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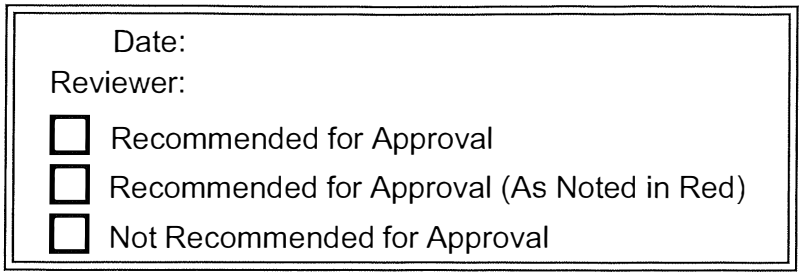
16 FALSEWORK DESIGN, ANALYSIS, AND INSPECTION

16.1 Review and Approval of Falsework Plans

The Contractor shall be responsible for designing and constructing safe and adequate falsework. The review or approval of falsework plans by the Engineer or permission to proceed with the work shall not relieve the Contractor of his responsibility for successful erection and satisfactory results. KDOT Specifications require falsework plans and details be designed and sealed by a licensed Professional Engineer. It shall be the Contractor's responsibility to engage a licensed Professional Engineer for design and plan preparation of falsework plans.

At the request of the KDOT Field Engineer, the KDOT Bridge Section (or KDOT's design Consultant) will review the falsework plans. Falsework for bridges designed by a Consultant shall be reviewed by the Consultant as part of the Construction Services phase of their Design Contract. Once falsework plans have been reviewed and considered satisfactory, the Bridge Section will place the stamp shown below (or similar) on all falsework plan sheets with the appropriate date and box marked. Locate the stamp as close to the lower right-hand corner of the sheet as possible. The plans are then sent along with a transmittal letter addressed to the KDOT Field Engineer who requested the review. The letter will document recommendations and other considerations deemed appropriate by the reviewing engineer. The approval or disapproval of the falsework plans and/or "as constructed" falsework shall be made by the Field Engineer.

Marking the box titled "Recommended for Approval (As Noted in Red)" is rarely used; its use is limited to time critical projects. It is preferred the falsework plans engineer make the necessary corrections as discussed with the reviewer and resubmit corrected plans. When used the transmittal letter should clearly document the corrections noted in red.



Requirement of cofferdam plan review by the Bridge Office is at the discretion of the design engineer in consultation with the Structures Design Leader. The plans and computations shall be sealed by a licensed Professional Engineer. A plan note on the General Notes sheet will need to be added to indicate the requirement of cofferdam plan review. The following is an example note to be edited as needed:

> COFFERDAMS: The cofferdams for Piers No. 2, 3 and 4 shall be the design responsibility of the Contractor. Footing seats have been designed for an assumed water level no higher than Elevation 1297.00.

Cofferdams shall conform to the requirements of Section 204 of the Standard Specifications. The Contractor shall submit to the Engineer for approval, computations and details for his proposed cofferdams, watertight forms, dewatering and excavation methods. The computations and drawings shall be sealed by a licensed Professional Engineer and shall be submitted at least six weeks before work is scheduled to begin to allow sufficient time for the Engineer's review.

When cofferdams are no longer required, the Contractor shall remove the entire cofferdam. Cutoff of steel sheet piling will not be permitted.

No measurement of cofferdams will be made. The pay item for "Class II Excavation" shall include all cofferdam construction materials and other miscellaneous items to allow the footings to be constructed as shown on the plans.

Work platforms or debris platforms used for concrete removal for widening or replacement of bridges over traffic ways or railroads shall be considered falsework, and falsework plans and methods of support shall be submitted to the Engineer and the Railroad for review. It is not required such plans for platforms bear the seal of a licensed Professional Engineer, however, they shall meet all requirements of falsework for structural adequacy and safety.

16.2 Design Considerations

See Figure 2.2.2.4-1 Construction Clearance Diagram for construction clearance requirements to public roads and railroads. Minimum clearance requirements are normally shown on the construction plans. Falsework supports adjacent to traffic ways must be protected by barriers and shall be designed to resist vibration forces caused by passing vehicles.

