

9-3 WIDENING EXISTING BRIDGES

The widening of an existing bridge presents a multitude of individual challenges during the planning and design phases, during construction, and throughout its service life. Special attention is required in both the design and detailing of the widening in order to minimize construction and maintenance problems.

A successful bridge widening begins with a careful study of relative movement between the new and existing structure. Dead load and live load deflections (both short and long term), temperature movements, prestress deflection and shortening, settlement, seismic movement, basic structure continuity and stability, are all factors that must be “tuned” to provide a widening that is structurally compatible with the existing bridge.

Information Sources

Detailed information should be obtained prior to deciding how to design the widening. Some sources which may be utilized are:

- a) Bridge Site Submittal: The District is responsible for providing the basic information concerning geometrics for the anticipated widening.
- b) Structure Maintenance & Investigations (SM&I): Designers should review bridge inspection records that are available in the Bridge Inspection Records Information System (BIRIS) (*). The Structures Replacement and Improvement Needs (STRAIN) Report should be checked for substandard items of work identified therein. A discussion with the Area Bridge Maintenance Engineer (ABME) is often helpful.
- c) Preliminary site investigation: Designers should perform a site investigation, request a Preliminary Report from the Preliminary Investigations Branch (PI), or obtain similar information from District survey crews, or local construction staff.
- d) Preliminary Foundation Report: Upon request, Geotechnical Services can perform initial evaluations of subsurface conditions based on as-built data (as the support locations will likely match the existing borings in the immediate vicinity) or perhaps obtain preliminary boring data.
- e) As-built construction drawings: Designers should review as-built drawings that are available electronically in BIRIS(*).

- f) Photo log: The Division of Traffic Operations in Headquarters maintains recent photos from a driver's perspective, which details approach rail, bridge rail, terrain, and possible deck overlays.
- g) Digital Highway Inventory Photography Program (DHIPP) (*): Contains aerial photographs along most state highway right of ways.
- h) Document Retrieval System (DRS)(*): Contains roadway as-built plans along most highways. It is useful for obtaining as-built plans for retaining walls, culverts, and other roadway facilities that are not in BIRIS.

Existing Structural Capacity

An existing bridge may not meet current standards in one or more of the categories discussed below:

- a) Hydraulic. When widening bridges over water, the Structure Hydraulics Branch, along with Structure Maintenance and Investigations, should be consulted and a hydraulic study developed. An existing bridge may not be listed as scour critical or may be listed as marginally scour critical in its present condition. However, degradation potential may increase due to the effect of the widening and can even make the bridge become scour critical. New footings may need to be located below existing footings and countermeasures taken to protect the existing footings from future scour.
- b) Safety. If a structure is slated for widening and doesn't meet current geometric standards, or if it has obsolete barriers or some other safety deficiency, the District should be notified, preferably in the Advanced Planning stage. Depending on the physical condition, operating characteristics, and remaining service life of the structure, it may be appropriate to estimate the cost to upgrade the structure accordingly.
- c) Seismic. Because of the large number of factors to be considered in widening a structure, the Design Engineer, after consultation with a representative of the Office of Earthquake Engineering (OEE), should decide whether a strategy meeting shall be held in the planning stage (K-phase) in order to obtain a consensus on the total scope necessary for the widening. A representative of OEE shall be invited to both the strategy meeting and the type selection meeting.

* For security reasons, these sources may not be directly available to consultants, outside agencies, or the general public.



- d) Live Load. With the implementation of the *AASHTO LRFD Bridge Design Specifications* and California amendments (hereafter LRFD), it is anticipated that the majority of California's bridge inventory will not meet the design live load criteria. However, Caltrans' bridge rating and posting criteria remains unchanged. A bridge should only be considered to be limited for live load when so directed by the Office of Structure Maintenance and Investigations.

