

Steel Reinforcement

Lesson 6



Standard and Special Provisions to be familiar with:

00512 – Drilled Shafts

00530- Steel Reinforcement for Concrete

02510 – Reinforcement

Documentation that you will need:

Drilled Shaft Installation Plan

Approved Steel Reinforcement Cage Shop Drawings

Lift Plan

Drilled Shaft Inspectors' Checklist

Susan C. Ortiz, P.E., G.E.



Univ. of Idaho, Moscow graduated in 1995

2016-Present, ODOT, Senior Bridge Geotechnical Engineer

2005-2016, ODOT, Geotechnical Engineer

Regions 1 & 2

Project Delivery

Emergency Response

Maintenance

Unknown Foundations & Seismic

1986-2005, US Forest Service, Civil Engineer

Shasta-Trinity, Flathead, Boise, Wasatch-Cache,

Humbolt-Toiyabe, Umpqua and Willamette National

Forests; and Intermountain Research Station

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Steel Reinforcement Learning Objectives

- Inspector's roles and responsibilities
- Describe how to verify the checklist questions
- Determine the circumference of a shaft and rebar cage and calculate the required number of side spacers
- Explain how to assess the Contractor's compliance with cage construction/placement requirements



Certificate of Materials Origin

00165.35(d) Certificate of Origin of Steel Material

When specified, complete this document (ODOT Form 734-2126) as required by 00160.20 for **FEDERAL-AID** Projects

00160.20(a) Buy America

Only Projects with **Federal Highway Funds**:

- The Contractor shall not **permanently incorporate** foreign-origin iron or steel materials in excess of one-tenth of one percent (0.1%) of the Contract Amount or \$2,500, whichever is greater.
- Includes all manufacturing processes in the casting of ingots, for iron or steel materials (including epoxy coating, galvanizing, painting, and any other coating)

- On page 52 of the 2015 Standard Specifications an explanation of what is required to be on a CMO.
- Page 45 2015 Standard Specifications has Buy America explanation.

Certificate of Materials Origin (continued)

00160.20(a) Buy America

Only Projects with **Federal Highway Funds**: (continued)

- **All foreign-origin iron or steel Materials incorporated in the Project in excess of the amount indicated shall be removed and replaced with domestic Materials at Contractor's expense.**
- The Contractor shall provide the Engineer with a Certificate of Materials Origin, on a form furnished by the Engineer, before material is incorporated.
- Unless a CMO has been provided to the Engineer, the Materials **shall be considered foreign.**



CMO

(Certificate of Materials Origin)

Form 734-2126

NOTE:
A CMO is always required!!

A statement of origin on the Quality Compliance Certificate does not satisfy the Buy America requirements

ODD's
MATERIALS &
INSPECTION

Section 00160 also states that unless the CMO has been provided, the material shall be considered foreign.

If you have iron or steel materials, and have not received the CMO, the PM can call the materials foreign. The Contractor shall provide a value for the materials - the cost of the product as of the date they are delivered to the project (not installed costs).

Certificate of Materials Origin Foreign Steel

**Project Name
and Bid Item**

OREGON DEPARTMENT OF TRANSPORTATION

CERTIFICATE OF MATERIALS ORIGIN

PROJECT NAME (SECTION) SEVENTH STREET BYPASS	CONTRACT NO. C12456
BID ITEM NO. 0480	BID ITEM NAME REINFORCEMENT
DOMESTIC MATERIAL SOURCE (NAME AND ADDRESS)	
DOMESTIC MATERIAL DESCRIPTION	
FOREIGN MATERIAL SOURCE INCLUDING MATERIAL OF UNKNOWN ORIGIN (NAME AND ADDRESS) TAIWAN STEEL, KOREA	
FOREIGN MATERIALS JOB OF UNKNOWN ORIGIN DESCRIPTION AND VALUE OF IRON OR STEEL PRODUCT AS IT IS DELIVERED TO THE PROJECT 287 EACH #32 round bars @ \$2.18/ea = \$625.00	
<p style="margin: 0;">This certification is made for the purpose of establishing materials acceptance under the Contract Special Provisions listed 00160.20(a) Buy America. All iron or steel manufacturing processes, including protective coatings, for the domestic materials described above occurred within the United States of America.</p> <p style="margin: 0;">Manufacturer's Certificates verifying the origin of the above described domestic materials will be kept on file for three years following final payment. Copies will be furnished to the Engineer upon request.</p> <p style="margin: 0;">I declare under penalty of perjury under Oregon and Federal laws that the foregoing is true and correct.</p>	
AUTHORIZED REPRESENTATIVE* NAME: Teo Stanley TITLE: President SIGNATURE: <i>Teo Stanley</i> DATE: 6/17/2015	COMPANY NAME AND ADDRESS Stanley Rebar 123 Maskey Avenue Jonesville, OR 90289

734-2125 (D-16) ORIGINAL TO PROJECT MANAGER

**Source of Material
Not Supplier**

**Description and
actual cost to Contractor**

Signatures and address

Form Number



Actual cost to the Contractor is on this form not the contracted bid price.



