The foundations of a bridge are particularly critical because they must support the entire weight of the bridge and the traffic loads that it will carry.
View ODOT Video, Part 6/12

Introduction to Bridge Foundations
Common Foundation Types

- Spread Footing
- Piling
- Drilled Shafts

Type Of Excavation

“Dry” Excavation:
- Generally stable with no waterway or de-stabilizing groundwater

“Wet” Excavation:
- In or near water or significant groundwater
Spread Footings
Spread Footings

• Bearing pressure ($P$/Footing Area) < Bearing Capacity of soil ($C$)

Spread Footings

Settlement “$d$” < allowable settlement in project specifications.
Spread Footings

Check the Foundation Report and Drill Logs to verify that the actual foundation material exposed below the footings matches what was anticipated.

If there are any questions related to foundation material suitability contact the Geotechnical Engineer.

Concrete volume of a spread footing:

\[ V = L \times W \times H \]
Footing Concrete Volume Example

Footing Size: 14 ft long x 10 ft wide x 5 ft high

Volume = \( \frac{(14 \text{ ft})(10 \text{ ft})(5 \text{ ft})}{(27 \text{ cf/cy})} \)

\( V = 26 \text{ cy} \)

---

Footing Concrete Volume Exercise

Footing Size: 12 ft long x 9 ft wide x 6 ft high

Volume =
Footing Concrete Volume Exercise Key

Footing Size: 12 ft long x 9 ft wide x 6 ft high

Volume = (12 ft)(9 ft)(6 ft) / (27 cf/cy)

V = 24 cy

Spread Footings

Open-Pit Excavations

Walls of excavation are sloped for safety.

No shoring required.

Wide enough for workers outside of footing.
Spread Footings

Open-Pit Excavations are permitted when:

- Not in or near water.
- The soil material is adequately stable to ensure worker safety.
- The soil can be maintained in a dry condition.
- There is no threat of compromising the stability of any nearby structure or the structure being built.

Spread Footings

**Shored excavations**

Shoring & Cribbing:

A series of horizontal and vertical members that resist the surrounding soil pressure.
Shoring & Cribbing

Shored Excavations must be used when:

- The excavation is greater than 4 feet deep.
- The soil is not stable enough to ensure worker safety.
- The presence of adjacent structures limits the allowable size of the excavation.
Spread Footings

Foundations on rock:

- Level
- Stepped
- Serrated
- Against Solid Rock

For Arches

Unsuitable soils for spread footings:

If any evidence of problematic soils is discovered during footing construction, work should be stopped and the Engineer should be contacted immediately.
Spread Footings

Items to inspect for with spread footings:

• Elevation
• Dimensions
• Reinforcement
• Soil Stability

Spread Footings

Items to inspect for spread footings:

• Concrete cover. Dobies settle into base rock and may require larger size to maintain proper clearance.
• 3” clearance if pouring against natural ground
Unstable or Disturbed Materials

- Must be removed and replaced as directed.
- Structure fill must be placed in layers of not more than 6 inches. (00510.46(a))
- Each layer must be compacted to 95% of maximum density, or as specified. (510.46(a))
- Any foundation must be approved by The Engineer before any concrete placement.

Foundation Location

Check correct position and preserve offset reference points.
Reference Points

Structure Excavation
Structure Excavation

Measuring Excavation / Backfill

• Cross-Section original ground before excavation begins.

• Normal volume bounded by vertical planes 1 foot outside the footing. (510.80(b)(2)(c))

Structure Excavation

Measuring Excavation

• Volume of excavation is from bottom of footing to natural ground line.
Structure Excavation

Measuring Backfill

• Volume of backfill is from bottom of footing to finished construction line.

Structure Excavation Volume Example

Pier footing size is 20 ft x 10 ft
Average Depth of excavation is 5 ft

What is the volume of excavation that will be paid for? Volume = L x W x H

Volume = (22 ft) (12 ft) (5 ft) / 27 cf/cy
Volume = 49 cy
Structure Excavation Exercise

Pier footing size is 18 ft x 15 ft
Average Depth of excavation is 7 ft

What is the volume of excavation that will be paid for?