Adequate diagonal and longitudinal bracing are important to the safety and stability of the entire shoring system. Diagonal bracing must be provided in both vertical and horizontal planes to provide stiffness and prevent buckling of individual members of the falsework. Experience shows most failures may be attributed to a lack of adequate lateral bracing (transverse or longitudinal) and a failure at one location may cause progressive failure for the entire structure (domino effect). Special consideration should be given to superelevated structures due to their inherent lateral instability and particularly to superelevated structures in combination with profile grades more than 4 percent.

Falsework bents shall be constructed with driven timber pile unless falsework can be founded in rock or shale. However, with approval, falsework pads may be used when underground utilities preclude the use of driven piling.

The Contractor is responsible for determining the safe bearing capacity of the foundation material on which the falsework supports will rest. Site drainage must be adequate to prevent soil saturation and washout of the soil supporting the falsework supports.

KDOT recommends the minimum bracing of timber bents to be 2 x 6 members with a minimum of two adequate fasteners (20d spikes or better) per connection. The bracing member must be able

to resist both tension and compression. Steel bands should not be used for bracing or splicing load carrying members.

16.3 Loads

16.3.1 Loads on Falsework

16.3.1.1 Dead Load Densities and Weights

Densities:

Concrete (normal weight): 160 lb/ft^3 (vertical, includes weight of reinforcing steel and forms)

85 lb/ft^3 (horizontal fluid pressure)

Timber: 50 lb/ft^3

Steel: 490 lb/ft^3

Weights:

Formwork (light): 3-5 lb/ft^2 (minimum)

(heavy): 6-10 lb/ft^2 (minimum)

Timber and steel member densities from appropriate manuals may be used. A weight of 10 lb/ft^2 may be estimated for timber formwork down to the falsework.

16.3.1.2 Live Load

Construction live load shall consist of the actual weight of equipment to be supported, applied as a concentrated load at point of application (screed rail, etc.) plus a uniform load of 20 lb/ft^2 applied over the entire area supported including the walkway, plus a load of 75 lb/foot applied at the outside edge of the deck. (Note: This loading does not apply to superstructure supported formwork. See Section 16.3.2 Loads on Formwork). To prevent an unrealistic loading condition when analyzing falsework members below the level of bridge soffit, it is KDOT's policy to limit the distance over which the 75 lb/foot live load will occur to a loaded zone of 20 foot in length measured along the edge of the deck. The loaded zone will be viewed as a moving load positioned to maximize stresses in the falsework member under consideration.

The Contractor furnished falsework plans should include expected concentrated equipment loads, including screed loads. If not, they should be requested by the reviewer.

16.3.1.3 Wind Load

Use a value of 20 lb/ft^2 on the exposed area (based on an approximate wind speed of 60 mph). Wind load should be considered for falsework over 30 foot high.

Figure 16.2-1 Formwork and Falsework Minimum Requirements (1)