CERTIFICATE OF MATERIALS ORIGIN

PROJECT NAME (SECTION) <p style="text-align:center">Coburg RD</p>	CONTRACT NO. <p style="text-align:center">14476</p>
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BID ITEM NO. <p style="text-align:center">750</p>	BID ITEM NAME <p style="text-align:center">Sign Support Footings</p>
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DOMESTIC MATERIALS SOURCE (NAME AND ADDRESS)

Vancouver Rebar/Farwest Steel Corp
 600 SE Maritime Ave Suite 150
 Vancouver, WA 98661

DOMESTIC MATERIALS DESCRIPTION

(#4) Rebar
 (#5) Rebar
 (#6) Rebar

FOREIGN MATERIAL SOURCE INCLUDING MATERIAL OF UNKNOWN ORIGIN (NAME AND ADDRESS)

FOREIGN MATERIALS (OR OF UNKNOWN ORIGIN) DESCRIPTION AND VALUE OF IRON OR STEEL PRODUCT AS IT IS DELIVERED TO THE PROJECT

This certification is made for the purpose of establishing materials acceptance under the Contract Special Provisions titles 00160.20(a) Buy America. All iron or still manufacturing processes, including protective coatings, for the domestic materials described above occurred within the United States of America.

Manufacturers' certificates verifying the origin of the above described domestic materials will be kept on file for three years following final payment. Copies will be furnished to the Engineer upon request.

I declare under penalty of perjury under Oregon and Federal laws the foregoing is true and correct.

<p>AUTHORIZED REPRESENTATIVE*</p> <p>NAME: <u>Joshua Hollinger</u></p> <p>TITLE: <u>Manager</u></p> <p>SIGNATURE: _____</p> <p>DATE: <u>6/1/2013</u></p>	<p>COMPANY* NAME AND ADDRESS:</p> <p style="text-align:center">Baker Rock Resources 21880 SW Farmington Road Beaverton, Oregon</p>
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Submit a new certificate for subsequent shipments if any of the above information changes. * May be Contractor, Sub-Contractor or supplier

6-9



Steel for Rebar Cages

What is rebar?

- “Deformed” bars
- With Specified Strength
 - 40 ksi
 - 50 ksi
 - 60 ksi
- Specified Size
 - High Modulus of Elasticity
 - 29,000 ksi

The diagram shows two views of a rebar. The left view shows a side profile with markings: 'H' (mill symbol), '#11' (bar size), and 'S' (type steel). The right view shows a top-down view of the deformed ribs with markings: 'H' (mill symbol), '#11' (bar size), 'S' (type steel), and '60' (grade mark). Labels with arrows point to 'Main Ribs', 'Letter or Symbol for Producing Mill', 'Bar Size #11', 'Type Steel*', and 'Grade Mark'. Below the diagram, it says 'Grade Line (One line only)' and '*Bars marked with an S and W meet both A615 and A706 GRADE 60'.

Steel Mills currently on the approved Qualified Products List (QPL) include:

- Cascade Steel Rolling Mills
- Nucor – Utah, Seattle
- Arcelormittal-Vinton, TX
- CMC Steel – Mesa, AZ
- EVRAZ Inc., N.A.
- Gerdau Ameristeel – Beaumont, Rancho Cucomonga, St. Paul, Wilton
- Harris Rebar (Epoxy Coated)
- Western Coating Inc.

QPL identification chart for each of the manufacturers is located at the web address below:

<http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/qpl/docs/rebar.pdf>

Steel Type

S – New Billet

W – Weldable

Dots or ribs maybe used for determination for grade.