Widenings on bridges designed using the *Caltrans Bridge Design Specifications* (BDS) shall be designed using the *AASHTO LRFD Bridge Design Specifications* as amended by Caltrans to the largest extent possible, without re-analyzing the existing structure for LRFD loads. Widenings on stand-alone substructure shall be LRFD. The *Caltrans Bridge Design Specifications, LFD April 2000* (BDS) may be used for overhangs without girders and elements connected to the existing structure such as closure pours, if the existing structure was designed using BDS. If the widening shares support, such as cantilevering the deck, slab, and/or bent cap off of the existing structure, BDS and its HS20 vehicular live load may have to be used in order to maintain an acceptable structure depth. Caltrans current practice is to design abutments based on working stress design (BDS) using the Service I limit state load combination from LRFD. After 2010 abutment design will be based on LRFD. See Table 1 for a complete list of components and design methodologies. An "exception" must be granted during the Type Selection meeting if designs deviate from the above or do not prescribe to the conditions listed therein.

Traffic handling and staging during construction, width and mass of widening (see Memo to Designers MTD 20-12), environmental constraints, number of structures on route that restrict permit loading, and other site-specific conditions should be considered when making recommendations.

When developing the project original scope of work, extra care should be taken in the early stages to identify all substandard aspects of the existing structure. It can be very difficult to get additional funds for unanticipated work once the original scope is set. Interagency funding agreements may limit cost increases. The limits of the environmental documents may not cover the limits of new work. Traffic restrictions may preclude some kinds of unanticipated work.

When unanticipated work is encountered, the District should be informed of the scope change and the updated costs as soon as possible. A Project Change Request (PCR) may be required.

When substandard capacities are discovered that cannot be adequately addressed in a project, these items should be reported to Structure Maintenance and Investigations for inclusion in the STRAIN Report. With limited funding available, STRAIN is designed to correct higher risk problems first.

Handling of Traffic

The reduction or elimination of traffic disruptions at construction sites is becoming more important each year. A higher commitment to context sensitive solutions has led to innovative ideas to speed construction and minimize road closures. Although this often leads to higher project costs, these can often be justified by reducing traffic disruption thereby resulting in better public relations. At no time should the safety of the public or construction personnel be compromised.

Traffic disruption should be minimized and separated from the work with a temporary barrier railing located in such a manner that public protection is provided. It is normally preferable to do as much of the work as possible prior to the removal of the existing curb and railing. Temporary road widths and details for the temporary barrier railing should be shown on the plans (MTD 14-19). When detours are not available during construction, efforts should be made to move traffic at least one lane away from the widening during placement of the deck concrete, particularly for structural steel girder widenings.

Falsework placement and removal has considerable impact on traffic and measures should be taken to minimize these impacts when possible. Allowing the contractor options to reduce traffic impacts due to falsework should be encouraged. Some examples are as follows:

- a) Use precast girders/members to eliminate falsework.
- b) Employ stay-in-place forms or permanent concrete deck forms for closure pours to reduce falsework removal over congested traffic (See MTD 8-7).
- c) Allow the bridge to be cast on higher falsework and, when completed, lowered into place. Cast high-and-lower will require special falsework design and specifications.

Discussion and planning for traffic handling, both on and below the structure, should commence with the District as early as possible. See MTD 21-19 for more detailed instructions on clearance needs and communications with the District.

Type Selection

Generally, in selecting the type of girder for a structure widening, the following considerations are involved: type of original structure, available space for falsework, relative economy, comparable live load deflection, and effect of construction on traffic. Whenever possible, every effort should be made to widen an existing structure with the same structure type. If this is not possible, the stiffness of the superstructure widening should be carefully considered with respect to the existing structure. To minimize the amount of falsework required, and its effect on traffic, the following solutions should be considered in addition to cast-in-place construction:

- a) Widening T-beam structures with a precast I-section.
- b) Widening steel structures with steel girders or precast I-girders.
- c) Widening box girder structures with precast inverted T-girders or precast box girders.
- d) Parallel box girder structures may have the median decked by utilizing precast I-girders.

Longitudinal Joints

Past performance indicates that longitudinal expansion joints between a widening and an existing bridge have been the greatest single source of bridge maintenance problems. Therefore, as a general policy, widenings are to be attached to the existing structure without longitudinal expansion joints. Special attention to the attachment detail cannot be overemphasized. The following recommendations should be followed when widening an existing structure.

