



An ACI Manual

# Formwork for Concrete

8<sup>th</sup> Edition

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*(Photo courtesy Morley Builders)*

## 1: INTRODUCTION

Formwork development has paralleled the growth of concrete construction from its earliest uses through its many applications today. As concrete has been used for increasingly complex and significant structural and architectural tasks, formwork engineers and contractors have had to keep pace. Projects involving rapid construction schedules create challenges for the form designer and for the control of field forming operations. The increasing use of concrete as an architectural medium presents the form builder with several challenges, ranging from the selection of appropriate sheathing materials to the maintenance of rigid tolerances.

Sawn lumber, manufactured wood products, plywood, steel, aluminum, reinforced polymers, and other materials are widely used as formwork components. In addition, new and specialized accessories are frequently introduced by manufacturers. Form designers, builders, and manufacturers must keep abreast of advancing technology in other material fields to develop and implement the creative and innovative solutions required to maintain both quality and economy.

In the early days of the concrete industry, formwork was frequently built in place, used once, wrecked (or stripped), and discarded. Because of high labor costs in the United States and many other countries, the trend over the last several decades has been toward increased prefabrication, assembly in large units, erection by mechanical means (such as “flying” forms into place by crane), and reuse of the forms. These developments are in harmony with the increased mechanization often found in other fields and the desired use of sustainable systems. Consequently, the forming system selection is often a primary factor in locating cranes and in allocating site space for storage and fabrication.

Not all of the important ideas are new, however. As early as 1908, members of the American Concrete Institute (then called the National Association of Cement Users) were debating the relative merits of wood and steel formwork at their annual convention. The discussion followed a presentation proclaiming the advantages of a modular metal panel forming system.<sup>1,1</sup> It could be adapted for most any project, had its own connecting hardware, and was good for extensive reuse. By 1910, steel forms for paving were being



Fig. 15.15: External ties and full-span wales used to avoid internal ties (Photo courtesy MEVA Formwork Systems)



Fig. 15.16: Formwork for a hammerhead pier cap supported on brackets attached with through bolts (Photo courtesy EFCO Corp.)

Pier cap and strut forms may be made as part of the shaft form or may be supported by shoring up from the ground with shoring frames or timber posts. They can also be supported on adjustable single-post shores for low elevations, or on steel beams attached to inserts or to large through-bolts placed in sleeves cast into a previous lift of pier concrete. For light beam caps on circular pier shafts, friction collars (Fig. 15.17) can be used to carry all or part of the cap formwork.

### 15.3 Superstructures

Bridge superstructures include girders, a deck or roadway, curbs, sidewalks, and railings or parapets. Concrete bridge decks may be simple slabs for short spans or slab and girder construction for longer spans. They may be entirely cast-in-place, entirely precast, or a combination of cast-in-place slab with steel or precast concrete supporting girders. Many of the forming problems and techniques are similar to those for other slab work, the major difference being the problem of support for formwork when spans are at great height, over water, or above unsatisfactory earth support. For special considerations and recommendations, refer to ACI 345R-11, "Guide for Concrete Highway Bridge Deck Construction," and ACI 345.2R-13, "Guide for Widening Highway Bridges." The use of mortar-tight deck and superstructure forms provides a smooth unblemished appearance that will enhance public confidence in the soundness of the structure.

#### 15.3.1 Monolithic—Simple Slab, Beam, and Girder

Bridges with short spans between supports (less than 25 ft) may be built as simple slab decks. Because these simple slab bridges are sometimes designed with the expectation that the curbs will supply part of the bending resistance, the curbs may be cast integrally with the deck slab. Formwork for a slab deck is like that for any other slab; sheathing of metal, wood, plywood, or other material is supported on joists and stringers. Edge forms are equal in height to the curbing and are braced externally from joists extending beyond the deck width. The form is supported from below by any one of the various types of shoring, or on heavy horizontal members supported on the piers. On projects where there are many identical short spans, large one-piece forms have been used for an entire span, then lowered to barges and floated to the next position for reuse.



Fig. 15.17: Round column friction collar example (Image courtesy EFCO Corp.)

### 15.3.2 Cast-in-Place Deck Supported on Steel or Precast Girders

Formwork details may differ, but the general method of forming slabs is the same whether supported on steel or precast concrete girders. Formwork members either rest on the lower flange or haunch of the beam, or they are hung with various manufactured devices from the upper flange. Several hanging devices are discussed in Chapter 11.

To eliminate the problem of stripping forms high in the air, stay-in-place deck forms are sometimes laid directly on steel or precast concrete bridge girders. The form material may be precast concrete, or corrugated metal so that no stiffening joists are needed. Such stay-in-place forms (Fig 15.18) are usually used on short spans where intermediate supports for the form are not required.