Rebar Sizes

Bar No.	Weight lb/ft	Diameter in.	Cross-Sectional Area in. ²	Perimeter in.
3	0.376	0.375	0.11	1.178
4	0.668	0.500	0.20	1.571
5	1.043	0.625	0.31	1.963
6	1.502	0.750	0.44	2.356
7	2.044	0.875	0.60	2.749
8	2.670	1.000	0.79	3.142
9	3.400	1.128	1.00	3.544
10	4.303	1.270	1.27	3.990
11	5.313	1.410	1.56	4.430
14	7.650	1.693	2.25	5.320
18	13.600	2.257	4.00	7.090



Bar Number is designated in terms of 1/8" diameter.

4/8" = 0.5 inch diameter

8/8" = 1 inch diameter, etc.

Why is rebar needed?

Longitudinal reinforcement (vertical)

- Resist bending stresses
- Resist tension stresses

Transverse reinforcement (spirals or hoops)

- Resist shearing forces
- Hold longitudinal steel in place
- Resist flexural stresses



Inspector's Roles, and Responsibilities

Review the Checklist

Reinforcing Cage (Construction & Placement)

<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> NA	25. Is the rebar the proper grade steel, correct sizes and correct configurations as shown in the project plans and shop drawings?
<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> NA	26. Is the rebar properly tied in accordance with Section 00530.41(b)?
<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> NA	27. Are the proper number of Crosshole Sonic Log (CSL) tubes furnished and installed according to the project plans?
<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> NA	28. Does the Contractor have the proper number and type of spacers for the steel cage in accordance with the approved Drilled Shaft Installation Plan and Section 00512.45(d)?
<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> NA	29. If the steel cage was spliced, was it done in accordance with the details shown on the contract plans?
<input type="checkbox"/> Yes	<input type="checkbox"/> No	<input type="checkbox"/> NA	30. Is the steel cage adequately secured to maintain vertical tolerance during concrete placement operations (00512.45(a) and 00512.47(e))?



Drilled Shaft Inspector's Checklist is form number 734-2625 (02-2016)

ODOT Construction Administration forms can be found at:

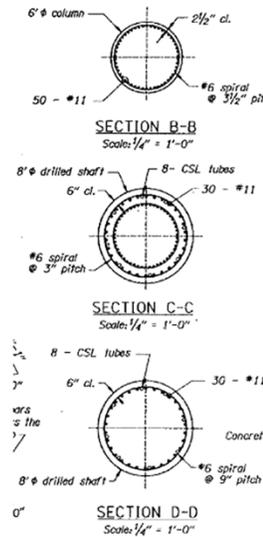
<http://www.oregon.gov/ODOT/HWY/CONSTRUCTION/Pages/HwyConstForms1.aspx>

The Drilled Shaft Inspector's Checklist is in the link D-E for "Drilled Shaft Inspector's Checklist"

Inspector's Roles, and Responsibilities

Verify

- Size and number of longitudinal bars
- Size, pitch (slope) and spacing of transverse bars
- Number of CSL tubes



BDDM provides rule of thumb for designers to include one CSL tube per foot of diameter of shaft.

OSSC 2015

00512.45 Reinforcing Steel - Furnish and place reinforcing steel as shown and according to the following:

(a) Placement - Do not place reinforcing steel in the shaft excavation until the Engineer has approved the final elevation of the bottom of the shaft. In each shaft, place reinforcing steel extending from 6 inches above the bottom of the shaft excavation to the elevation shown. The reinforcing cage may be supported on the bottom of the shaft excavation if approved. Support the reinforcing cage to prevent distortion or settlement during concrete placement. If concrete placement does not immediately follow cage placement, remove the reinforcing cage from the excavation and rectify the integrity of the excavation prior to reinstallation of the cage.

(b) Bracing - Rigidly brace the reinforcing cage to retain its shape for lifting. Lift the cage in a manner that does not cause permanent racking or distortion. Show bracing and any extra reinforcing steel required for fabrication of the cage on the submitted shop drawings. Remove cross bracing during cage placement unless otherwise approved.

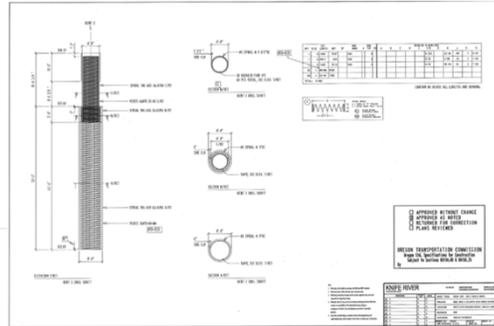
(c) Splicing - Splice all drilled shaft reinforcement using approved mechanical splicer's unless otherwise shown or approved.

