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ENGINEERING INSTRUCTION

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

CONTINUOUS STRUCTURE
DECK SLAB PLACEMENTS

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CONTINUOUS STRUCTURE DECK SLAB PLACEMENTS

GENERAL

Deck slabs on continuous structures are subject to transverse cracking during construction. The cracking is found in areas where the deck has already been placed, and is caused by tensile elongation of the extreme fibers of the beams supporting those areas. The elongation is in response to the downward deflection of the structural support system in the remaining deck areas as the deck is being placed there.

The frequency of the cracking can be reduced if proper construction methods are used and strict control over the timing and sequencing of the deck placement operation is exercised.

Deflection cracks usually occur for one of the following three reasons:

I. SLOW RATE OF PLACEMENT.

When the concreting operation progresses slowly, some of the already-placed concrete may take its initial set prior to full deflection of the steel. As additional concrete is placed, during the same placement operation, cracks will occur in concrete which has set. To prevent this from happening, either the duration of the pour should be decreased, or the time to initial set of the concrete should be lengthened.

The time required to complete a pour depends on its size and complexity, concrete delivery logistics, available rate of supply, and Contractor efficiency. Responsibility for attaining the highest practical rate of pour, and the shortest possible pour time, at any particular project location rests with the Contractor.

The setting time for concrete can vary widely. It depends on many factors, such as mix design, use of admixtures, and atmospheric conditions. Retarding admixtures are intended to lengthen the time to initial set of the concrete.

To avoid cracking caused by the occurrence of initial set prior to completion of the placement, the duration of each pour shall be kept to a minimum, and no concrete shall be placed without sufficient retarding admixture to assure that initial set will not occur prior to completion of the placement.

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II. INCORRECT LOADING SEQUENCE.

Most continuous structures require a total volume of concrete which is too large to be placed prior to the occurrence of initial set at some point in the deck. In such cases, the total concrete volume must be divided into a sequence of pours. Although this method lessens the probability of cracking related to initial set, cracking may still occur if the sequence of applying concrete loads is incorrect.

When a sequence of pours is used, the location of the first pour is vital. Concrete cannot be placed in negative moment areas first because subsequent pours will impose tensile stresses on this concrete, resulting in transverse cracking.

Further, if any pour results in the upward deflection of concrete previously placed in a positive moment area, the concrete in that area may crack. Consequently, it is necessary to place concrete in each positive moment area during the initial pour. If the volume of concrete required to fully place all positive moment areas is very large, this may be difficult. Initial set could occur before placement is completed. This must be avoided. Therefore, either the concrete volume or the placement rate must be modified. The placement rate can be increased by the use of an additional finishing machine, in some cases. The volume can be decreased by adding some of the positive area to the negative area, to improve the balance between placement volumes. As a last resort, the positive moment area placement can be divided and placed in separate pours, but, in such a way as to minimize the potential for cracking.

On skew structures, the placement of the concrete and the operation of the finishing machine should parallel the skew angle. Loading the structure in this manner equalizes steel deflections. It may be necessary to operate the finishing machine at a reduced skew angle on certain very wide or highly skewed structures.

III. EARLY APPLICATION OF LOADS.

Immediately after initial set, deck concrete has little or no compressive (or tensile) strength. At this time, minor loads or deflections can cause serious cracking in the new deck. However, compressive strength increases rapidly to a point where moderate stresses (due to loads or deflections) can be resisted. For this reason, deck concrete, which will have any measurable effect on recently placed concrete, shall not be placed until adequate early strength may be assumed. A 72 hour waiting period, measured from start of pour to start of pour, is considered sufficient.

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INSTRUCTIONS TO DESIGNER

The Contract Plans for every continuous steel structure shall include a deck placement sequence. Two pours shall be shown, except for structures comprised of unusually long or numerous spans which will require special treatment. A pour is defined as the total volume of concrete placed during a continuous work period. It may result from one placement operation in one area, one placement operation in several areas sequentially; or two, or more, placement operations in several areas simultaneously.

"Pour 1" shall include the positive moment areas (except as noted below) in all spans. "Pour 2" shall include all the negative moment areas. Construction joint locations shall be shown in the deck placement sequence details. These joints shall be located at or near points of dead load contraflexure. (See Sketch A). In addition to delineating the pours, this information may be helpful to the Engineer should he be forced to terminate the Contractor's deck placement operation due to unforeseen circumstances.

