Falsework & Formwork
Section 3

Falsework Construction
00540.42
Falsework

Temporary construction used to support the permanent structure until it becomes self supporting.

Falsework must support the weight of the Forms, Fresh concrete, and Construction equipment.

All falsework to be in accordance with the contractor's reviewed falsework plans.

Falsework Construction 00540.42

- Construct per AASHTO Construction Handbook for Bridge Temporary Works

- Do not place concrete until the falsework design engineer inspects work.
Falsework

Piling is often used. The inspector should verify that bearing has been reached.
Mudsills may be used with the approval of the engineer.

Watch for excessive settlement.
Falsework

Support System:

• Rigid vertical posts and diagonal braces
• Secure fasteners

Look for items not matching the approved falsework plans.
Vertical 4x4’s?
Falsework

Vertical 4x4 supports?
Falsework EOR site visit before placing concrete

Wedges Under Beam

Hardwood wedges
Used in pairs with only one additional block allowed
Toenail after adjustment
Pier Falsework

Falsework Bent
Falsework Footings

Set Telltales from Deck Forms to Ground

Near Interior Falsework
Bents To Measure Settlement
Telltale from Deck Forms to Ground

Mark Before & After
Pour To Determine
The Total Settlement
& Crush

Compare To EOR’s Estimate

Deck Falsework

Deck overhang brackets – they are designed to support the cantilevered deck overhangs.
Screwjacks

Adjusted to Grade with Uniform Bearing

Case Study
Hwy 149 @ Hwy 70, Oroville, CA
Falsework

Cable removed.

Thoughts?

Falsework Collapse
Falsework Collapse

Hwy 149 @ Hwy 70, Oroville, CA

July 30, 2007

Fatalities: 0

Injuries: 2

Hwy 149 @ Hwy 70
Causes

• Falsework erection plan not followed by Contractor.

• Contractor told Inspector they would be working several spans away from this area.

• Cable bracing for falsework removed without permission from engineer.

Formwork Construction
00540.45
The following illustration shows many of the commonly used terms and requirements for fixed forms.

**BUILDING AND ERECTING THE FORMWORK**

- Wood Spreader
- Ties
- Plywood Sheathing
- Board Sheathing
- Brace to solid construction
- Studs
- Double Wals
- Sill or Plate
- Sill or plate

Typical wall form with components identified. Alternate sheathing materials are indicated. Wood spreaders are shown, but frequently the spreader device is part of the prefabricated tie.
Formwork Construction

• Check forms for correct dimensions and shapes.
• Forms to be mortar tight.
• Internal tie rods or snap-ties have 1” recess (2” within 25 miles of ocean).

2x4 Imprint On Outside Of Exterior Stemwall?

Any Shape Inside The Forms Will Not Be Poured Concrete
Deck Forms Against Stemwall

Overhang of Deck Forms?
Nylon Mesh to Make Forms Mortar Tight?

Nylon Mesh?
Gap Under Plywood?

Excess Foam?
Support at Hole?

Drip Strip Nailed Sideways on Form? Note Clearance, Too.
Chamfer Strip on Beam?

Form Construction
00540.45

- Provide a ¾" chamfer on all exposed concrete edges.
- Apply form release oil.
Chamfer Strips on Exposed Edges

Chamfer Strips on Exposed Edges
Abutment & Retaining Wall With Chamfers

Wingwall With vs. Deck Without Chamfers
“E” Beam Without Chamfers @ Shear Block

Is There Preformed Joint Material?
No Chamfers

Top Of Wingwall Spalling
Chamfer @ Wingwall

Abutment with Chamfers At Cold Joint?
Form Construction Cont’d

• Remove sawdust, dirt, excess water and other foreign materials prior to placement.

• Saturate with water immediately before placement and keep damp during placement.

Debris at Abutment Cold Joint
Debris Between Beam & Deck

Look for Good Lines and Shapes
Shape of Collar?

Collar Shape
Odd Lines?