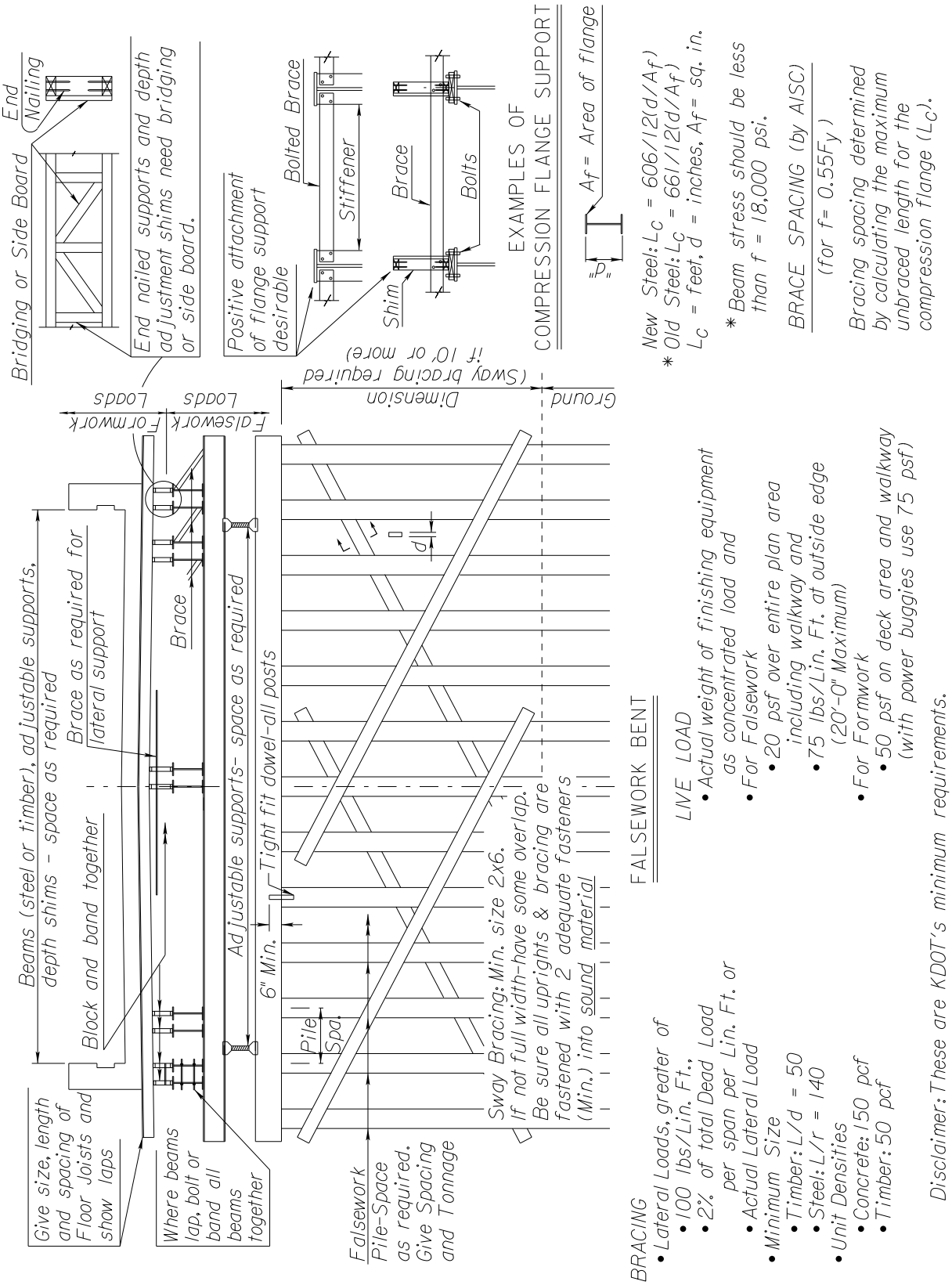