- a) Structures with sufficient length of original transverse deck reinforcing to develop adequate bond length for lap splicing should be attached by removing the concrete from the overhang.
- b) Structures, with overhangs that would not provide sufficient bond length should either be doweled to the widening or have transverse reinforcing exposed and extended by butt welding or mechanical lap splice.
- c) Structures with no overhangs should be attached by doweling the existing structure to the widening. Double row patterns for the dowels perform better than a single row. Cutting into the existing exterior girder as a means of support has proven to be unsatisfactory.

When doweling reinforcing into existing concrete two methods can be utilized: drill and grout dowels or drill and bond dowels. Drill and bond dowel is the preferred method. Both methods require a sloped hole, at least 3:1. When a 3:1 sloped hole cannot be provided, drill and bond (chemical adhesive) should be used for doweling reinforcing. See BDA Chapter 5 for details about concrete anchorage methods.

Dead Load Deflection

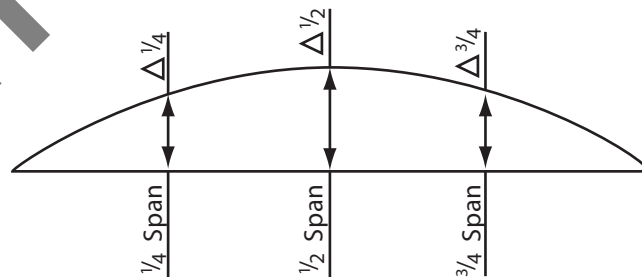
Two important facts must be recognized when considering dead load deflection; namely, the widening must initially be built above the grade of the existing structure to allow for dead load deflection, and the deflected widening must meet the grade of the existing structure. If proper provisions are not made to accommodate the dead load deflection, maintenance and construction problems will likely occur.

To minimize maintenance problems, it is recommended that when the dead load deflection exceeds $\frac{1}{4}$ inch, the main portion of the widening be allowed to deflect and a closure pour be utilized to complete the attachment to the existing structure. A minimum closure width of 3 feet is recommended.

Dead load deflection can be placed into two groups: precast or steel girder construction where the largest percentage of girder deflection occurs when the deck concrete is placed, and cast-in-place construction where the deflection occurs after the falsework is released. Cast-in-place post-tensioned girders can sometimes be designed for “zero” dead load cambers.

Precast or Steel Girder

The following sketches show the different stages of precast or steel girder deflection as the deck concrete is placed from one end of the girder to the other. Analysis of these sketches illustrates the importance of using a closure pour so that the grade of the widening will match that of the existing. For example, if the calculated camber for a structure is 2 inches at mid-span and $1\frac{1}{2}$ inches at $\frac{1}{4}$ span, when the deck has been placed for $\frac{1}{4}$ of the span $\frac{3}{8}$ inch of the $1\frac{1}{2}$ inches ultimate camber at $\frac{1}{4}$ span will have deflected. A few hours later, when the girder has been completely loaded, the remaining 1 inch of deflection will have occurred. In this case, a closure pour serves two useful purposes: It defers final connection to the existing structure until after the deflection from the deck slab weight has occurred; and it provides width to make a smooth transition between differences in final grade that result from design or construction imperfections.