Access for Inspection
Inspection Facilities
(00150.20 (b))

The Contractor shall furnish walkways, railings, ladders, tunnels, platforms and other facilities necessary to permit The Engineer to have safe access to the Work to be inspected.

Safe Access?
Safe Access?

Safe Access?
Protected Access to Deck

Stairway Access
Ladder Access

Ladder Supported
Abutment Access

Work Platform for Abutment
Check Form Placement
(Are Forms Squared Up?)

Pythagorean Theorem

\[ a^2 + b^2 = c^2 \]

\[ c = \sqrt{a^2 + b^2} \]
Footing Example

\[ 3^2 + 4^2 = c^2 \]

\[ c = \sqrt{3^2 + 4^2} \]

\[ c = \sqrt{9 + 16} \]

\[ c = 5 \]

Footing Exercise

A footing is 6’ wide by 8’ long. What is the diagonal distance “c”?

[Diagram of a right triangle with sides 6’ and 8’, and diagonal “c”]
Footing Exercise Key

\[ 6^2 + 8^2 = c^2 \]

\[ c = \sqrt{6^2 + 8^2} \]

\[ c = \sqrt{36 + 64} \]

\[ c = 10 \]

Similar Triangles

\[ \frac{10}{8} = \frac{5}{4} \]
Right Triangle Exercise

\[
\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}
\]

Law of Sines
Law of Cosines

\[ c^2 = a^2 + b^2 - 2ab \cos C \]

Other Types of Checks

- Measure Chord Distances (Bent Checks)
- Measure Middle Ordinates (Edge of Deck Checks)
Bridge In 10° Curve
(How To Check Forms Are Positioned Correctly?)

Bottom Slab Form of PT Box

Rebar and stem wall layout marked on bottom slab forms.
Curve Data
Curve Data

\[ \frac{D}{\Delta} = \frac{100'}{L} \]

Curve Defined As \( D = 1° \)

\[ \frac{1°}{360°} = \frac{100'}{2\pi R} \]

\[ R = \frac{5,729.578'}{D} \]

Curve Data

\[ \frac{\Delta}{L} = \frac{D}{100ft} \]

\( \Delta \) = The Subtended Angle Of The Curve

\( D \) = Degree Of Curve

(Subtended Angle Of 100’ Of Arc)

\( L \) = Length Of Curve

\( R \) = Radius Of Curve

\[ \Delta = \frac{D(L)}{100ft} \]

\[ R = \frac{5,729.578'}{D} \]
Trig Functions

Sin ▲ = O / H
Cos ▲ = A / H
Tan ▲ = O / A

Check Chord Distance
Chord Distance

\[
\sin\left(\frac{1}{2} \theta \right) = \frac{1}{2} \frac{C}{R}
\]

\[
R \sin\left(\frac{1}{2} \theta \right) = \frac{1}{2} C
\]

\[
2R \sin\left(\frac{1}{2} \theta \right) = C
\]

Chord Distance = \(2R \sin\left(\frac{1}{2} \theta \right)\)

Chord Distance Example

D = 10°  Bent 1 @ 10+00  Bent 2 @ 12+00

What is the chord distance between Bents 1&2?

L = (12+00)-(10+00) = 200ft

\[\theta = \frac{D(L)}{100ft} = 10°(200ft)/100ft = 20°\]

R = \(\frac{5,729.578}{D} = \frac{5,729.578}{10°} = 572.958ft\)

C = \(2R \sin\left(\frac{1}{2} \theta \right)\)

C = \(2(572.958ft) \sin\left(\frac{1}{2}(20°)\right) = 198.99ft\)
Chord Distance Exercise

D = 5°
Bent 1 @ 10+00
Bent 2 @ 11+50

What is C?