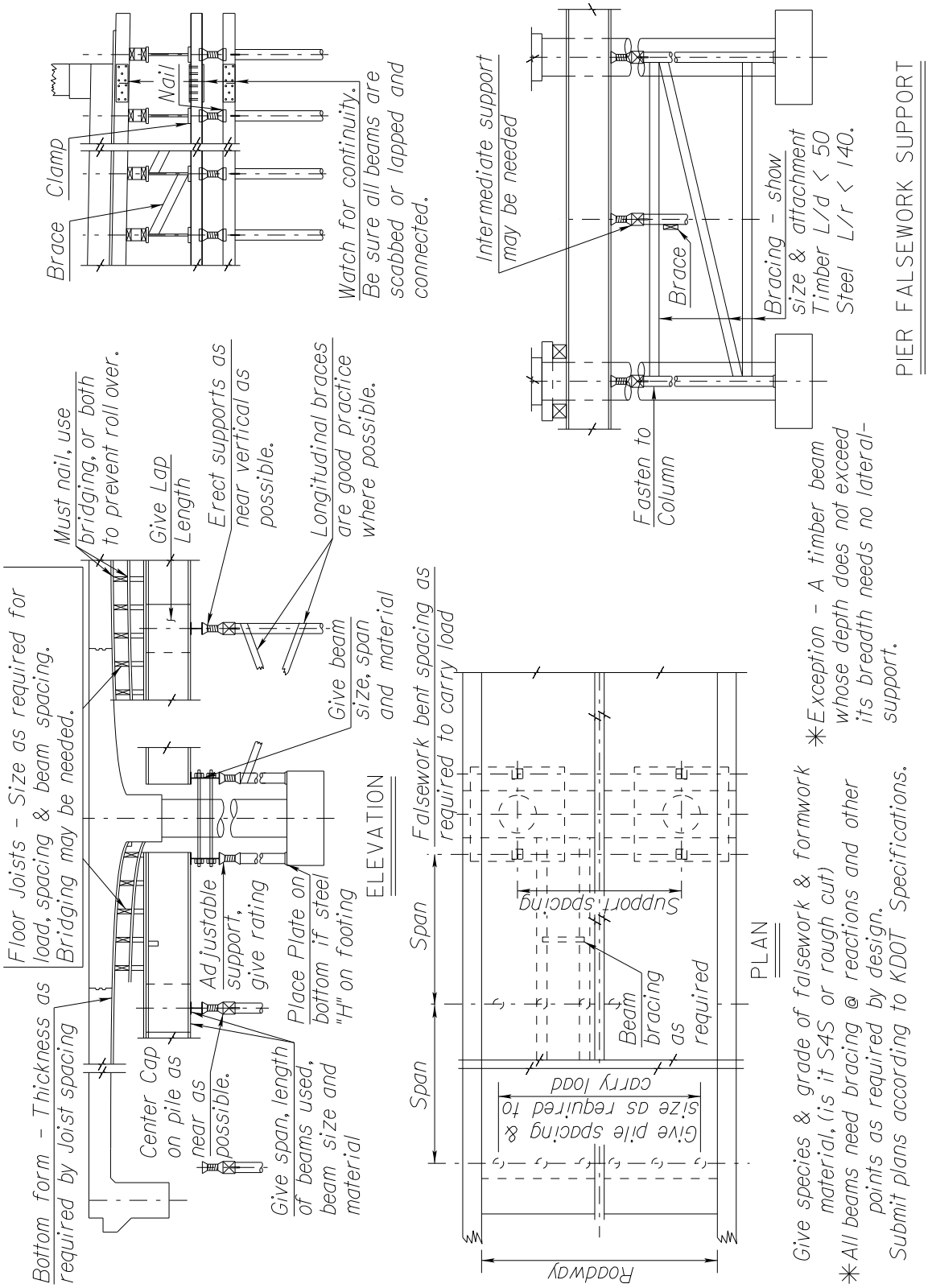