(d) Concrete Cover - Maintain the required concrete cover shown on the plans by placing concentric spacer bars or other approved devices around the reinforcing cage. Provide details of the proposed centering method on the shop drawings submitted according to 00512.40.

Inspector's Roles, and Responsibilities

Shop drawings consistent with the plans?

- Size and number of longitudinal bars #25
- Size, pitch (slope) and spacing of transverse bars #25
- Number of CSL tubes #27
- Splice length #29



Approved shop drawings and bracing should be detailed in the shop drawings.

OSSC 2015

00150.10 Coordination of Contract Documents - The Contract Documents, including but not limited to Contract Change Orders, the Special Provisions, the Plans, and the Standard Specifications are intended to collectively describe all of the items of Work necessary to complete the Project.

(a) Order of Precedence - The Engineer will resolve any discrepancies between these documents in the following order of precedence:

- Contract Change Orders;
- Special Provisions;
- Agency-prepared drawings specifically applicable to the Project and bearing the Project title;
- Reviewed and accepted, stamped Working Drawings;
- Standard Drawings;
- Approved Unstamped Working Drawings;
- Standard Specifications; and
- All other Contract Documents not listed above.

Notes on a drawing shall take precedence over drawing details. Dimensions shown on the drawings, or that can be computed, shall take precedence over scaled dimensions.

Inspector's Roles, and Responsibilities

Is the rebar properly tied? #26

What does the specification say?

00530.41(b)




OSSC 2015

00530.41 Placing and Fastening - Place all reinforcement within the tolerances recommended in the

CRSI "Manual of Standard Practice" unless otherwise specified. Hold reinforcement firmly during the placing and setting of concrete.

(b) Ties and Supports - Keep reinforcement properly positioned during placement of concrete according to the following:

Bullet 2

- Tie all other bars at all intersections except where spacing is less than 1 foot in each direction; in that case tie alternate intersections.

(c) Clearances:

Bullets 1

- Provide the same surface clearance for ties and splices that is shown or specified for the reinforcement.

Bullets

- Use precast concrete blocks with approved shape and dimensions and with the same or greater compressive strength as the concrete to be placed.
- Do not use pebbles, pieces of broken stone or brick, metal pipe or wooden blocks as bar supports or to separate layers of bars.
- Use stainless steel metal chairs conforming to the requirements of ASTM A 493, Type 430 or plastic chairs from the QPL when the legs of the chair will be on an exposed surface.

Inspector's Roles, and Responsibilities

Standard Provisions

Are the proper number of CSL tubes furnished and installed according to the plans? #27



CSL Tubes →



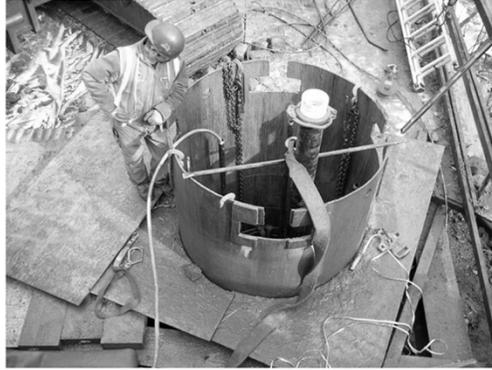
CSL results are based on distance between two tubes. If the tubes are not straight CSL tests results will be affected and may provide erroneous data.

OSSC 2015

00512.46 Crosshole Sonic Log Test Access Tubes - Furnish and install access tubes for CSL testing as shown. Attach CSL access tubes securely to the interior of the reinforcement cage as near to **parallel** as possible in each drilled shaft and in the pattern shown. **Extend the access tubes from the bottom of the reinforcement cage to at least 24 inches above the top of the shaft.** Joints required to achieve full-length access tubes shall be **watertight**. Do not damage the access tubes during reinforcement cage installation and concrete placement. Fill the tubes with potable water, according to 02020.10(b), as soon as possible, but no more than one hour after concrete placement and reinstall the top watertight caps. Check water level and top off as needed. Replace all access tubes that the test probe cannot pass through to the full depth of the shaft at no additional cost to the Agency. Replace all damaged access tubes with 1.5 inch to 2.0 inch diameter holes cored through the concrete for the entire length of the shaft. Unless otherwise directed, locate replacement core holes approximately 6 inches inside the reinforcement. Do not damage the shaft reinforcement during coring operations. Fill the access tubes with grout only after all CSL testing has been completed and the shaft has been accepted.

