November 14, 2011

Ms. Laura Peterson, P.E.
Structures Engineer
Columbia River Crossing (CRC) Project
700 Washington St., Suite 300
Vancouver, WA 98660

Subject: CRC Drilled Shaft & Driver Pile Test Program
WSDOT / ACEC Structures Team Review Comments

Dear Ms. Peterson:

The Washington State Department of Transportation/ American Council of Engineering Companies of (WSDOT/ACEC) Structures Team reviewed the *CRC Drilled Shaft & Driven Pile Test Program* documentation provided in your e-mail to Mr. Swett dated October 5, 2011 at our October 28, 2011 monthly meeting. This effort was undertaken consistent with one of the Structures Team Purposes, "to provide design review and design feedback for submitted projects during all phases of design".

The Structures Team has reviewed the *CRC Drilled Shaft & Drilled Pile Test Program* materials and offer the following comments so that the test program can best capture the relevant information that will be most useful to the consulting community for design:

Drilled Shaft Design/Construction:

1. Will the design-builder be required to use the same installation methods used in the test program?
2. Document the specifics of the type of concrete mix used for the test.
3. Is there an opportunity to go with temporary casing versus the permanent casing currently specified in the test program?
4. For the 6 foot diameter shafts, consider one shaft using conventional methods and one shaft using an oscillator to provide a range of methods. Record issues, if any, with each.
5. The addition of shaft tip grouting should be considered to evaluate the feasibility and potential to increase shaft capacities at shallower depths, below the depth of liquefaction. Consider testing prior to grouting and then testing after grouting.
6. Shaft testing should be designed to provide useful information on the potential use of slurry in lieu of temporary casings for hole stability during excavation. If soil conditions are appropriate, consider specifying shaft installation by both methods to evaluate slurry installation methods. Use of synthetic slurry is likely preferred over bentonite slurry to limit reductions in skin friction values.

7. Reinforcing cage installation will probably be a major constructability issue for the 10' diameter 200+ foot long shaft. It would be good to show a suggested splicing detail in the plans to inform the bidder up front of the complexity of installing the rebar cage. The cage will likely be spliced together while one section is partially in the hole and the other held above it. What type of couplers (if any) would be allowed? Consider the likely design reinforcement ratio (e.g. bundled bars).
8. Use an actual reinforcing cage in at least one drilled shaft (reinforcement %) that will likely be used in a production shaft so constructability and installation of the shaft cage can be documented.
9. Record how the cages are picked and installed.
10. For BS-1, the rock socket is about 35 feet into the Troutsdale formation. Consider allowing the rock socket in the Troutsdale to sit for a day or days to verify stand-up time for an uncased socket.
11. Will temporary casing be allowed for 6 foot diameter drilled shafts?
12. Consider methods of concrete strength verification of insitu concrete near extreme fibers full length.
13. The proposal to compare CSL results with thermal integrity testing is a good idea and should produce useful comparative results.
14. Consider locating a test shaft in the water to better represent the actual shaft capacities for in-water shafts and to represent the actual construction techniques required for the in-water work.
15. Carefully consider the order of testing for O-cells to best capture skin-friction versus end bearing. Loading sequences should be well documented and planned prior to testing.

Pile Design/Construction:

1. Consider driving both open ended and closed ended pipe piles to get a comparison for drivability, capacity, etc.
2. Consider vibrating verses driving. Some contractors may want to consider vibrating and proof testing some of them, and then just vibrating the rest. Try to get a correlation to allow the Contractors to just vibrate, (e.g vibrate and check with PDA, then proof and retest capacity with PDA).
3. Allow the spirally welded piles per recently developed WSDOT standard specification.
4. Densification effects of driving closed ended piles may be beneficial if potentially liquefiable soils are present. It may be desirable to provide an assessment of these effects to proposers.
5. The program should include thorough evaluation of pile drivability including a pile drivability analysis to aid in selection of driving equipment and to establish driving criteria as the basis for PDA testing.
6. Consider specifying use of a hydraulic hammer as the hammers can provide a blow by blow report of energies during driving which will mesh nicely with the driving data from the PDA testing and the strain gages during testing.
7. Consider specifying more than one hammer size for pile driving. Compare differences during installation.
8. Test using both swinging leads and fixed leads. Compare the test results for each (e.g. capacity).

