STATE OF WASHINGTON
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WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

C. G. PRAHL, DIRECTOR
HIGHWAYS-LICENSES BUILDING
OLYMPIA

December 28, 1966

Mr. George Stevens
Bridge Engineer
Highways-Licenses Bldg.
Olympia, Washington

C.S. 1753 PSH 1-RE (SR-405) & 2-BO (SR-522), L-1978
N.E. 132nd St. to N.E. 195th St.
Woodenville Interchange
N.B. and S.B. Over Sammamish River and PSH 2-BO
S.E. and E.N. Ramps
N.W. and N.E. Ramps
E.S. and W.S. Ramps

Dear Sir:

This report will complete our foundation recommendations for the subject interchange. Attached you will find soil profiles depicting the foundation soil stratification along centerline of each structure within the interchange. Also attached are detailed foundation recommendations, pier by pier for each structure.

In previous correspondence, letters dated June 9 and August 19, 1966, we have dealt with some of the problems associated with design and construction within this interchange. Due to the major revisions in structure length, recommendations made herein will supercede those made previously. In order to expedite the design of the structures within the interchange, this report will include the foundation recommendations for all of the proposed structures.

N.B. and S.B. Over Sammamish River and PSH 2-BO and S.E. and E.N. Ramp Structures and Approaches

In general, the excessive depth of soft compressible soils dictates the use of pile support for all piers of the above noted structures. Presently the hillside at the southerly end of the structures is subject to shallow landslide activity necessitating extensive correction. The landslide correction will not be discussed herein; however, as was previously noted, letter dated June 9, 1966, pier No.'s 1, 2, 3 and 4 of the N.B. and S.B. structures should be designed to resist a lateral earth load equal to a depth of 20 to 30 ft of sliding material. The 20 ft depth applies to pier No.'s 1-S.B., 1-N.B., 2-S.B. and 2-N.B., while the 30 ft depth applies to pier No.'s 3-S.B., 3-N.B., 4-S.B. and 4-N.B. For design purposes the slide load can be assumed to act over an area equal to $1\frac{1}{2}$ times the shaft diameter and as a fluid having a density equal to 60 pcf. It should be noted that the intent of these design recommendations is to provide a reserve capacity within the structures in case the slide treatment presently contemplated proves inadequate and renewed sliding occurs at a later date. In case of renewed slide activity, it will be necessary to take immediate action to protect the structures, since the structures

are not being designed to support the full potential slide load. It is our opinion that these piers could best be supported by large diameter cast in place concrete piles deriving their support below the potential slide plane. The pile bearing capacity can be established by use of an allowable end bearing value of 5 tsf and a shaft adhesion of 0.33 tsf. These values are based on load tests on similar soil in the Seattle area and contain a factor of safety of 3. Use of the design values recommended should result in pier settlements of less than 1 inch. This material is suitable for belling; however, if it is elected to use belled ends, it should be specified that the excavated bell cavity not remain unsupported for more than 24 hours. In general, the shaft excavation can probably be performed without casing; however, there are zones especially near the surface which may be susceptible to caving and require casing. In any event, the bored shafts should not be allowed to remain unsupported for any extended period--preferably no longer than 24 hours.

In addition to establishing a shaft sufficiently long to provide vertical support, it will be necessary to provide sufficient penetration below the potential slide plane to resist the previously mentioned lateral earth load. For design purposes a horizontal subgrade modulus (K_h) of 200 pci can be assumed for a beam of unit width (refer to Hetenyi, "Beams on Elastic Foundations") with a maximum soil resistance (Q_o) of 10 ksf. Both the subgrade modulus and the soil resistance values can be assumed to be constant with depth. These values are based on lateral load tests performed in Seattle on similar soil.

The remainder of the piers should also be pile supported and since the soils to the north of the Sammamish River are essentially granular, they are well suited to displacement type piles. Standard State practice is to design timber and 13-in. concrete piles for a bearing capacity of 40 tons, 16-in. concrete for 50 tons and 18-in. concrete for 70 tons. For estimating purposes it can be assumed that pile penetrations of 20 to 40 ft are needed in the compact to very compact sand layer found immediately below the loose surface soils. The sand layer becomes thinner beneath pier No.'s 12 and 13, reaching a thickness of approximately 25 ft beneath pier No. 13. It appears that this layer will support pile loads in the range cited above; however, it is our opinion that the pile bearing should be verified at this pier or pier No. 12 by a pile load test or at least a test pile.

The piles for pier No. 13 should be designed to accommodate an additional load of 15 to 20 tons per pile due to downdrag. In order to penetrate the fill it will probably be necessary to pre-bore.