Inspector's Roles, and Responsibilities

- Fill CSL Tubes with water
- Straight
- Water tight
- Capped at both ends



Inspector's Roles, and Responsibilities

Verify Splices #29

- Lap
- Mechanical
- Non-contact lap splice



Verify Splice

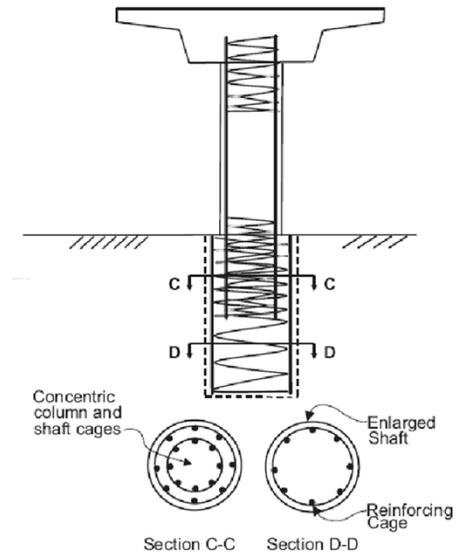
Mechanical Splice



Mechanical splices – couplers – should be staggered for structural considerations.

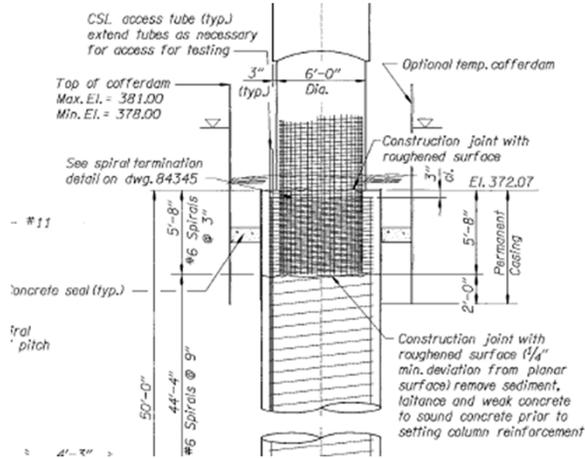
Verify Splice

Non-Contact Lap Splice



Non-Contact Splice Example

Calapooya Plans



Verification

- Storage and handling (should not be in contact with soil)
- Keep away from oil or other deleterious materials



OSSC 2015

00530.40 Protection of Material - Store reinforcement above the surface of the ground on dunnage. Protect reinforcement from damage at all times. Ensure reinforcement is free of dirt, detrimental rust or scale, paint, oil and other foreign substances when placed in the work. In addition to the requirements above, store epoxy coated bars with supports close enough to prevent sagging in the bundles. Provide protective padding when bundles are stacked or when supported on metal. Store bars as close as practical to where they will be placed in the structure. Cover bars with an opaque material during storage to protect them from exposure to sunlight and saline mist. Move bars to or from storage according to 02510.11(c) to minimize damage to the coating. Do not allow the total exposure time from bar delivery to concrete placement, while in storage or in place, to exceed 2 months.

Required Concrete Cover

Recommended concrete cover to reinforcing steel:

<u>Drilled Shaft Diameter</u>	<u>Minimum Concrete Cover</u>
Less than or equal to 3'-0"	3"
Greater than 3'-0" and less than 5'-0"	4"
5'-0" or larger	6"



OSSC 2015

00512.45 Reinforcing Steel(d) Concrete Cover - Maintain the required concrete cover shown by placing concentric spacer bars or other approved devices around the reinforcing cage. Place spacing devices on maximum 10 foot vertical spacing the full length of the shaft. At each 10 foot level, place spacers on a maximum 30 inch circumferential spacing with at least three spaces per level. Do not use wood spacers or concrete dobies. Provide details of the proposed centering method on the shop drawings submitted according to 00512.40.

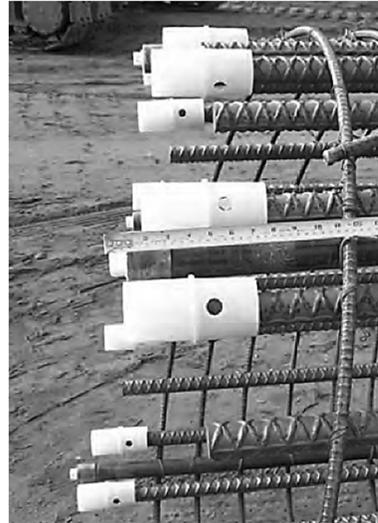
Verification #28

What are spacers used for?