9. 24" pipe piles are at the smaller end of the size range for typical use with major bridge crossings. Assuming this is for temporary works, consideration should also be given for installation of larger test piles (e.g. 36", 48", or 60") to be used in foundations for permanent structures, possibly approach structures.
10. Since 24" piles are used, can precast concrete piles be used?

General Design:

1. The location of the drilled shaft BS-1 is not in the water, but is stated to be similar to shafts planned in the river. Confirm prior to the testing, that the higher resistance factors obtained from the test drilled shaft located on the land can be used at the in-water locations.
2. Record torque requirements of the equipment to be used for in-water and off barge or platform.
3. Measure the plumbness of the pile as current construction tolerances may not be achievable, especially at the 260 foot long drilled shaft. Develop acceptable construction tolerances for long drilled shafts (i.e. excess of 150 feet) as a result of the test program findings.
4. Document the strength of the concrete(s) used. Structure capacity of the shaft could be an issue so higher strength concrete may be appropriate.
5. Look at ways to limit the reduction typically applied to design for in-water concrete placement.
6. Assess how designers can extrapolate for different size drilled shafts.
7. Consider the addition of a drilled shaft lateral test depending upon the type of soils encountered at the CRC site. SR520 project did some lateral tests that could be used as an example. Confirm prior to test how the test data can be extrapolated to use on larger diameter shafts.
8. Downdrag loads: Is there a way to predict downdrag loads, (e.g surcharge pile after in place to see if you can obtain a downdrag estimate).
9. Will an option be allowed / explored to use larger diameter driven piles down to the deep Troutdale formation for permanent structure?
10. Collect load capacity as well as shaft movement.
11. AASHTO provides an upper limit on resistance factors if static load tests are performed. The code also suggests that a reduction in the resistance factor be applied if the test data is extrapolated to production shafts in different locations. Report should be specific on what reductions should be applied for production shafts at various locations.

General:

1.
2. Collect data on PPV vibration from construction methods used. Note: There will be a report available from the AWV project that may be useful as a reference. A sheet pile cofferdam was an effective shield for vibration (sheets to ~30 feet deep).
3. Noise and Vibrations: Consider some construction (pile driving and / or drilled shaft) in-water to measure the decibel level at various distances from the source to help with permitting Agencies.
4. Allow all interested Contractors on site to observe the work during the testing program.
5. Provide well documented video and photo records of all aspects of the test program, (e.g. specific construction methods, issues encountered, etc.).

The WSDOT / ACEC Structures Committee appreciate this opportunity to provide these comments in support of the CRC program. If you would like additional information regarding specific comments, or additional assistance in the future on other issues, please contact our committee.

Contributions were provided by the following team members:

• Bijan Khaleghi, PE/SE	WSDOT Bridge Design Office
• Geoff Swett, PE/SE	WSDOT Bridge Design Office (Co-Chair)
• Eric Schultz, PE	WSDOT Bridge Design Office
• Jeri Bernstein, PE/SE	WSDOT WA State Ferries
• Jim Schettler, PE/SE	Jacobs Engineering (Co-Chair)
• Jake Menard, PE	David Evans Associates
• Paul Guenther, PE/SE	Ben C. Gerwick, Inc.
• Chester Werts, PE/SE	HDR
• Paul Bott, PE/SE	HDR (past committee member)

Sincerely,

Geoff Swett, PE, SE
Co-Chair, WSDOT/ACEC Structures Team
WSDOT Bridge & Structures Office

Jim Schettler, PE, SE
Co-Chair, WSDOT/ACEC Structures Team
ACEC - Jacobs Engineering

cc: Jerry Lenzi – WSDOT Engineering Programs Director, WSDOT Team Sponsor
Dave Peters – HDR, ACEC Team Sponsor
Jugesh Kapur – WSDOT Bridge and Structures Engineer

Drilled Shaft & Driven Pile Test Program

Program Description

The Columbia River Crossing (CRC) project is planning to conduct a drilled shaft and driven pile test program to increase bid-ability, build-ability, and cost savings for the project through increased reliability of foundation design and construction. CRC would like to get the most beneficial information for prospective proposers out of this program. CRC would like to hear what information will be most valuable to prospective proposers to ensure that this information is documented as part of the program.