Volume =

Structure Excavation Exercise Key

Pier footing size is 18 ft x 15 ft
Average Depth of excavation is 7 ft

What is the volume of excavation that will be paid for?

Volume = \( \frac{(20 \text{ ft} \times 17 \text{ ft} \times 7 \text{ ft})}{27 \text{ cf/cy}} \)
Volume = 88 cy
Calculate Volume by Average End Area

- Measure end areas
- Average end areas
- Measure horizontal distance “d” between areas
- Multiply average end area by horizontal distance “d”

### Average End Area Example

Left End of Excavation is 10 ft wide x 6 ft high
Right End of Excavation is 10 ft wide X 10 ft high

What is volume of excavation if it is 30 ft long:

Left End Area = (10 ft)(6 ft) = 60 sf
Right End Area = (10 ft)(10 ft) = 100 sf

Volume = ((60 sf + 100 sf) / 2)(30 ft) / 27 cf/cy
Volume = 89 cy
Average End Area Exercise

Left End of Excavation is 12 ft wide x 4 ft high
Right End of Excavation is 12 ft wide X 10 ft high

What is volume of excavation if it is 20 ft long:

Left End Area = 
Right End Area = 

Volume = 

Average End Area Exercise Key

Left End of Excavation is 12 ft wide x 4 ft high
Right End of Excavation is 12 ft wide X 10 ft high

What is volume of excavation if it is 20 ft long:

Left End Area = (12 ft)(4 ft) = 48 sf
Right End Area = (12 ft)(10 ft) = 120 sf

Volume = ((48 sf + 120 sf)/2)(20 ft) / 27 cf/cy

Volume = 62 cy
Foundation Reports

Geotechnical and Foundation Report
Dodge Canyon Creek Bridge, Bridge 21102, M.P. 20.05
Dodge Canyon Creek Bridge, Bridge 21103, M.P. 21.55
Calapooia Creek Bridge, Bridge 20845, M.P. 22.95
CB15RR: Dodge C/Calapooia C/Bridge Replacement
Edition - South US Hwy 211 (M.P. 20.74 - 22.20)
Douglas County
Published: August 2010
Revised: November 2010
OAH 1340T033.109
Key 16790 (old Keys 14813 and 15576)

Oregon Department of Transportation
Regulations and Procedures
Environmental Unit
proposed structures and one along the proposed NW section) was designed by the Region 3 Transportation Engineer's Unit. Soil and rock samples recovered in the explorations were classified on site utilizing the methods described in ODOT's Soil and Rock Classification Manual. Subsequently, independent checks of the samples were made by a Certified Engineering Geologist for quality control (Dan Baker, C.E.G.). Laboratory testing was also performed to verify soil classifications and engineering properties.

3.7 Subsurface investigation summary

The following test in subsections 3.1.1, 3.1.2, and 3.3.2 are quoted from the ODOT Engineering Geology Report titled, "Eaton Sutherlin Highway", Highway 231, Douglas County, Oregon", dated October 2009 as prepared by Dan Baker C.E.G., and Kimberly Wyebrew, R.D. References made to these quotes are appended to the report in the Appendix.

3.8.1 Dodge Creek Bridge 21162

A total of two borings were advanced for the proposed Dodge Creek Bridge 21162. Test borings 1056725 and 1056726, were advanced at or near the proposed new bridge location, on the proposed new bridge alignment, to the west of the proposed bridge location. The borings were advanced for the Region 3 Geotechnical Unit. The borings were advanced to a depth of 15 feet below the proposed bridge elevation. The borings were advanced using a CME-125 track mounted drill rig and were equipped with an electronic Standard Penetration Test (SPT) hammer. The drilling methods used to advance the borings were 4" diameter hollow Stem Auger in the upper soils with a SPT taken at 15 foot intervals, and H-3.5 wire line system to core bedrock.

At the proposed location for Bridge 21162, the test holes were positioned along the western edge of the proposed bridge. The geologic conditions encountered from the surface down are as follows:

At Bore 1 associated with test hole 1056725 the material encountered was approximately 10 feet of fill material that overlaps approximately 10 feet of alluvium. The alluvium directly overlies the maximum thickness of the Terrace Formation at the contact elevation of approximately 41.2 feet or approximately 22 feet below the ground surface. The fill associated with the existing roadway approach embankment extends approximately 15 feet onto the west edge of the proposed bridge location at Bore 1. As a result, a portion of the fill material will be encountered along the western edge of the proposed bridge location.