To maintain the minimum concrete cover between the cage and the walls of the shaft.

What are standoffs used for?

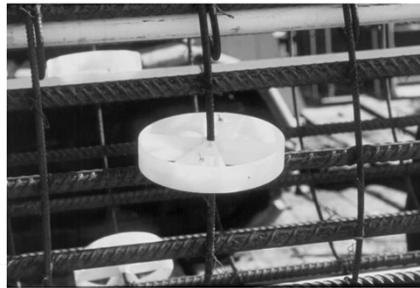
To maintain the bottom of the cage a certain distance, generally 6".

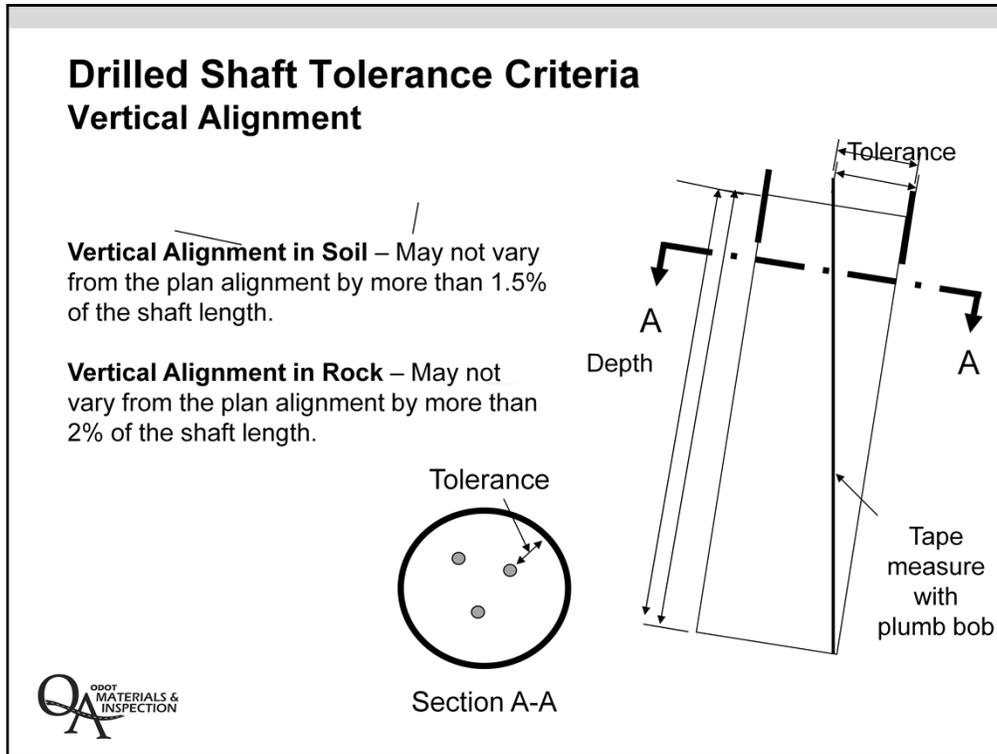


Space between cage and walls of the shaft are to provide room for the concrete to cover the rebar.

Verification #28

Spacers





OSSC2015

00512.42 Construction Tolerances - Excavate drilled shafts as accurately as possible at the locations shown and within the specified tolerances listed below. Determine the drilled shaft dimensions and alignment with approved methods. The following construction tolerances apply to drilled shafts unless otherwise stated:

- **Horizontal Position (At the Plan Elevation of the Top of Shaft):**
- **Shaft Diameter Less Than or Equal to 6 Feet** - 3 inch horizontal tolerance from the location shown.
- **Shaft Diameter Greater Than 6 Feet** - 6 inch horizontal tolerance from the location shown.
- **Top Elevation of Shaft Concrete:**
- **Top Elevation Above Water** - Minus 3 inches to plus 1 inch from the plan top of shaft elevation.
- **Top Elevation Under Water** - Minus 3 inches to plus 6 inches from the plan top of shaft elevation.
- **Vertical Alignment in Soil** - May not vary from the plan alignment by more than 1.5 percent of the shaft length.
- **Vertical Alignment in Rock** - May not vary from the plan alignment by more than 2 percent of the shaft length.
- **Top of Steel Reinforcement** - Plus or minus 6 inches from the plan top of steel reinforcement elevation.