Due to the potential settlement of the clay soil beneath the sand layer at pier No. 13 it is recommended that provisions for jacking be designed into this pier.

Previously we had indicated that the north approach fill was unstable. Lengthening the structure has reduced the fill height only slightly with a fill height of 32 to 34 ft resulting. A fill of this height is unstable and while the foundation soil will probably gain strength rapidly enough under conditions of controlled fill construction to result in a stable embankment, considerable settlement will occur. Our calculations indicate a settlement of 3.2 ft is possible at this point, with 2 years required for 90 per cent. Therefore it is our opinion that some other form of foundation treatment should be specified. This is based on the understanding that embankment and bridge construction are to be under the same contract. You will recall, letter dated June 9, 1966, that we recommended early fill construction to allow for major fill adjustment prior to start of bridge construction. It is our

opinion that present plans do not allow sufficient time and therefore, it is recommended that sand drains be installed to hasten consolidation. The sand drains should be 18 in. in diameter on 10-ft spacing and extending in depth at least to elevation minus 20. The sand drains should extend full depth for a minimum of 100 ft from the bridge end. From that point they can be shortened gradually to a point where the fill height does not exceed 20 ft. Control media, in the form of pore pressure devices and settlement indicators, will be required in the sand drain section and also to the north to aid in the control of fill construction.

Fill stability north of the structure limits is questionable due to the fact that recent investigation by Mr. Johnson has disclosed some very soft organic soils along the proposed roadway alignment in the vicinity of stations 875 to 890. Laboratory test results indicate that if this material is retained in place, the proposed embankment of 10+ft is unstable. If a stable embankment could be constructed on it, fill subsidence of 4 to 5 ft would result. Therefore, it is our opinion that the organic soils should be removed.

Where foundation treatment is not specified, the rate of fill construction should not exceed 2 ft per 7 calendar days.

The 24-ft approach fill at the west end (station S-E 72+37) of the S-E ramp should be stable; however, settlement estimates indicate it will subside 1.4 ft. The settlement should occur rapidly with 90 per cent occurring within 3 months after completion of embankment construction (refer to attached graph).

The 33-ft approach fill at the east end (station E-N89+93) of the E-N ramp should be stable. Settlement estimates indicate it will subside 2.5 ft with 90 per cent occurring within 4 months after completion of fill construction (refer to attached graph).

Both of the above approach fills should be constructed at the earliest possible date to reduce to a minimum the differential settlement between the approach fill and the bridge end.

N.W. and N.E. Ramp Structures and Approaches

The recommendations given in our report of June 9, 1966, no longer apply due to the lengthening of the N.W. ramp structure and to the substitution of a structure along PSH 1-RE instead of the previously proposed embankment. The revised recommendation sheets and soil profile sheets are attached.

All piers of the subject structures will require pile support. Due to potential lateral earth loads on pier No.'s 1, 2, 3 and 4 of both structures (refer to previous comments N.B. and S.B. structures on hillside stability) these piers should be designed to accommodate earth loads of a depth of 20 to 30 ft. The 20-ft depth applies to pier No.'s 1 and 2 of both bridges while the 30-ft depth applies to pier No.'s 3 and 4 of both bridges. These piers should be designed using the same recommendations as given for the N.B. and S.B. structures.

Pile support for the remaining piers of both structures should be displacement type with the loadings listed previously. Pile penetrations will be in the order of 20 to 40 ft into the compact to very compact layer directly beneath the soft surface soils.

Extension of the N.W. ramp structure to the west (station 65+58) has reduced the

approach fill height to 31 ft. Approximately 2.3 ft of fill subsidence will occur at the bridge end with 90 per cent within 7 months. The magnitude of settlement predicted is an increase over the magnitude reported previously and is due to the presence of softer soils at this point. In its revised position the N.W. ramp embankment should not adversly affect the existing PSH 2-BO embankment.

Previously we had recommended a controlled rate of embankment construction for this embankment of 2 ft per 7 calendar days; it now appears that there may be considerable advantage in installing sand drains at this location, since it is our understanding that the bridges and grading are to be under the same contract. If this embankment is not to be scheduled for early construction then it is recommended that 18-in. sand drains, 20 ft long on a 10-ft spacing be installed.

The 30-ft approach fill at the north end (station N.E. 57+98) of the N.E. ramp should be stable; however, settlement estimates indicate it will subside 1.6 ft. The settlement should occur rapidly with 90 per cent occurring within 7 months after completion of embankment construction. This embankment should also be constructed at the earliest possible date.