Figure 16.2-2 Formwork and Falsework Minimum Requirements (2)



16.3.1.4 Lateral Load

Minimum of two percent of total dead load. Superelevation and steep profile grades may combine to produce very large lateral loads. Falsework supporting bridge roadways with combination of profile grade and/or superelevation greater than 0.04 ft/ft shall use a minimum lateral load of four percent of total dead load.

16.3.1.5 Vertical Load

The minimum vertical load to be used in the design of falsework member shall be 100 lb/ft^2 measured over the total area supported by the member.

16.3.2 Loads on Formwork

Loads on formwork shall be investigated for all members down to the main support members. For dead load, use the weight of the formwork plus the weight of the freshly placed concrete. For live load use 50 lb/ft^2 unless motorized carts are to be used in which case, 75 lb/ft^2 should be used over the deck area. The finishing machine shall be added as a concentrated load. The minimum design value of combined dead load plus live load on the bridge deck (excluding walkway) shall not be less than 100 lb/ft^2 (125 lb/ft^2 if motorized carts are used.) The walkway and supports should be designed for a live load of 50 lb/ft^2. See Figure 16.3.2-1 Loads on Formwork and Falsework.

Superstructure supported formwork such as overhang brackets, deck walers, hangers and needle beams used on girder bridges are subject to direct and nonredundant load distribution and therefore it is KDOT's policy to design these members using the more conservative formwork live loading as described above. See Figure 16.3.2-2 Loads on Superstructure Supported Formwork. With respect to falsework review requirements, the normal proprietary deck stringer/joist/overhang brackets used on girder bridges need only be reviewed when used on Category 1 or Category 2 structures. Use of needle beams is categorized as a Category 1 structure. See KDOT specifications.

16.4 Analysis

In general, due to the condition of used material, the variance in quality of construction, unexpected construction loads and the consideration of safety for construction personnel and the traveling public, it shall be KDOT's policy to use conservative values of allowable structural capacity.

Unless otherwise directed on the plans, used material will be permitted when it conforms to the dimensions and material specified on the falsework plans. Used material shall be free of splits, cracks, holes, and any other imperfections which will reduce the structural capacity. Number 2 Grade or better material is required.

When the Contractor can certify his material can support a greater stress, higher values may be used.

Refer to the latest editions of *AASHTO LRFD Bridge Construction Specifications* and *AASHTO Guide Design Specifications for Bridge Temporary Works* for design parameters and procedures.

16.4.1 Timber - Allowable Stresses

Refer to the latest edition of the *National Design Specification for Wood Construction* (NDS) for wood material allowable stresses.

For driven timber piling the maximum unfactored design loads shall not exceed:

8” diameter = 10 ton/pile
10” diameter = 16 ton/pile

Compute pile capacity using the ENR pile driving formula.

16.4.1.1 Fasteners

For lateral load and strength of fasteners consult the current edition of ACI 347 Formwork for Concrete. It is KDOT policy to assume, for temporary structures, 100 percent of allowable design values may be used for lag bolts, nails, spikes, or thru bolts. When wind load is a design factor, connection values shall be 125 percent of design values.

16.4.2 Steel - Allowable Stresses

16.4.2.1 Bending

Steel used in falsework is often salvaged from older structures therefore use 33,000 psi for Fy. If the Contractor provides certification his material has a greater strength value (Fy), the higher value may be used.

In determining the lateral support of compression flanges developed by other falsework members, it is KDOT policy to ignore friction between the joists and top flange of a beam.

16.4.3 Deflection

When checking deflections, use dead load only.

16.4.3.1 Formwork

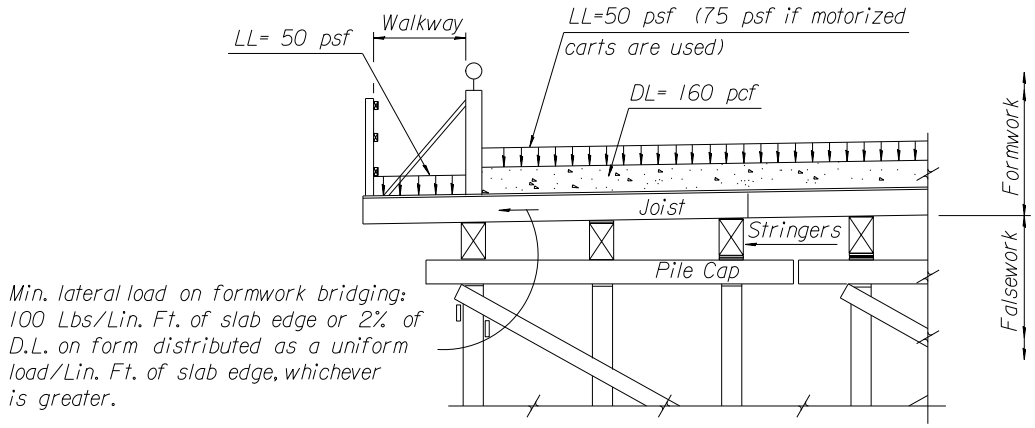
The deflection for formwork should be limited to span/360 with a maximum of 1/16” for deck plywood and 1/4” for walers.