Frequently check the plumbness, alignment, and dimensions of the shaft during construction.

Correct all out-of-tolerance shaft excavations and completed shafts to the satisfaction of the Engineer. Materials and work necessary to complete corrections for out-of-tolerance drilled shafts will be at the Contractor's expense, and no extension of the Project completion date will be granted.

Materials and work necessary to complete corrections for out-of-tolerance drilled shafts resulting from the removal of unexpected drilled shaft obstructions will be paid for according to 00195.20.

Verification

How many spacers are needed around the cage at each 10 ft. or less interval? Go to your approved Drilled Shaft Installation Plan!

Special Provisions 00512.45(d) Concrete Cover –
 a maximum 30-inch circumferential spacing with at
 least three spaces per level

maximum 10-foot vertical spacings the full length of
 the shaft



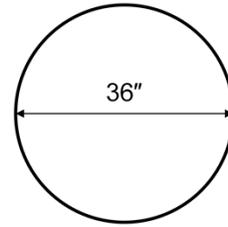
OSSC 2015

(d) Concrete Cover - Maintain the required concrete cover shown by placing concentric spacer bars or other approved devices around the reinforcing cage. Place spacing devices on maximum 10 foot vertical spacing the full length of the shaft. At each 10 foot level, place spacers on a maximum 30 inch circumferential spacing with at least three spaces per level. Do not use wood spacers or concrete dobies. Provide details of the proposed centering method on the shop drawings submitted according to 00512.40.

Verification

Circumference of a Circle

- Where: C = circumference
D = diameter
 $\pi = 3.14$

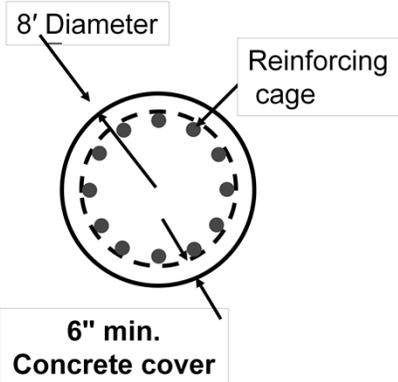


- What is the circumference of the rebar cage in inches?
C = πD
C = 3.14 (36")
C = 113 inches



Circumference of the Cage

Where: Diameter of cage (D) = Shaft diameter – (2 x Concrete cover)
 Circumference (C) = πD
 $\pi = 3.14$



PROBLEM

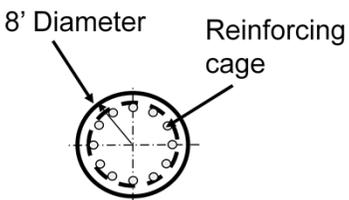
What is the circumference of the cage in inches?

$$C = 3.14(8' - 2(0.5'))$$

$$C = 3.14 \times 7' = 22'$$

$$C = 22\text{ft} \times 12\text{in} / \text{ft} = 264"$$

Side Spacers for Shaft Alignment

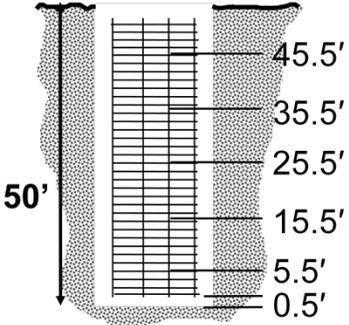


8' Diameter

Reinforcing cage

- a maximum 30-inch circumferential spacing with at least three spaces per level
- maximum 10-foot vertical spacings the full length of the shaft

Same Circumference as Previous Page



50'

45.5'

35.5'

25.5'

15.5'