Dead Load Camber Diagram

Figure 1

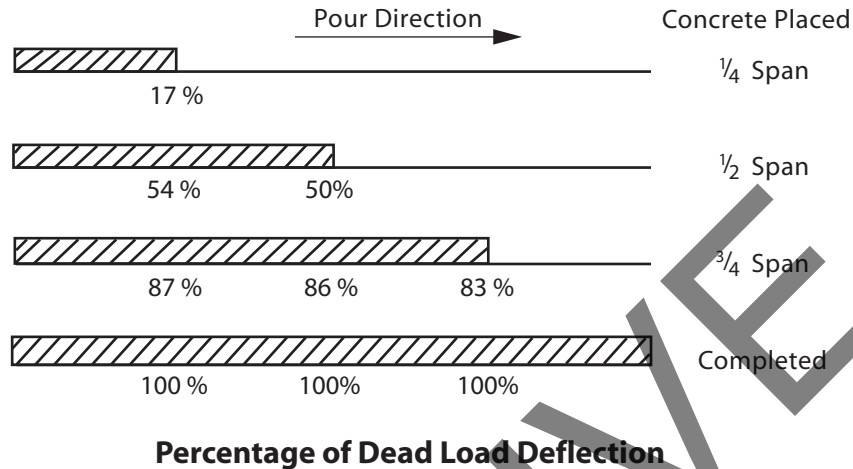


Figure 2

Cast-In-Place Construction

For cast-in-place structures, the dead load deflection continues after the falsework is released. The amount of deflection is of most concern in conventionally reinforced concrete structures, where approximately $\frac{2}{3}$ to $\frac{3}{4}$ of the total deflection occurs over a 4-year period after the falsework is released. A theoretical analysis of differential deflection that occurs between the new and existing after closure will usually show that it is difficult to design for this condition. Past performance indicates, however, that the theoretical overstress in the connection reinforcing has not been a maintenance problem, and it is generally assumed that the additional load is distributed to the original structure with no difficulty or is dissipated by plastic relaxation. Good engineering practice dictates that the closure width should relate to the amount of dead load deflection that occurs after the closure is placed and closure depth should be kept to a minimum. A minimum closure width of 3 feet is recommended.

Total deflection can be minimized by using prestressed girders and a balanced design. This will require an increase in prestress force beyond that required for dead load plus live load. Also, it is advantageous to delay the placing of the closure pour to reduce the transfer of load to the existing structure, to improve the riding quality of the deck, to lower the stresses in the closure slab and to allow for shortening of prestressed girders.

When the widening is constructed on falsework over traffic, it is desirable to remove the falsework as soon as possible to minimize the hazard to public traffic. In this case, the structure should be allowed to deflect for a long period of time before placing the closure pour. The following note should be placed on the plans:

“Falsework shall be removed as soon as permitted by the specifications. Closure pour shall not be placed sooner than 60 days after the falsework has been released.”

When falsework for a widening is not a hazard to traffic, the same overall results can be obtained in a shorter time by delaying the release of the falsework. If this is feasible, the Contractor should be given an option, and the following notes placed on the plans:

Falsework Release

Alternative 1:

Falsework shall be released as soon as permitted by the specifications. Closure pour shall not be placed sooner than 60 days after the falsework has been released.

Alternative 2:

Falsework shall not be released less than 28 days after the last concrete has been placed. Closure pour shall not be placed sooner than 14 days after the falsework has been released.

When Falsework Release Alternative 2 is used, camber values are 0.75 times those shown.

The falsework release note is available in the Microstation Standard Cell Library.

Seismic Standards for Widening

Bridges that are to be widened must meet the current seismic safety standards as discussed in *Memos to Designers* (MTD) Chapter 20. The extent and methods of upgrading will vary with each individual structure and will depend on the characteristics of the widening. MTD 20-12 provides guidance on the need to reassess the seismic retrofit requirements for existing bridges.

It is important to accurately identify the retrofit needs as early in the project as possible so that the project can be properly scoped and adequately funded. It is recommended that this be accomplished during the Advanced Planning Stage with preliminary seismic analysis. Potential replacement costs including staging and additional roadway work, should also be included to determine the appropriate strategy.

When developing bridge-widening plans, the designer is responsible for analyzing seismic behavior and ensuring the entire structure meets the required performance standard. The designer is referred to MTD 20-4 for seismic retrofit requirements and guidance and may consult with the Office of Earthquake Engineering (OEE) for conceptual recommendations. In addition, the designer may also consider upgrading the approach slabs to current standards (see MTD 5-3 for guidance).