A total of three drilled shafts will be installed at two on-land locations: the I-5/SR 14 and Hayden Island interchange areas. Additionally, on Hayden Island, a test pile array will be installed and static uplift and compression tests will be performed. The specific goals of the drilled shaft and driven pile test program are as follows:

- Evaluate shaft construction techniques for proposed river crossing structure foundations. Currently, the estimated lengths of 10-foot-diameter shafts proposed for the river crossing foundations are on the upper end of typical construction depths.
- Determine the nominal axial base resistance of the drilled shafts at locations along the project alignment. The nominal axial base resistance of the shafts is obtained directly via single- and multi-level O-cells and instrumentation installed along the length of the shaft.
- Determine the load distribution along the shaft length via single- and multi-level O-cells and strain gauge instrumentation at selected depth intervals. Geotechnical engineering parameters will be developed for various soil units (nominal side and base resistance values) for final design of the production shaft foundations.
- Determine the nominal axial resistance in compression and of uplift of a 24-inch diameter closed-end pipe pile. Geotechnical engineering parameters will be developed for various soil units (nominal side and base resistance values) for final design of the production pile foundations.
- Determine the load distribution along the length of the pile via strain gauge instrumentation.
- Enable the use of an increased resistance factor to determine the factored axial compressive resistance for final design. The use of an increased resistance factors, enabled by this drilled shaft and driven pile test program, may result in reduced foundation lengths or reduced number of drilled shafts required to support structures.

Besides the geotechnical and constructability aspects of the program, environmental aspects including noise and vibration will be monitored. In addition to the standard cross-hole sonic logging (CSL) testing, thermal integrity testing will be used to evaluate concrete integrity in the drilled shafts. This will enable direct comparison of the two methods and allow for the possibility of increased use of thermal integrity testing in the future.

The CRC drilled shaft and driven pile program consists of three drilled shafts and one pile array as outlined below. A vicinity map is also attached showing the location of the tests.

Hayden Island Tests (Location B)

- BS-1: 10-foot diameter, 260-foot deep drilled shaft on Hayden Island, Oregon founded in the Troutdale Formation
    - This shaft will use permanent casing extending to the top of the Troutdale formation (approximately 225 feet below grade). This shaft is similar to the shafts planned in the Columbia River.

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- BS-2: 6-foot diameter, 130-foot deep drilled shaft near the Hayden Island Interchange (Oregon) bearing in dense sand alluvium
- BP-1: Array of five 24-inch diameter pipe piles. The array consists of four reaction piles and one instrumented test pile. All five piles will be driven 130 feet deep into the sand alluvium.

Vancouver Tests (Location C)

- CS-1: 6-foot diameter, 160-foot deep drilled shaft near the I-5/SR-14 Interchange (Washington) embedded in the gravel alluvium

A report will be complied after completion of the drilled shaft and driven pile test. The outline below lists what information is anticipated to be included in this report. As prospective proposers for the final design and construction of the CRC project, is there additional information that you would find useful and should also be included in the report?

Drilled Shaft and Driven Pile Test Report Outline

Overview

- Intent and benefits
- Detailed descriptions of the driven piles and drilled shafts that were tested
- Subsurface characteristics at each site
- Testing methods for shafts and piles (O-cell, tension per ASTM D3689, and compression per ASTM D1143)
- Thermal integrity testing methods
- Descriptions of environmental considerations and monitoring (noise & vibration)

Field Observation Documentation

Drilled Shaft Installation and Testing

- Drilled shaft construction equipment, methods, and constructability for each shaft location
- Casing installation method and equipment
- Troutdale socket excavation method
- Shaft clean out equipment, including bottom of shaft testing and inspection methods
- Slurry use and management, including specific type of slurry used
- Spoils and groundwater management, including disposal methods and location
- Rebar cage construction and installation
- Concrete placement and concrete sampling
- CSL testing
- Thermal integrity testing
- O-cell testing
- Backfill and restoration
- All equipment on site
- Constructability observations including problems encountered and solutions
- Construction timeline
- Production rates
- Photos of each event, embedded in report
- On site representatives for significant construction and testing activities
- Crew sizes

Driven Pile Installation and Testing

- Pile installation and constructability
- Pile installation method and equipment
- Pile splicing (length of test pile spliced before initial driving, length of reaction piles driven before splicing)
- Load frame installation
- Pile removal, or cutoff and backfill procedures
- Description and photos of pile condition after removal
- All equipment on site
- Constructability observations including problems encountered and solutions
- Construction timeline
- Production rates
- Photos of each event, embedded in report
- On site representatives for significant construction and testing activities
- Crew sizes
- Pile instrumentation and testing documentation
- Documentation of test pile instrumentation in field
- Drawing and labeled photos
- Photos of each piece of instrumentation labeled with installed location and instrument type
- Complete documentation of compression and tension testing, including testing observations