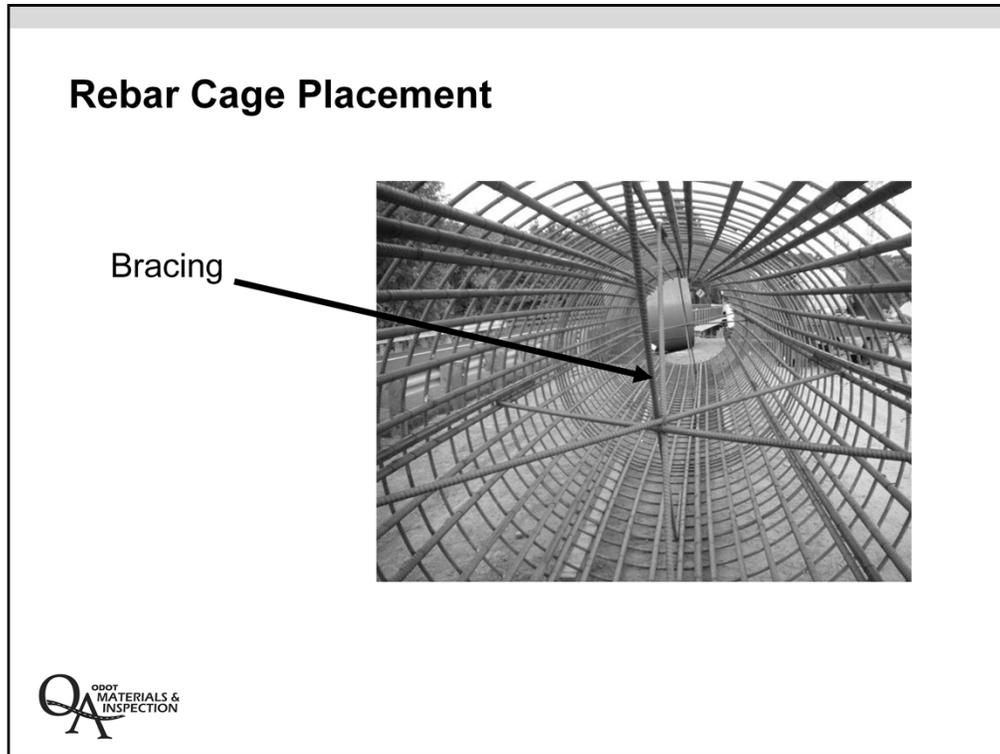
5.5'

0.5'

How many side spacers are required?

If the length of the shaft is 50 feet how many levels are required? =

Total number of spacers =



OSSC 2015

00512.45 Reinforcing Steel (b) Bracing - Rigidly brace the reinforcing cage to retain its shape for lifting. Lift the cage in a manner that does not cause permanent racking or distortion. Show bracing and any extra reinforcing steel required for fabrication of the cage on the submitted shop drawings. Remove cross bracing during cage placement unless otherwise approved.



Rebar Cage Placement

Lifting

What is the weight of the rebar cage?



OSSC 2015 spec language?

The Drilled Shaft Installation Plan requires:

- a bracing plan to stiffen the rebar cage
- Lifting methods – equipment type, where will straps be attached.







Mud on the sides of the cage will make it difficult for the concrete to adhere to the sides of the cage.

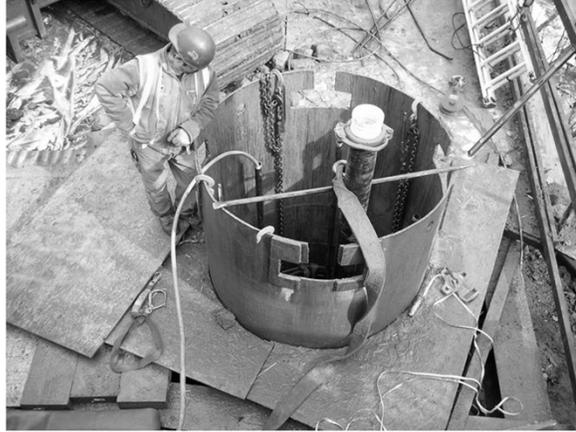




Securing the Rebar Cage #30

Suspend using

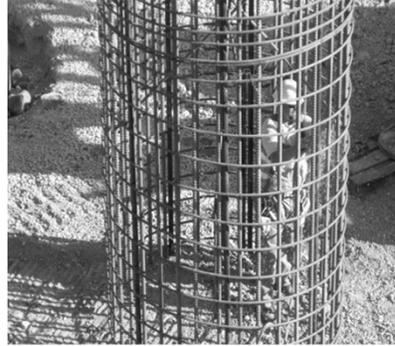
- Chains
- Equipment



Review

What details of the rebar cage construction are you verifying?

- Size
- Grade
- Configuration – bracing
- Properly tied
- Splice construction
- Splice placement
- Number of CSL tubes
- Number of spacers



Unit Review

- Inspector's roles and responsibilities
- Describe how to verify the checklist questions
- Determine the circumference of a shaft and rebar cage and calculate the required number of side spacers
- Explain how to assess the Contractor's compliance with cage construction/placement requirements