Existing Deck Overhangs

The concrete beneath the curb and railing in existing deck overhangs may be of questionable quality due to the rough finishing and likely damage done in removing the curb and railing. In some cases, particularly in structures with short or non-existent overhangs, the concrete beneath the curb and railing must remain and the deck surface refinished. The specifications dictate the procedure for refinishing bridge decks, so only the limits of deck refinishing are required on the plans. When the concrete under the curb and railing is to be removed to expose sufficient bond length of reinforcing steel, show only the limits of concrete removal. The Standard Specifications, "Removal Methods," defines the procedure for concrete removal. As a general rule, omit all reference to saw cuts in the plans. Simply delineate and identify the limit of concrete removal. If other than the specified one-inch cut depth is desired, request a changed dimension in the special provisions by means of a memo to the Specifications Engineer.

When existing overhang removal is required to expose existing reinforcement for lap splicing, expect that some of the existing bars will be lost. It is a good idea to include a drill and bond replacement detail.

Some slab structures were originally designed for a future widening by providing 4-#10 bars near the edge of deck. For these slab structures it is recommended that the concrete under the curb and railing remain and the widening be attached to the existing structure by using a double row of dowels.

Live Load Deflection

All structures deflect when subjected to live loading and many bridge widenings are constructed with traffic on the existing structure. Fresh concrete in the widening, and later in the deck closure, is sensitive to deflections and vibrations caused by traffic. This can result in loss of bond between concrete and reinforcing steel. The deflection can be a particular problem with existing steel girder structures where the live load (LL) deflection is large compared to the widening.

Designers should work with the District to determine if, when, and how long traffic could be diverted to minimize vibration of a closure pour. If the time available is a matter of days, Class A PCC is satisfactory. If the vibration-free time is a matter of hours, a high early strength concrete product should be considered for the closure pour, and requested in a memo to the Specifications Engineer.

To minimize these effects when traffic is anticipated, statements similar to the following should be included in the special provisions:

- a) During placement of deck concrete, except that in the deck closure, reinforcing steel protruding from the new deck into the closure space shall be completely free of contact with the existing structure. Contact with existing reinforcing steel or concrete or attachments thereto, including forms, shall not be permitted.
- b) During placement of deck closure concrete, the new and existing transverse reinforcing steel within the closure shall be securely connected together or to common longitudinal reinforcement.
- c) Forms for the deck closure pour shall be supported from the superstructure on both sides of the closure space, unless otherwise directed by the Engineer.

A standard special provision is available for this purpose. It should be requested by means of a memo to the Specifications Engineer.

Relative LL deflection is a concern when widening a stiff bridge (CIP box girder) with a more flexible bridge type (steel girder). The LL deflection of the widening must be compatible with that of the existing structure or these movements usually result in a spalled deck at the connection. To minimize these effects for steel structures when traffic is anticipated, flexibility must be retained in the closure slab with the closures as wide and thin as possible.

Substructure

An existing structure will ordinarily not be subjected to any settlement of its footings by the time the widening is done. Pile capacities of existing structures should be checked by Geotechnical Services if additional loads are to be imposed on them by the widening. Equal axial and/or lateral load distribution between new and existing piles may not be appropriate. It is possible for footings under a widened portion of a structure to settle. Suitable provisions should be made to prevent possible damage when such movements are anticipated.

Generally, for cast-in-place structures, the bent caps should not be attached unless structurally beneficial to the bridge. When widening bent caps are to be rigidly attached to existing caps of continuous post tensioned structures, the designer should consider extending the closure pour wait time well beyond 60 days to allow maximum amount of prestress shortening to take place. Bent caps should not be widened by using drill and bond dowel methods.

Diaphragm abutments should be attached by doweling into the existing diaphragms. For widenings, the diaphragm abutments, pier walls or other rigid connections should not be attached initially until the structure has shortened and then a closure pour should be used to complete the attachment to the existing structure.

