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
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.
Spread Footings

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

\[ V = 26 \text{ cy} \]
Footing Concrete Volume Exercise

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

Volume =

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.
Spread Footings

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
Spread Footings

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

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.
- Volume to nearest 0.1 cy (190.10 (e))

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 = 48.9 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 =
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 = \((60 \text{ sf} + 100 \text{ sf}) / 2\)(30 ft) / 27 cf/cy
Volume = 88.9 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 =

Foundation Reports
Geotechnical and Foundation Report

Dodge Canyon Creek Bridge, Bridge 21162, M.P. 20.95
Dodge Canyon Creek Bridge, Bridge 21163, M.P. 21.15
Calapooya Creek Bridge, Bridge 20861, M.P. 22.10

OR138W: Dodge Cr/Calapooya Cr Bridge Replacements
Elkton – Sutherlin Hwy (Hwy. 231, M.P. 20.74 – 22.22)
Douglas County

Published: August 2010
Bid Date: November 2010
EA PE001472-000
Key 16796 (old Keys 14813 and 15970)

Oregon Department of Transportation
Region 3 Tech Center
Geo\Environmental Unit
event) of the soil samples appeared to have liquefaction potential. Given the disjointed nature of the alluvial stringers which have been deposited and re-cut by the creek, it is believed the samples indicating liquefaction potential are not continuous enough to suggest a layer of soil is subject to appreciable liquefaction risk.

6.0 FOUNDATION DESIGN RECOMMENDATIONS

In accordance with ODOT’s design practice, the foundation design was performed using AASHTO LRFD Bridge Design Specifications, 2007, 4th edition (with 2008 interims). Foundation design recommendations for the bridge are discussed below under the subsection following headings.

6.1 Dodge Creek Bridge 21162

It is recommended that the end bents (Bent 1 & 2) of the proposed single-span bridge be founded on HP14x89 driven H-pile with tip protection. Piles are considered the best option for the subsurface conditions encountered. The piling will derive their axial capacity, primarily through end bearing on and within the Tenmile Bedrock Formation.

The resistance factor for Bents 1 and 2 is 0.40 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 Nordlund and Tomlinson 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 A572, Grade 50 (50 ksi yield strength). Due to driving stress limitations induced during the driving process, the recommended factored resistances are based on ASTM A36 (36 ksi yield strength) and are therefore less than the actual structural capacity of the pile. Table 1 provides detailed information for the piling recommended for Bents 1 and 2.
Table 1 – Dodge Creek Bridge 21162, Axial Pile Capacity Information

The pile sizes provided in Table 1 are based on axial loading of the pile. If controlling loads other than the axial loads contemplated, are anticipated, then the pile should be evaluated for those loads and sized accordingly. The cutoff elevation was estimated by assuming 2 ft. embedment into the pile cap. If the cutoff elevation listed in Table 1 is revised by 2 ft. or more, the Geotechnical Engineer should be given the opportunity to revise the estimated pile lengths to be included in the Special Provisions for the project. The estimated pile length is based on the difference between the estimated cutoff elevation and the estimation that the pile will have a penetration of approximately 7 ft. into the moderately to slightly weathered Tenmile Bedrock Formation. The minimum required tip elevation for this bridge is based on the rock contact of the adjacent test holes.

For pile foundations designed in accordance with the above recommendations, settlement is estimated to be less than approximately 1 inch and to be elastic in nature, occurring as the load is applied.

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.
### OREGON DEPARTMENT OF TRANSPORTATION

**Project:** Dodge Creek Bridges  
**Purpose:** Bridge Foundation  
**Highway:** Hwy 138 W  
**County:** Douglas  
**Hole Location:** Northing: 650,185.61  
**Easting:** 4,155,421.75  
**Equipment:** CME 75  
**Driller:** Cascade  
**Project Geologist:** Dan Raker  
**Recorder:** Kim Wyttenberg  
**Drilling Remarks:** Drilling Method - HSA (0'-25')

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Test Type, No.</th>
<th>Soil</th>
<th>Rock</th>
<th>Test Type</th>
<th>Test Type Recovery</th>
<th>Drilling Remarks</th>
<th>Water Level/Date</th>
<th>Discontinuity</th>
<th>Rock</th>
<th>Soil</th>
<th>Percent Recovery</th>
<th>Natural Moisture</th>
<th>Unit Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(0.0) Final Log 10/22/09</td>
<td></td>
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<td></td>
<td>0.0 - 8.0 Dodge Unit-1 Sandy CLAY with some silt trace gravel, CL; orange-brown, low plasticity, damp, medium stiff, has subrounded to angular gravel; (Fill)</td>
</tr>
<tr>
<td>5</td>
<td>N1 40 2-2-3</td>
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<td></td>
<td>0.0 - 8.0 Dodge Unit-1 Sandy CLAY with some silt trace gravel, CL; orange-brown, low plasticity, damp, medium stiff, has subrounded to angular gravel; (Fill)</td>
</tr>
<tr>
<td>10</td>
<td>N2 60 1-1-5</td>
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<td></td>
<td></td>
<td>0.0 - 8.0 Dodge Unit-1 Sandy CLAY with some silt trace gravel, CL; orange-brown, low plasticity, damp, medium stiff, has subrounded to angular gravel; (Fill)</td>
</tr>
<tr>
<td>15</td>
<td>N3 87 2-1-3</td>
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<td></td>
<td></td>
<td>0.0 - 8.0 Dodge Unit-1 Sandy CLAY with some silt trace gravel, CL; orange-brown, low plasticity, damp, medium stiff, has subrounded to angular gravel; (Fill)</td>
</tr>
<tr>
<td>20</td>
<td>N4 73 7-9-5</td>
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<td></td>
<td></td>
<td></td>
<td>0.0 - 8.0 Dodge Unit-1 Sandy CLAY with some silt trace gravel, CL; orange-brown, low plasticity, damp, medium stiff, has subrounded to angular gravel; (Fill)</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>0.0 - 8.0 Dodge Unit-1 Sandy CLAY with some silt trace gravel, CL; orange-brown, low plasticity, damp, medium stiff, has subrounded to angular gravel; (Fill)</td>
</tr>
</tbody>
</table>