Results

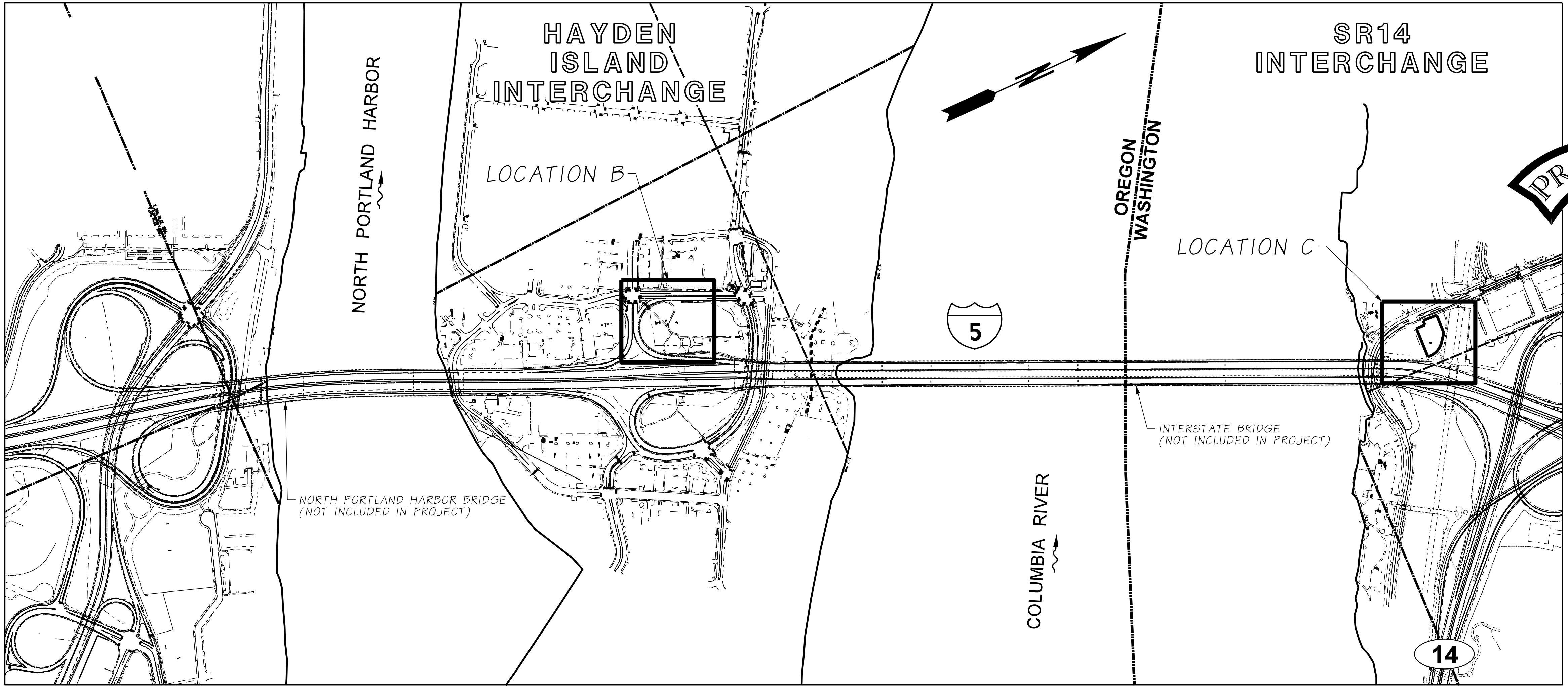
- PDA/CAPWAP Results
- Geotechnical Analysis and Recommendations
- Thermal Integrity Testing
- Environmental Monitoring
    - Noise and Vibration monitoring
    - Focused Environmental Assessments
    - Archaeological monitoring

Appendices

- Plans and Specifications
- Shaft Installation Plan
- Shaft Instrumentation Plan
- Pile Driving Records
- O-cell results, Pile testing data (raw field data from testing, provided by contractor)

MULTNOMAH COUNTY **CLARK COUNTY**

SEC.34, T.2N., R.1E., W.M. **SEC.27, T.2N., R.1E., W.M.**



VICINITY MAP
NOT TO SCALE