Checklist of Issues to be considered

- Traffic staging with location of barriers.
- Existing cross slope (generally match existing) and drainage.
- Polyester overlay.
- Vertical clearance to falsework if over traveled way.
- Vertical clearance of widened structure.
- Closure width if applicable.
- Closure pour wait period.
- Closure at abutment and walls if applicable.
- Show existing conditions as accurately as possible.
 - Concrete
 - Reinforcement
 - Joints
 - Utilities, Drainage, and Electrical
- Address any salvaged material.
- If existing structure has expansion joints, show details for cleaning and replacing full width whenever possible. This can be complicated if there is a large skew.
- Check for any changes that were made after the original structure was built such as utilities, drainage, electrical, slope paving, right-of-way (including lease space), etc.
- If possible, verify existing span lengths, and skews. They may vary from As-Built data.
- Grades on As-Built plans may be based on different datum than currently being used.
- Where concrete is removed and new concrete is added, show existing reinforcement as accurately as possible and designate the reinforcement that is to remain in place.

- If dowels are placed, show section of existing concrete with location of dowels.
- If a temporary support is required, show support load value and location.
- Show camber diagram.
- Sometimes a structure is widened without using a closure pour. If so, place a note stating that all concrete for the span shall be in place before performing final strike-off.
- Falsework removal note.
- Contractor shall verify all controlling field dimensions before ordering or fabricating any material.
- Scour.
- Non-typical situations:
 - Soundwall and affects on overhangs and existing exterior girders.
 - Widening curved bridges with straight precast girders.
 - Stability of narrow cast-high-and-lowered widenings.
 - Closed end cellular abutments. See MTD 9-8.
 - Long falsework spans over congested roadways in median widenings (high skew)
 - Flat casting precast girders may result in lower vertical clearance than anticipated on a high profile curvature. See MTD 11-8.
 - Girder camber fails to meet expectations.
- Typical Special Provisions/Items for widenings:
 - Bridge Removal.
 - Concrete.
 - Deck Closure Pours.
 - Drill and Bond Dowel
 - Drill and Bond (Chemical Adhesive)
 - Refinish Bridge Deck.
 - Temporary Supports

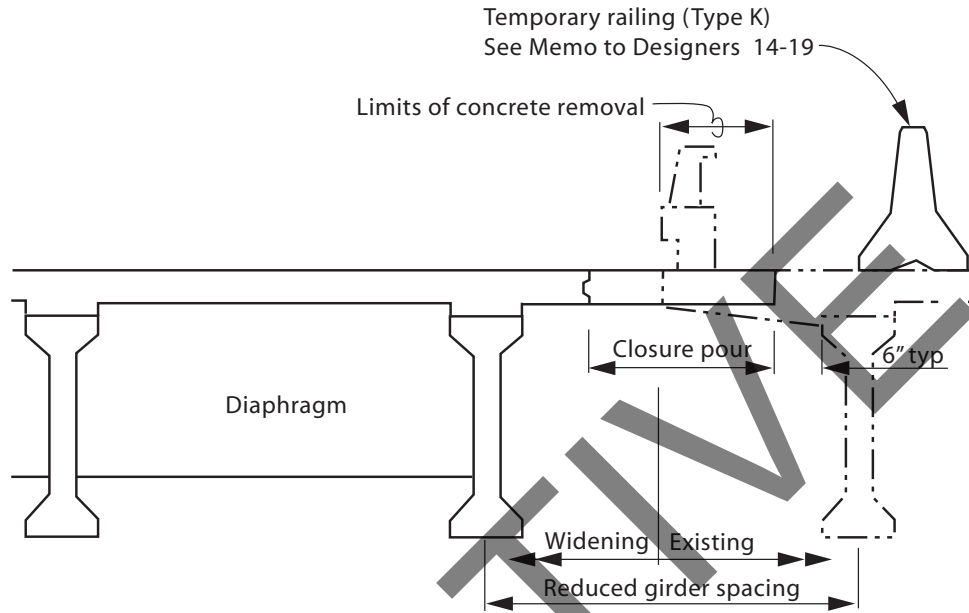
Details

The following sketches illustrate some preferred details, which have given satisfactory results. Since each widening job usually represents a unique situation, these details are offered as ideas rather than as complete solutions for every problem.