**Material Description:**
- **SOIL:** Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin.
- **ROCK:** Rock Name, Color, Weathering, Hardness, Structure, Origin.

**Discontinuity Data:**
- **J - Joint**
- **B - Bedding**
- **Fo - Foliation**

**Core Recovery:**
- **J - Joint**
- **B - Bedding**
- **Fo - Foliation**

**Unit Description:**
- **0.0 - 8.0 Dodge Unit-1 Sandy CLAY with some silt trace gravel, CL; orange-brown, low plasticity, damp, medium stiff, has subrounded to angular gravel; (Fill)**
- **8.0 - 18.0 Dodge Unit-2 Sandy CLAY with some silt trace gravel to Clayey SAND with some silt, SC; brown, low plasticity, damp to moist, medium stiff and very loose, has subrounded gravel; (Alluvium)**
- **18.0 - 22.0 Dodge Unit-3 Silty Sandy GRAVEL, GM; brown, nonplastic, wet, medium dense, fine rounded gravel; (Alluvium)**
- **22.0 - 41.4 Dodge Unit-4 MUDSTONE, gray, fresh, soft, very close to moderately close jointing, laminated to Bedrock contact 22'**

**Typical Drilling Abbreviations:**
- **WL - Wire Line**
- **HS - Hollow Stem Auger**
- **DF - Drill Fluid**
- **SA - Solid Auger**
- **CA - Casing Advancer**
- **HA - Hand Auger**
- **A - Auger**
- **C - Core**
- **N - Standard Penetration Test**

**Soil Sample:**
- **Lab No. 09-001632**
- **LL=27**
- **PI=8**

**Rock Sample:**
- **Lab No. 09-001633**
- **LL=26**
- **PI=5**

**Graphic Log:**
- **Slopes:**
  - **Cleaved**
  - **Massive**
  - **Bedded**
  - **Cross-bedded**
  - **Sandy**
  - **Clayey**

**Backfill/Instrumentation:**
- **Date:** 5/11/09
- **Remarks:** Wet spoon
- **Tube Height:** 437.3 ft
### Material Description

**SOIL:** Soil Name, USCS, Color, Plasticity, Moisture, Consistency/Relative Density, Texture, Cementation, Structure, Origin.

**ROCK:** Rock Name, Color, Weathering, Hardness, Discontinuity Spacing, Joint Filling, Core Recovery, Formation Name.

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Test Type No.</th>
<th>Soil Recovery</th>
<th>Rock Recovery</th>
<th>Soil Discontinuity Data</th>
<th>Rock Discontinuity Data</th>
<th>Soil Natural Moisture</th>
<th>Rock Natural Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>N5</td>
<td>100</td>
<td>50/2°</td>
<td>RQD = 0</td>
<td>R2</td>
<td>WC brown, then light gray to white (Tenmile Formation)</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>C1</td>
<td>92</td>
<td>R2 RQD = 88</td>
<td></td>
<td></td>
<td>WC brown, then light gray to white (Tenmile Formation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>100</td>
<td>R2 RQD = 78</td>
<td></td>
<td></td>
<td>WC brown, then light gray to white (Tenmile Formation)</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>C3</td>
<td>100</td>
<td>R2 RQD = 26</td>
<td></td>
<td></td>
<td>WC brown, then light gray to white (Tenmile Formation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C4</td>
<td>100</td>
<td>R2 RQD = 28</td>
<td></td>
<td></td>
<td>WC brown, then light gray to white (Tenmile Formation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(41.4) Bottom of hole.</td>
<td></td>
</tr>
</tbody>
</table>

### Unit Description

**thin bedded dipping 20 deg, fissile along bedding; (Tenmile Formation)**

- Drilling method changed to HQ3-WL (25'-41.4')
- WC Gray
- Backfilled with bentonite chips (41.4'-0')
- Bottom of hole 41.4'
Foundation Exercise

From the Foundation Report (page 14), determine the type of bridge foundation to be used for Bridge #21162. From the Drill Log determine the anticipated type of material to be encountered.

Bridge foundation: ________________________

_____________________________________

_____________________________________

Anticipated material:  ________________________

Cofferdams
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

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

• Under water 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
- 3,300 psi

**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.