When the total volume of deck concrete to be placed during "Pour 1" exceeds 350 Cubic Yards, two simultaneous placement operations shall be used. The Designer should specify this by including Note No. 7 (see attached notes) in the deck placement sequence details.

At a few project locations, the available supply of concrete will not support the use of two placement operations. The Designer must determine that sufficient concrete is available before specifying the use of two placement operations on the plans. The determination may be obtained by asking the Regional Materials Engineer. When the use of two placement operations is impractical, or when special treatment is in order due to unusual length or number of spans, Pour 1 may be divided into Pour 1A and Pour 1B. The plans should show Pour 1A to be comprised of end span positive moment areas only. A note shall be added stating that the segments labelled Pour 1B shall not be placed until a minimum of 72 hours after the start of the Pour 1A placement. This procedure confines the risk of deflection cracking to end span areas near the points of contra-flexure only.

In certain instances, where the concrete volume is very large, the Designer may elect to modify the "Pour 1" segment lengths to include some positive moment area in "Pour 2". This may be accomplished in either of two ways:

1. Move the location of construction joints up to 5% of the span length into the positive moment area (See Sketch B).

2. Introduce an additional construction joint within 20% of the span length from the abutment, in end span positive moment areas only (See Sketch C).

Either, or both, of these methods will reduce the duration of "Pour 1". The total placement volumes of "Pour 1" and "Pour 2" will also become more equal, thus facilitating the Contractor's operations.

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INSTRUCTIONS TO DESIGNER (CONTD)

Construction joints shall be shown parallel to the skew angle, regardless of the orientation of the reinforcement.

Longitudinal construction joints shall not be used to reduce pour size.

The direction of pour shall be shown on the plans. When the finish grade of the bridge deck exceeds 3%, the direction of pour shall be uphill.

Camber-deflection data shown on the plans shall be based on the pour sequence shown on the plans. The loads imposed by "Pour 1" will be supported by the non-composite beam section and partial deflections shall be computed accordingly. The loads imposed by "Pour 2" will be supported by the composite beam section, n = 27, in positive moment areas, and by the non-composite section in negative moment areas. Partial deflections from the various placements included in "Pour 2" shall be computed, assuming simultaneous placement. Since the effect of placing these concrete loads in negative moment areas is relatively minor, no revisions to plan values for camber or haunch dimensions shall be made in the event that the Contractor deviates from the "Pour 2" sequence during construction.

The Designer shall check for uplift at bearings. Where uplift is anticipated, a load vector shall be shown at the free end bearing line (usually an abutment) toward which "Pour 1" is progressed. It shall be accompanied by a note reading: "Provide uplift restraint equal to _____ Pounds/Bearing. The cost of this restraint shall be included in the price for the appropriate concrete deck item." (See Sketch A).

NOTES TO BE SHOWN ON THE PLANS

The following notes shall be used in conjunction with the deck placement sequence details shown on the plans:

1. The concrete deck slab for this structure shall be placed according to the placement sequence shown. The Contractor may, at his option, submit an alternate procedure to the Engineer, for review and approval of the D.C.E.S. No related work, including the installation of forms, may be progressed by the Contractor until the written approval of the alternate procedure is received from the D.C.E.S. The D.C.E.S. will reply within ten (10) working days after receipt of Contractor's procedure. The D.C.E.S. will not approve procedures which increase the probability of deflection cracking.

2. Concrete placement and finishing operations shall be performed as rapidly as possible. The Engineer may order the Contractor to stop his pour operations at any time if, in the Engineer's opinion, concrete placed during the pour has started to set, or is about to set, and further placement of concrete will cause deflection cracking.

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NOTES TO BE SHOWN ON THE PLANS (CONTD)

3. In the event the Contractor's deck placement operation is stopped prior to completion of Pour 1, whether by his own decision or by order of the Engineer, the Contractor shall be responsible for providing a finished deck grade which matches the planned profile. Any subsequent revisions to deck forms made necessary by such action shall be at the Contractor's expense.