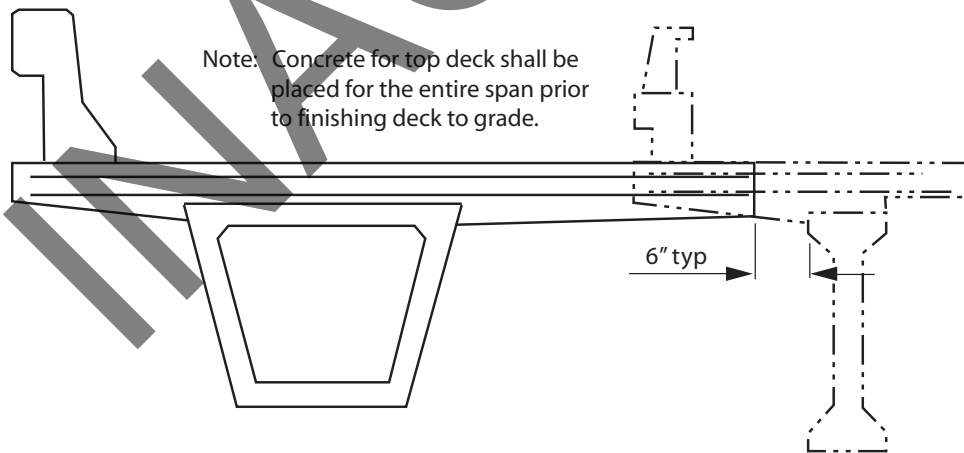
Experience has shown that positive attachment of the widened and original decks by lapping reinforcing steel provides a better riding deck, is usually better appearing, and reduces maintenance problems. It is recommended that a positive attachment of the old and the new decks be made for the entire length of the structure, rather than using longitudinal joints.

Closure pour details should be compatible with adjacent members.

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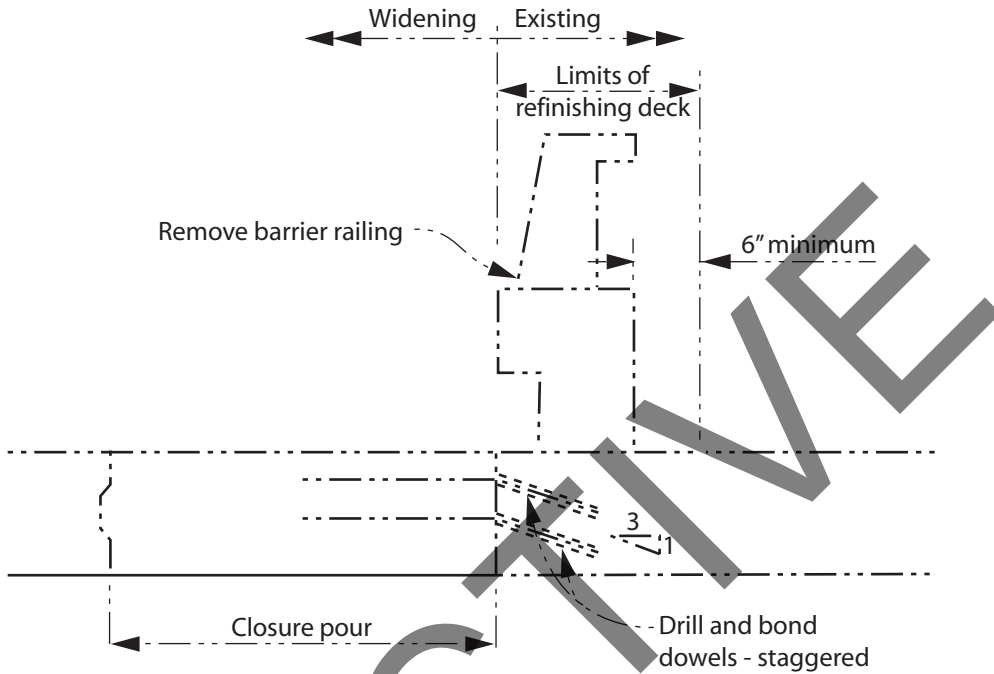
Multi-Girder Widening