Corrugated metal may rest on top of or between the already-placed bridge framing. Precast concrete deck forms (Fig. 15.19) usually become an integral part of the load-bearing deck after the cast-in-place deck concrete hardens and bonds to the forms. The roughened top surface of the panel improves bond with cast-in-place concrete. Projecting loops of reinforcing steel provide shear reinforcement and also serve as lifting attachment points. The panels are placed on a grout bed that provides both a sealer and elevation adjustment to compensate for different stringer elevations and camber.

When there are excessive variations in the camber of steel or precast concrete girders, adjustment of the slab thickness to give a smooth upper roadway may go beyond tolerances permitted in slab construction and result in greater dead load on the girders than anticipated. A typical design approach uses small haunches over the top flange. Changing the depth of haunch compensates for camber variations without changing slab thickness. Forming for such a haunch is shown in Fig. 15.20.

Figures 15.20 and 15.21 show example arrangements for forming a bridge deck using adjustable hangers supported on the top flange of the steel beam. Main supporting form members are first hung between the steel girders and adjusted for elevation. Spacer blocks are set on these wood members and joists laid across the spacer blocks. Decking



Fig. 15.18: Stay-in-place steel forms attached by self-tapping screws to angle ledgers that have been welded to structural steel bridge girders (Photo courtesy of New York State Department of Transportation©)



Fig. 15.19: Stay-in-place precast concrete deck forms supported directly on concrete girders

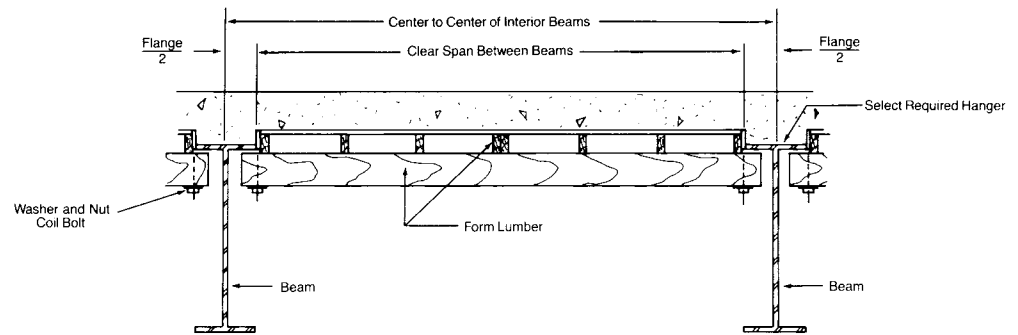


Fig. 15.20: Construction arrangement for removable bridge deck formwork (Image courtesy Dayton Superior)

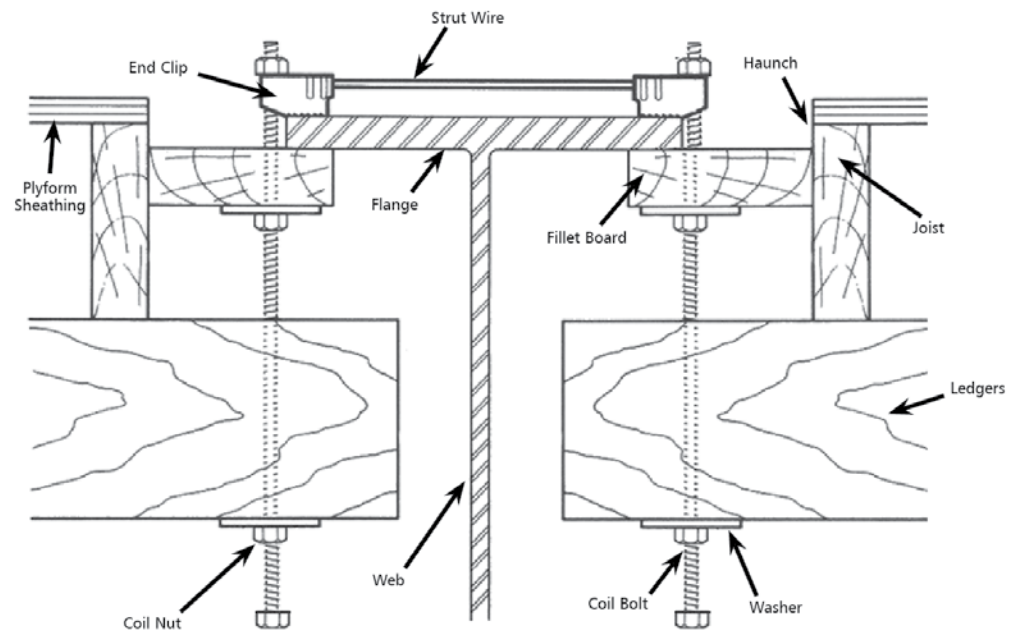


Fig. 15.21: Example hangers for bridge deck formwork (Image courtesy Dayton Superior)



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