E.S. and W.S. Ramp Structures and Approaches

All piers of the subject structures will require pile support. Due to potential lateral earth loads on pier No.'s 1, 2, 3 and 4, these piers should be designed to resist the earth load previously mentioned in the section dealing with the N.B. and S.B. structures. The 20-ft earth load should be applied to pier No's 1 and 2 and the 30-ft earth load to pier No.'s 3 and 4. Design should be based on recommendations given in previous sections.

The remaining piers of both bridges can be supported by displacement type piles. Pile lengths can be estimated by assuming a 20 to 40 ft penetration into the compact to very compact layer found immediately below the soft surface soils with the exception of the piers noted on the attached recommendation sheet where minimum pile tip elevations are specified. Pile support for pier No.'s 6W-S, 7W-S, 8W-S, 9W-S and 10W-S should extend below the thin clay layer found approximately at elevation minus 20. Some means, such as jetting or pre-boring, may be needed to attain the desired pile penetrations.

Pile bearing for support of pier No.'s 15W-S, 16W-S, 17W-S, 18W-S, 19W-S and 20W-S can probably be developed in the thin sand stratum found generally between elevations minus 30 and minus 50; however, pile load tests should be performed to confirm adequate bearing capacity.

The 30-ft approach fill at the north end of the E-S ramp structure (station E-S 80+70) should be stable; however, settlement estimates indicate fill subsidence of 1.6 feet. The settlement should occur rapidly with 90 per cent occurring within 3 months after completion of embankment construction (refer to the attached graph).

The 30-ft approach fill at the east end of the W-S ramp structure (station W-S 66+16) should be stable with 0.6 ft of settlement the majority of which should be realized during construction

cc: Mr. E. I. Roberts
Mr. K. A. Johnson
Mr. V. G. Rinehart
B.P. R.

Attach. Data Summary Sheets
Soil Profile
Foundation Recommendations
Settlement Graphs

Yours very truly,

C. G. PRAHL, P.E.
Director of Highways

BY: R. V. LeCLERC, P.E.
Materials Engineer

WASHINGTON STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
MATERIALS LABORATORY

FOUNDATION DESIGN RECOMMENDATIONS

P S.H NO. 1-RE PROJECT NB Over Sammamish River & PSH #2-BO

JOB NUMBER L-1978 CONTROL SECTION 1753 DATE December 28, 1966

PIER NO.	STATION	PILE SUPPORT	MINIMUM TIP ELEVATION	SPREAD FOOTINGS	FOOTING ELEV. AS SHOWN ON LAYOUT	RECOMENDED FOOTING ELEVATION	ALLOWABLE BEARING VALUE
Northbound							
1-NB	L-850+07	Yes	----*	----	----	----	----
2-NB	L-851+04	Yes	----*	----	----	----	----
3-NB	L-852+26	Yes	----*	----	----	----	----
4-NB	L-853+48	Yes	----*	----	----	----	----
5-NB	L-854+70	Yes	----***	----	----	----	----
6-NB	L-855+86	Yes	----**	----	----	----	----
7-NB	L^R-857+02	Yes	----**	----	----	----	----
8-NB	L^R-858+18	Yes	----**	----	----	----	----
9-NB	L^R-859+34	Yes	----**	----	----	----	----
10-NB	L^R-860+50	Yes	----**	----	----	----	----
11-NB	L^R-861+65	Yes	----**	----	----	----	----
12-NB	L^R-862+81	Yes	----**	----	----	----	----
****13-NB	L^R-863+58	Yes	----**	----	----	----	----

REMARKS: The water table varies from elevation 70 to elevation 20 (0 to 20 ft below ground surface)

*Refer to letter text.

**To be determined by test pile

***To be determined by test pile; pile tips should not be allowed to bear in the clay and silty clay between approximate elevations - 8 to -18.

****The pile support for this pier will have to be designed to carry an additional load of 15 to 20 tons per pile due to downdrag if the piers are constructed before fill settlement becomes tolerable.

APPROACH FILLS

STABILITY South approach lies on an old slide mass. North approach is potentially unstable, but with controlled loading stability can be attained.

SETTLEMENT South approach settlement negligible if slide mass remains stable. North approach will settle 3.2 ft with 90% occurring within 2 years.