16.4.3.2 Falsework

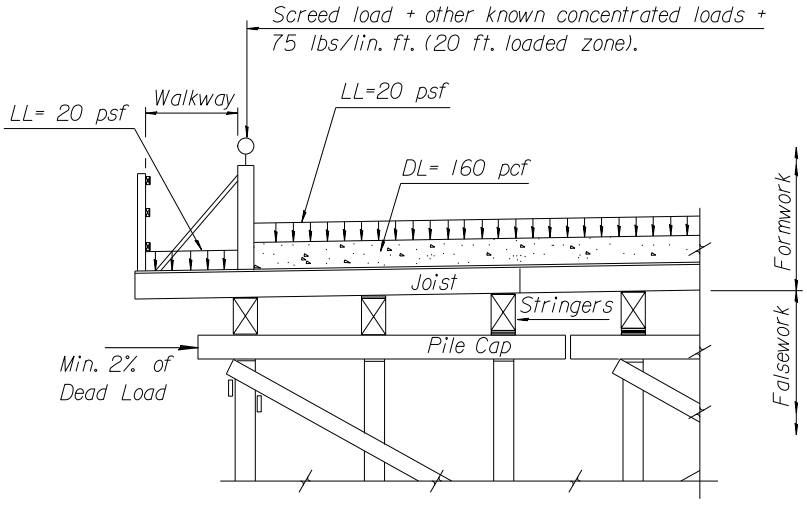
For falsework the deflection shall be limited to span/240 with a maximum of 1". Whenever the deflection on falsework beams exceeds 1/4”, adjustments should be made at the quarter points.

Figure 16.3.2-1 Loads on Formwork and Falsework

Note: Min. DL + LL on bridge deck (excluding walkway) = 100 psf (125 psf if motorized carts are used.)