4. Construction joints shall be placed parallel to the skew angle. Deck concrete shall be placed so that the leading edge parallels the skew. Finishing machine(s) shall be operated as close to the skew angle as practicable. Texturing shall be done parallel to the alignment of the finishing machine.

5. All areas shown on the Plans as "Pour 1" must be placed during the initial continuous work period. Subsequent pours (continuous placements) will not be permitted until 72 hours after the start of the previous pour.

6. Longitudinal construction joints will not be permitted.

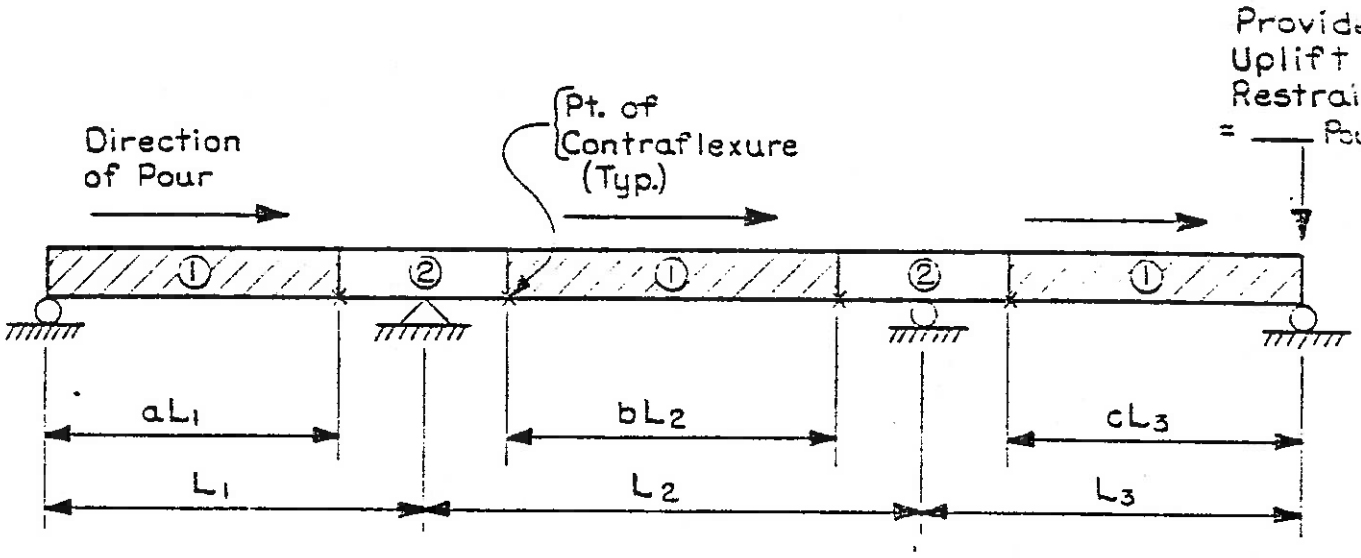
   OPTIONAL NOTE: Insert the following note when the Designer specifies that two simultaneous placement operations shall be used.

7. Pour 1 shall be accomplished by the simultaneous operation of two finishing machines and crews. A minimum rate of placement of 30 CY/HR shall be maintained by each machine.