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FOUNDATION DESIGN RECOMMENDATIONS

P.S.H NO. 1-RE PROJECT SB Over Sammamish River & PSH #2-BO

JOB NUMBER L-1978 CONTROL SECTION 1753 DATE December 28, 1966

PIER NO.	STATION	PILE SUPPORT	MINIMUM TIP ELEVATION	SPREAD FOOTINGS	FOOTING ELEV. AS SHOWN ON LAYOUT	RECOMENDED FOOTING ELEVATION	ALLOWABLE BEARING VALUE
Southbound							
1-SB	L-849+62	Yes	----*	----	----	----	----
2-SB	L-850+84	Yes	----*	----	----	----	----
3-SB	L-852+06	Yes	----*	----	----	----	----
4-SB	L-853+88	Yes	----*	----	----	----	----
5-SB	L-854+50	Yes	----***	----	----	----	----
6-SB	L-855+65	Yes	----**	----	----	----	----
7-SB	L-856+80	Yes	----**	----	----	----	----
8-SB	L-857+95	Yes	----**	----	----	----	----
9-SB	L-859+10	Yes	----**	----	----	----	----
10-SB	L-860+25	Yes	----**	----	----	----	----
11-SB	L-861+40	Yes	----**	----	----	----	----
12-SB	L-862+55	Yes	----**	----	----	----	----
****13-SB	L-863+41	Yes	----**	----	----	----	----

REMARKS: The water table varies from elevation 70 to elevation 20 (0 to 20 ft below ground surface).

*Refer to letter text.

**To be determined by test pile

***To be determined by test pile; pile tips should not be allowed to bear in the clay and silty clay between approximate elevations -8 to -18.

****Refer to previous sheet.

APPROACH FILLS

STABILITY South approach lies on an old slide mass. North approach is potentially unstable, but with controlled loading stability can be attained.

SETTLEMENT South approach settlement negligible if slide mass remains stable. North approach will settle 3.2 ft with 90% occurring within 2 years.

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FOUNDATION DESIGN RECOMMENDATIONS

P.S.H NO. 1-RE PROJECT S-E Ramp & E-N Ramp

JOB NUMBER L-1978 CONTROL SECTION 1753 DATE December 28, 1966

PIER NO.	STATION	PILE SUPPORT	MINIMUM TIP ELEVATION	SPREAD FOOTINGS	FOOTING ELEV. AS SHOWN ON LAYOUT	RECOMENDED FOOTING ELEVATION	ALLOWABLE BEARING VALUE
S-E Ramp							
***1	SE-72+37	Yes	----**	----	----	-----	----
2	SE-71+49	Yes	----**	----	----	----	----
3	SE-70+34	Yes	----**	----	----	----	----
4	SE-69+19	Yes	----**	----	----	----	----
5	SE-68+04	Yes	----**	----	----	----	----
9-SB	L^{L}-859+10	Yes	----**	----	----	----	----
E-N	Ramp						
***1-EN	EN-89+93	Yes	----**	----	----	----	----
2-EN	EN-90+85	Yes	----**	----	----	----	----
3-EN	EN-92+03	Yes	----**	----	----	----	----
10-NB	L^{R}-860+50	Yes	----**	----	----	----	----

REMARKS: The water table is at or near the ground surface.'

**To be determined by test pile.

***The pile support for these piers will have to be designed to carry an additional load of 15 to 20 tons per pile due to downdrag if the piers are constructed before fill settlement becomes tolerable.

APPROACH FILLS

STABILITY The approaches of both ramps should be stable.

SETTLEMENT S-E Ramp Approach settlement approximately 1.4 ft with 90% in 3 months.
E-N Ramp Approach settlement approximately 2.5 ft with 90% in 4 months.

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FOUNDATION DESIGN RECOMMENDATIONS

P S.H NO. 1-RE PROJECT N-W & N-E Ramps

JOB NUMBER L-1978 CONTROL SECTION 1752 DATE December 28, 1966

PIER NO.	STATION	PILE SUPPORT	MINIMUM TIP ELEVATION	SPREAD FOOTINGS	FOOTING ELEV. AS SHOWN ON LAYOUT	RECOMENDED FOOTING ELEVATION	ALLOWABLE BEARING VALUE
N-W	Ramp						
1	50+89.5	Yes	---*	---	---	---	---
2	51+86.5	Yes	---*	---	---	---	---
3	52+95.5	Yes	---*	---	---	---	---
4	54+04.5	Yes	---**	---	---	---	---
5	55+13.5	Yes	---**	---	---	---	---
6	56+22.5	Yes	---**	---	---	---	---
7	57+31.5	Yes	---**	---	---	---	---
8	58+38.1	Yes	---**	---	---	---	---
9	59+21.3	Yes	---**	---	---	---	---
10	60+28.0	Yes	---**	---	---	---	---
11	61+34.6	Yes	---**	---	---	---	---
12	62+15.2	Yes	---**	---	---	---	---
13	63+21.9	Yes	---**	---	---	---	---

REMARKS: The water table north of the Sammanish River is within 6 feet of the ground surface. South of the river it varies from 6 to 19 feet in depth.

*Refer to letter text.

**To be established by test pile

APPROACH FILLS

STABILITY South approach rests on hillside that has shown slide activity in the past.

SETTLEMENT South approach settlement should be negligible.