Chord Distance Exercise Key

L = (11+50)−(10+00) = 150ft
▲ = D(L)/100ft = 5° (150ft)/100ft = 7.5°
R = 5,729.578 / D = 5,729.578 / 5° = 1,145.916ft

C = 2(1,145.916ft)Sin(1/2(7.5°)) = 149.89ft
Middle Ordinate Check

Curve Data
Middle Ordinate Distance

\[ \cos\left(\frac{1}{2} \Delta \right) = \frac{A}{R} \]

\[ A = R \cos\left(\frac{1}{2} \Delta \right) \]

\[ M = R - A \]

\[ M = R - R \cos\left(\frac{1}{2} \Delta \right) \]

Middle Ordinate = \( R \left(1 - \cos\left(\frac{1}{2} \Delta \right) \right) \)

Middle Ordinate Example

\[ M = R \left(1 - \cos\left(\frac{1}{2} \Delta \right) \right) \]

Example: \( D = 10^\circ \)

\( \text{Bent 1} \: @ \: 10+00 \)

\( \text{Bent 2} \: @ \: 12+00 \)

\( L = (12+00)-(10+00) = 200\text{ft} \)

\( \Delta = \frac{D(L)}{100\text{ft}} = 10^\circ \frac{(200\text{ft})}{100\text{ft}} = 20^\circ \)

\( R = \frac{5,729.578}{D} = \frac{5,729.578}{10^\circ} = 572.958\text{ft} \)

\( M = 572.958\text{ft} \left(1 - \cos\left(\frac{1}{2}(20^\circ)\right) \right) = 8.70\text{ft} \)
Middle Ordinate Exercise

D = 5°
Bent 1 @ 10+00
Bent 2 @ 11+50

What is M?

Middle Ordinate Exercise Key

D = 5°
Bent 1 @ 10+00
Bent 2 @ 11+50
L = (11+50)-(10+00) = 150ft
\[ \Delta = \frac{D(L)}{100ft} = \frac{5°(150ft)}{100ft} = 7.5° \]
R = 5,729.578 / D = 5,729.578 / 5° = 1,145.916ft

M = 1,145.916ft(1 - Cos(1/2(7.5°))) = 2.45ft
Form & Falsework Removal

• No forms or falsework may be removed until approved by the Engineer.

• All forms and falsework must eventually be removed unless there is no permanent access, e.g., box girder bridge.
Field Cured Cylinders (00540.52)

- Need to verify strength
- In like conditions or worse
- Coolers are for Lab cured cylinders

Table 00540-1

<table>
<thead>
<tr>
<th>Part 1: Form and Falsework Removal for:</th>
<th>Percent of Specified Strength</th>
<th>Counting Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLabs for slabs, walls, abutments, caps</td>
<td>–</td>
<td>1</td>
</tr>
<tr>
<td>Bridge deck rib spacers</td>
<td>–</td>
<td>3</td>
</tr>
<tr>
<td>Bridge deck composite girders</td>
<td>–</td>
<td>7</td>
</tr>
<tr>
<td>Coolers</td>
<td>–</td>
<td>7</td>
</tr>
<tr>
<td>Coolers for Lab cured cylinders</td>
<td>–</td>
<td>7</td>
</tr>
</tbody>
</table>

Part 2: Subsequent Loading ² at:

<table>
<thead>
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<th>Percent of Specified Strength</th>
<th>Counting Days</th>
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</thead>
<tbody>
<tr>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>90</td>
<td>7</td>
</tr>
<tr>
<td>60</td>
<td>6</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>All other members</td>
<td>7</td>
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</tbody>
</table>

Early removal of forms does not eliminate the curing requirement of 00540.51.
Form Removal & Loading Exercise

Situation: Crossbeam poured @ 4 p.m. the day before with 4,000 psi concrete.

Can side forms be removed at 6 a.m. the next day? 

What is the minimum concrete strength to remove the bottom forms? 

7 days later concrete strength is 3,000 psi and the contractor wants to set girders on top of the crossbeam. Is this acceptable? 

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Form Removal & Loading Exercise Key

Situation: Crossbeam poured @ 4 p.m. the day before with 3,000 psi concrete.

Can side forms be removed at 6 a.m. the next day? 
No

What is the minimum concrete strength to remove the bottom forms? 
3,200 psi

7 days later concrete strength is 3,000 psi and the contractor wants to set girders on top of the crossbeam. Is this acceptable? 
No