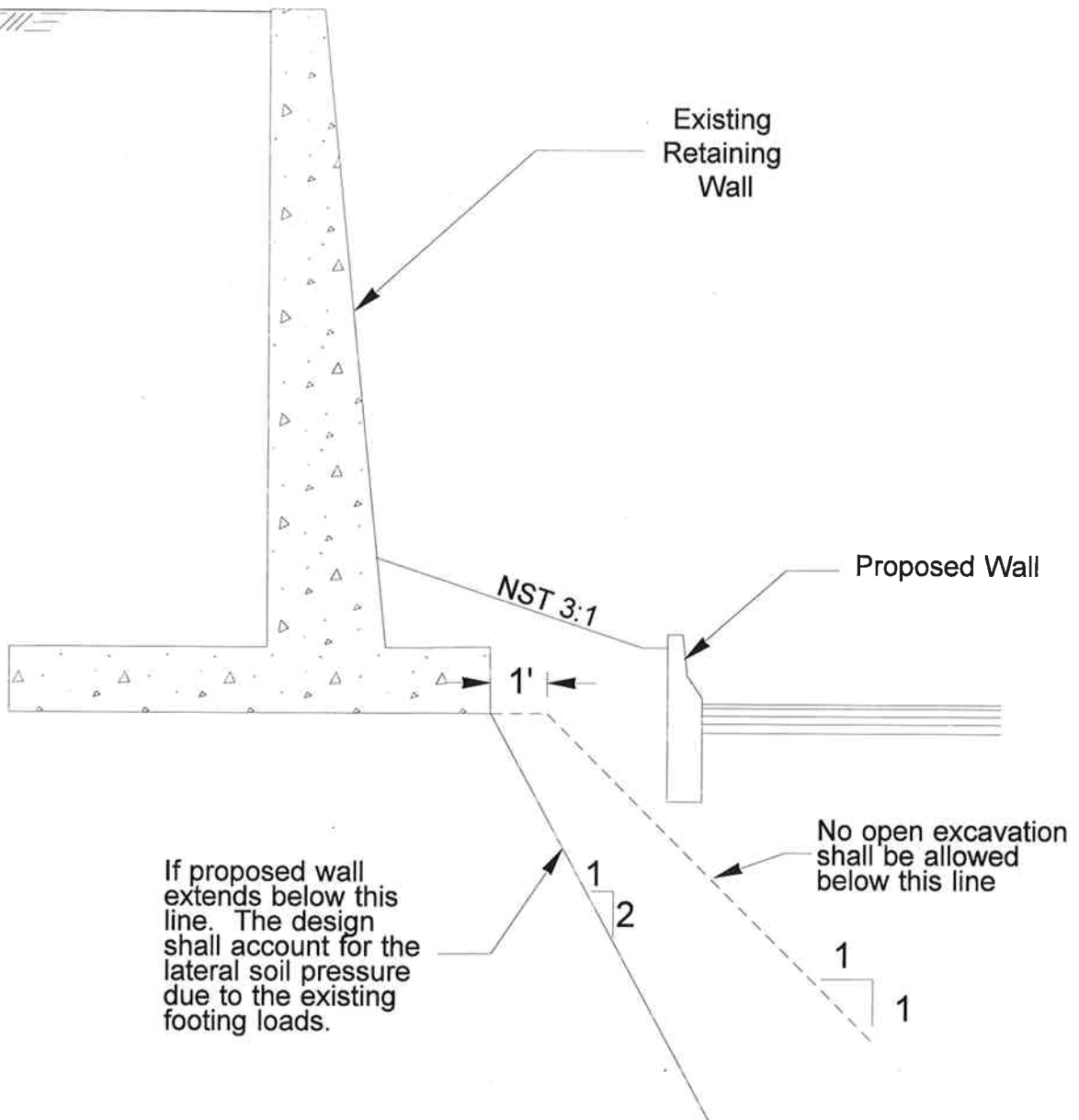



Figure 8: Typical Section
Walls 27, 28, 29, and 31

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. _____
	SHEET _____ OF _____
	DRAWN BY <u>DWG</u>

... \EarthPressure.dgn 12/8/2005 1:25:25 PM