At Bore 2 associated with test hole 1056726 the material encountered was approximately 10 feet of alluvium that directly overlies the maximum thickness of the Terrace Formation at the contact elevation of approximately 41.2 feet or approximately 32 feet below the ground surface.

3.8.2 Dodge Creek Bridge 21163

A total of 4 borings were advanced for the proposed Dodge Creek Bridge 21163. Test borings 1056727, 1056728, 1056729, and 1056730, were advanced at or near the proposed new bridge location to the depth as indicated. Test hole 1056727 (15 feet) was advanced near the deepest portion of the proposed roadway approach embankment to the northward of the proposed bridge. See Figure 4 in Appendix B for test hole locations. The subsurface investigation was directed by the Region 3 Geotechnical Unit. The borings were conducted between March 10th and 12th, 2009. The borings were advanced using a CME-125 track mounted drill rig and were equipped with an electronic Standard Penetration Test (SPT) hammer. The drilling methods used to advance the borings were 4" diameter hollow Stem Auger in the upper soils with a SPT taken at 5 foot intervals, and H-3.5 wire line system to core bedrock.

At Bore 1 along the western edge of the proposed structure associated with test hole 1056727 the material encountered was approximately 3 feet of fill material overlying approximately 12.5 feet of alluvium. The alluvium directly overlies the maximum thickness of the Terrace Formation at the contact elevation of approximately 44 feet below the ground surface. In addition, at Bore 1 along the western edge of the proposed structure associated with test hole 1056727, the alluvium encountered was approximately 1.25 feet of fill material that directly overlies the maximum thickness of the Terrace Formation at the contact elevation of approximately 42.4 feet. The fill associated with the existing roadway approach embankment extends approximately 30 feet onto the west edge of the proposed bridge location at Bore 1. As a result, a portion of the fill material will be encountered along about half of the western edge of the proposed roadway approach embankment.

At Bore 2 associated with test hole 1056728 the material encountered was approximately 7 feet of fill material overlying approximately 11.0 feet of alluvium. The alluvium directly overlies the maximum thickness of the Terrace Formation at the contact elevation of approximately 42.3 feet or approximately 15 feet below the ground surface. The fill associated with the existing roadway approach embankment extends approximately 15 feet onto the west edge of the proposed bridge location at Bore 2. As a result, only a small portion of the fill material will be encountered along the western edge of the proposed bridge location.

The testhole roadway approach embankment associated with test holes 1056727-2 and 1056728 encountered approximately 15 feet of aluvium that directly overlies the...
Geotechnical and Foundation Report
Dodge Creek and Calapooia Creek Bridge Replacements Section
Page 14 of 30

6.8 FOUNDATION DESIGN RECOMMENDATIONS

In accordance with ODOT's design practice, the foundation design was performed using
design recommendations for the bridge are discussed below under the
subsections following headings.

6.8.1 Bridge Creek Bridge 21632

It is recommended that the end bents (Beams 1 & 2) of the proposed single-span bridge be
founded on H-Pile driven into piles with tip protection. Piles are considered the best option
for the subsurface conditions encountered. The piles will provide the axial capacity,primarily through end bearing on and within the Terrebonne Bedrock Formation.

The resistance factor for Beams 1 and 2 is 0.46 as determined from LRFD Table 10.5.5.2.3.1
for nominal resistance of a single pile in compression using static pile analysis with a
combination of the Nordenson and Tononien methods and pile driving criteria determined
by Wave Equation. Due to driving stress limitations induced during the driving process, the
piles are recommended to be ASTM A522, Grade 50 (50 ksi yield strength). Due to driving
stress limitations induced during the driving process, the recommended factored
resistances are based on ASTM A522, Grade 50 and are therefore less than the
actual structural capacity of the pile. Table 1 provides detailed information for the
piling recommended for Beams 1 and 2.