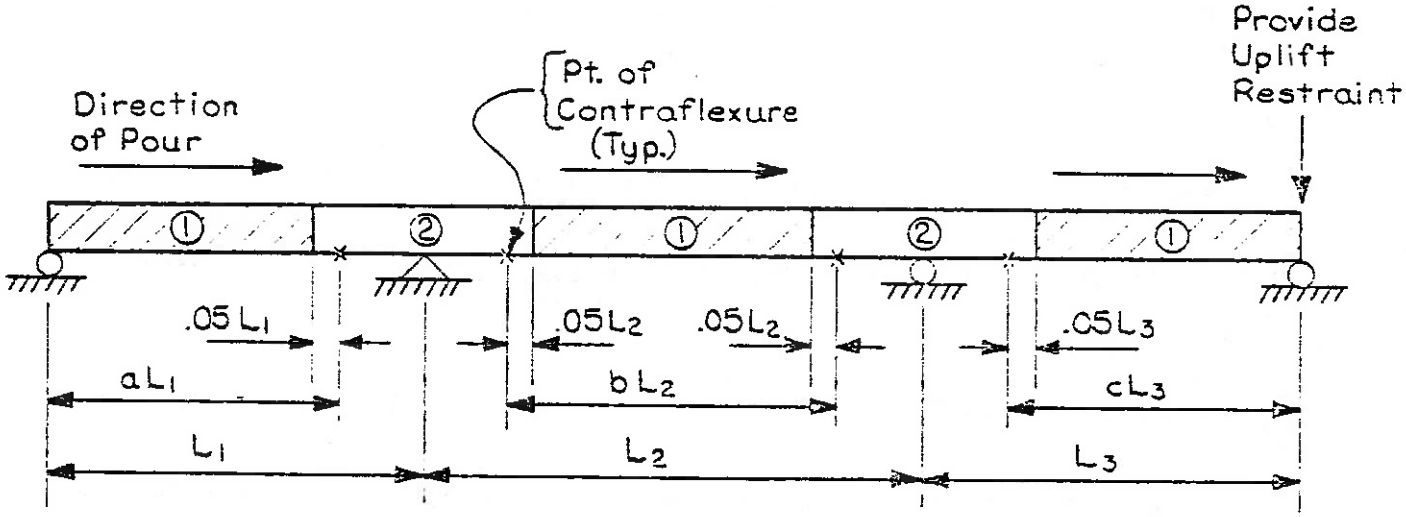
   OPTIONAL NOTE: Insert the following note when the structure contains three or more spans.

8. The Contractor may divide Pour 2 into separate segments provided the 72 hour waiting period between pours is observed.

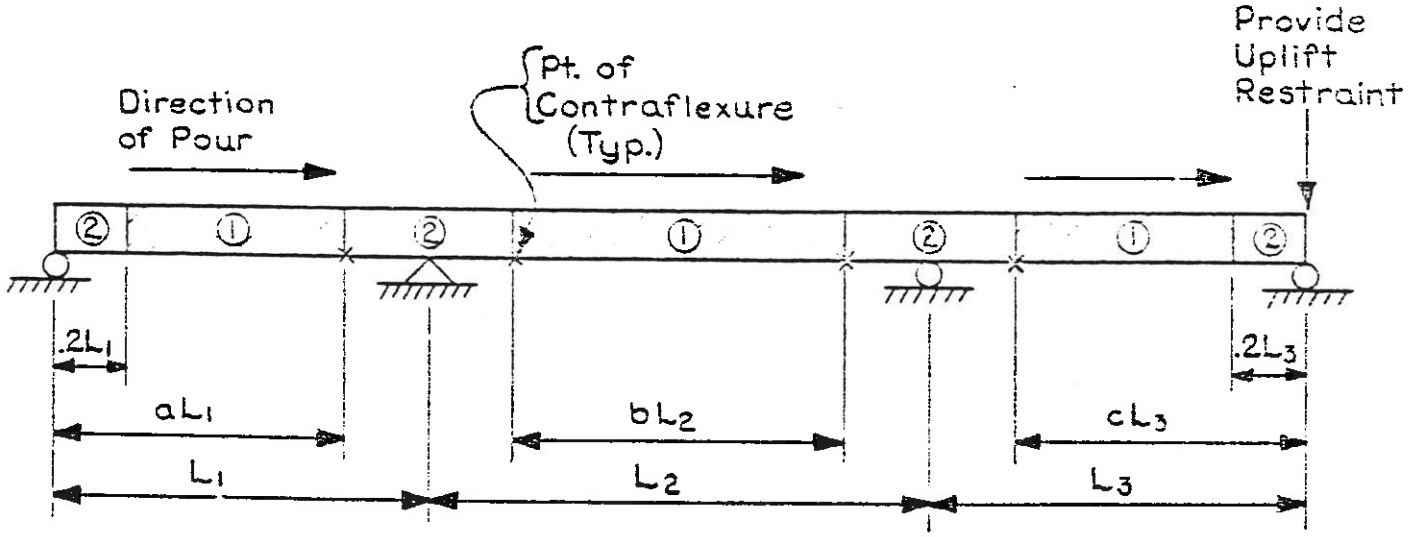
EXAMPLES OF DECK PLACEMENT SEQUENCES



SKETCH A



SKETCH B



SKETCH C