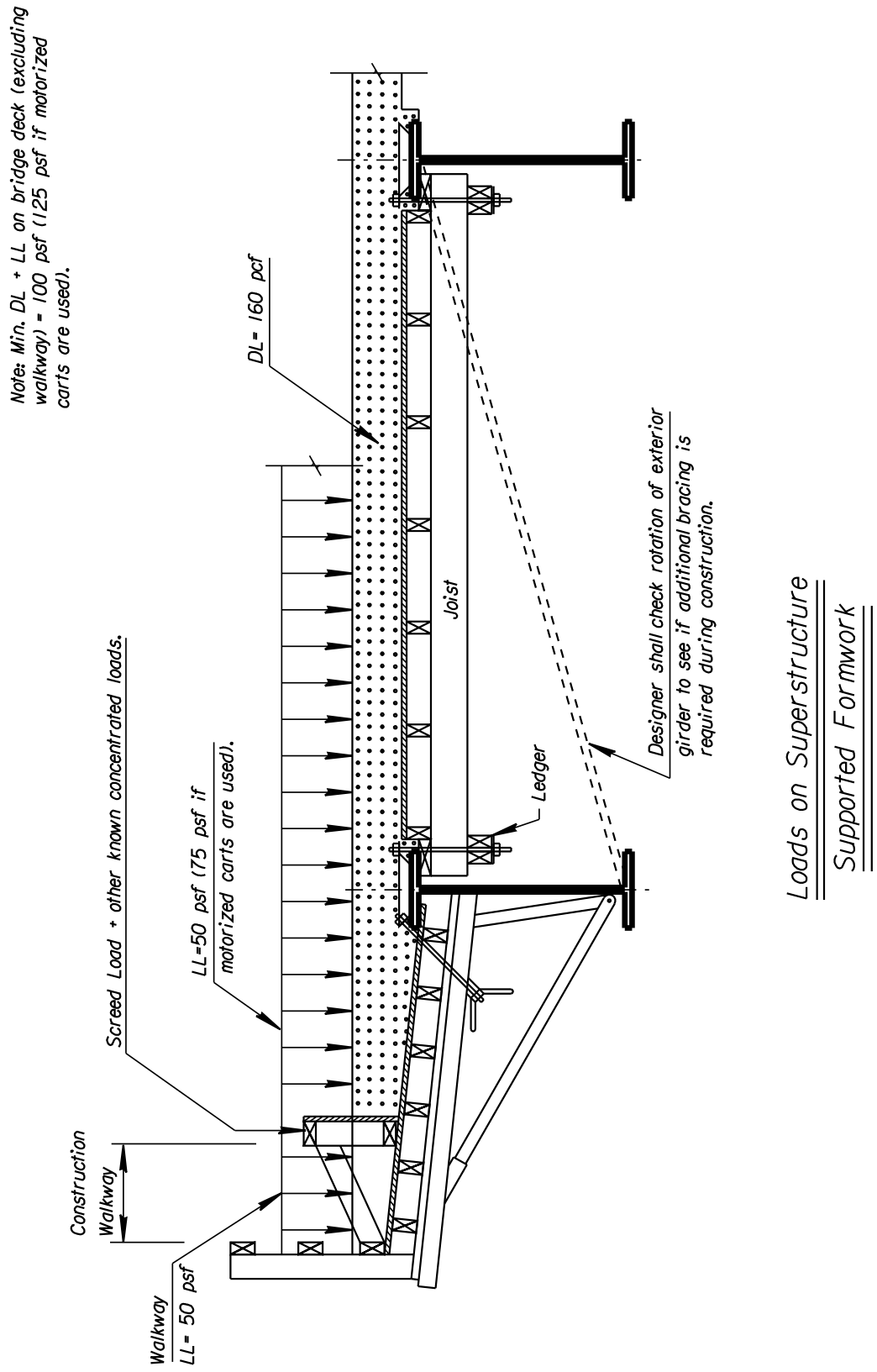
Loads on Formwork



Note: Min. vertical load to be used in the design of any falsework member shall be 100 psf measured over the total area supported by that member.

Loads on Falsework

Figure 16.3.2-2 Loads on Superstructure Supported Formwork



16.4.4 Soil Bearing

When checking the adequacy of a spread footing or sill, use the following allowable bearing values:

Below average soil: 2,000 lb/ft^2
Average soil: 3,000 lb/ft^2
Pavement: 6,000 lb/ft^2

Soil can be classified as average if it is firm enough to walk on without indentation of the heel of a shoe. Jacks may be required for adjustment of falsework due to settlement. Longitudinal bracing between bents founded on sills may be required to provide stability from lateral forces. Drainage can affect soil bearing capacity.

16.4.5 Friction

Coefficient of Friction: steel on steel: 0.10
steel on wood: 0.20
wood on wood: 0.30

Do not rely on friction for lateral support. Vibration, uplift, partial loading, etc., can reasonably be expected to reduce contact bearing during placement or erection.

16.4.6 Torsion - Exterior Girder

Overhang falsework design should not exceed the screed loads shown on the plans otherwise (if not already required) a licensed Professional Engineer will be required to analyze.

16.5 Manufactured Assemblies

If stock form accessories are used, the Contractor should submit technical data or a "Statement of Compliance" from the Contractor and signed by the manufacturer pertaining to the product showing safe load, material, intended use, how spliced or lapped, and how attached. Examples are:

- Jacks
- Coil ties
- Coil rods
- Overhang brackets
- Metal scaffolding

The Engineer must be able to verify the item is being used as the manufacturer intended.

16.6 Construction Plan Notes Relating to Falsework

The following plan notes should be used concerning falsework and camber for concrete slab bridges:

NOT4100, 4120, 4130, 4140, 7800 and 7810

The following plan note should be used concerning falsework bents at field splices and would be applicable to either bolted or welded connections for steel girders:

NOT6520

Standard Notes can be found on the Internet at http://www.ksdot.org/bureaus/burStructGeotech/standard_notes/main.asp

16.7 Structure Erection

For bridges that require Erection plans, Contractors are required to submit a detailed Erection Plan that follows the requirements of the Category noted in the design plans. The Erection Plan requirements by Category are defined in the KDOT Specification Field Erection.