---

### Table 1 - Dodge Creek Bridge 21632, Axial Pile Capacity Information

<table>
<thead>
<tr>
<th>Beam</th>
<th>Pile Type</th>
<th>Nominal Diameter</th>
<th>Ultimate Capacity (kips)</th>
<th>Piled Resist</th>
<th>Piled Resist (kips)</th>
<th>Piled Resist (kips)</th>
<th>Piled Resist (kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H-Pile</td>
<td>840</td>
<td>690</td>
<td>275</td>
<td>1021</td>
<td>2</td>
<td>1012</td>
</tr>
<tr>
<td>2</td>
<td>H-Pile</td>
<td>840</td>
<td>690</td>
<td>275</td>
<td>1021</td>
<td>2</td>
<td>1012</td>
</tr>
</tbody>
</table>

---

6.1.1 Lateral Pile Load Capacity

The pile foundations will be subject to lateral loads resulting from live loads, wind and
earthquake loading. The laterally loaded pile analysis may be performed with the aid of the
"L-Pile" computer program, geotechnical input parameters for the L-Pile program are
provided in Table 2. Ground water should be assumed at an elevation of 420 ft.
Foundation Exercise

You are the bridge construction inspector on the Dodge Canyon Creek Bridge. From the Foundation Report, determine the anticipated type of material that will be encountered and the recommended type of bridge foundation to be used for Bridge #21162.

Anticipated material: ________________________
                        ———————————————————
                        ———————————————————
                        ———————————————————

Bridge foundation: ________________________

Cofferdams
View ODOT, Part 8/12

PART B
Wet Structures
Excavation
Cofferdams

A water-tight enclosure that allows the construction of a bridge foundation in the dry.

Cofferdams

Used in or near water.
Cofferdams

• A seal is used when sheet piling cannot be driven to sufficient depth to cut off water flow.

Cofferdam With Seal
Construction Steps with Seal

– Drive Sheet Piles
– Cut Vent Holes
– Install Bracing
– Excavate
– Drive Foundation Piles
– Placing Concrete Seal

Construction Steps with Seal Cont’d

– De-water
– Construct Footing and Column in The Dry
– Flood Cofferdam
– Remove Cofferdam
– Place Riprap
Sheet Piles

- Check sheet piling Size and Grade.
- Deep-arch interlocking sheet piles are used.

Sheet Piling Is Often Driven Using a Temporary Guide Structure

All sheet piles must be plumb.
Vibratory Hammer

Sheet Piles

Drive sheet piling at a cofferdam corner first and then work your way around.
Sheet Piles

- Each sheet piling section is driven about 3 feet at a time.
- Sheet Piling sections are driven progressively around the cofferdam until the required depth is reached.

Vent Holes

- Cut vent holes at high water elevation
- Allows water to enter the cofferdam to prevent cofferdam failure
Bracing

Cofferdams require adequate bracing.

Wet Excavation
Underwater Exploration

- The inspector should take and record soundings to determine underwater elevations.

- Underwater inspection may be required by divers to determine proper excavation to the edges of the cofferdam, so that seals will hold.

Driving Foundation Pile

Template is often used

- As a guide for pile location.
- To establish elevation references.
Driving Foundation Pile

The inspector must:

– Monitor Penetration and Bearing.

– Take soundings after pile driving to check for soil displacement.

Placing Concrete Seal

• Keep water levels the same on both sides of the cofferdam to prevent flow through the seal.

• Place concrete under water by means of a Tremie Pipe.

• Use a suitable plug in the Tremie Pipe during the initial discharge of concrete to keep water out.
Placing Concrete Seal 00540.48(e)

- The concrete shall be placed continuously until seal is completed. Minimum of 50 cy/hr.
- Do not vibrate.
- Tops of seals should be kept nearly horizontal at all times.
- Take soundings of the surface of the seal.

Placing Concrete Seal 2001.20(c)

- Slump of 6”-10”
- Entrained Air not required
De-water Cofferdam
00540.48(e)

- After seal concrete reaches 2,200 psi
- Sump pump usually required to keep work area dry

Completing Construction

- Footing and pier constructed in the dry as in other situations.
- Cofferdam flooded.
- Natural streams bed lines and grades restored to avoid scour.
- Riprap placed as required.