Single Girder Widening - No Closure Pour

Widening Precast Prestressed Girder Bridges

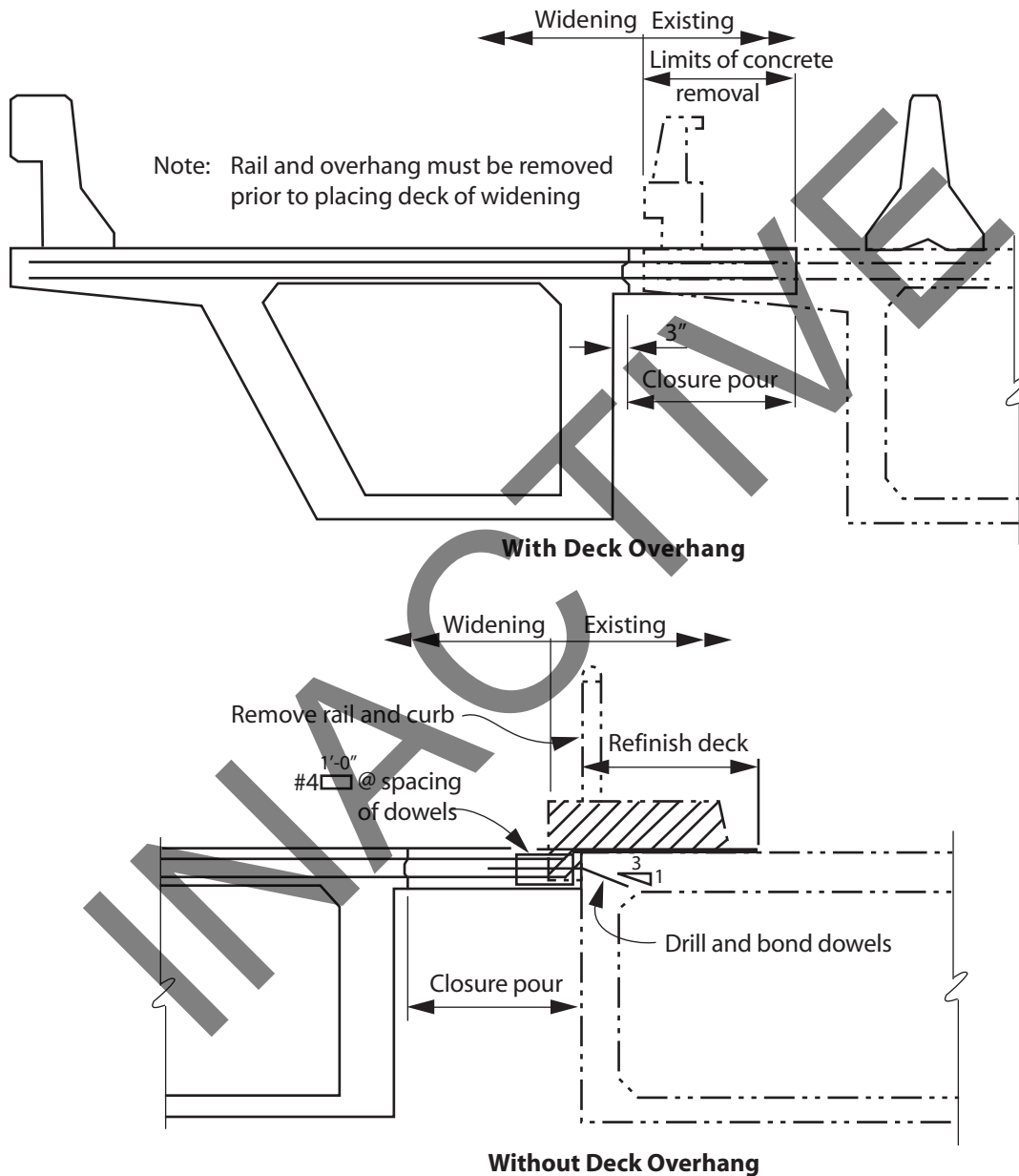
Figure 3



Widening Slab Bridges

Figure 4

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Widening Cast-In-Place Bridges

Figure 5

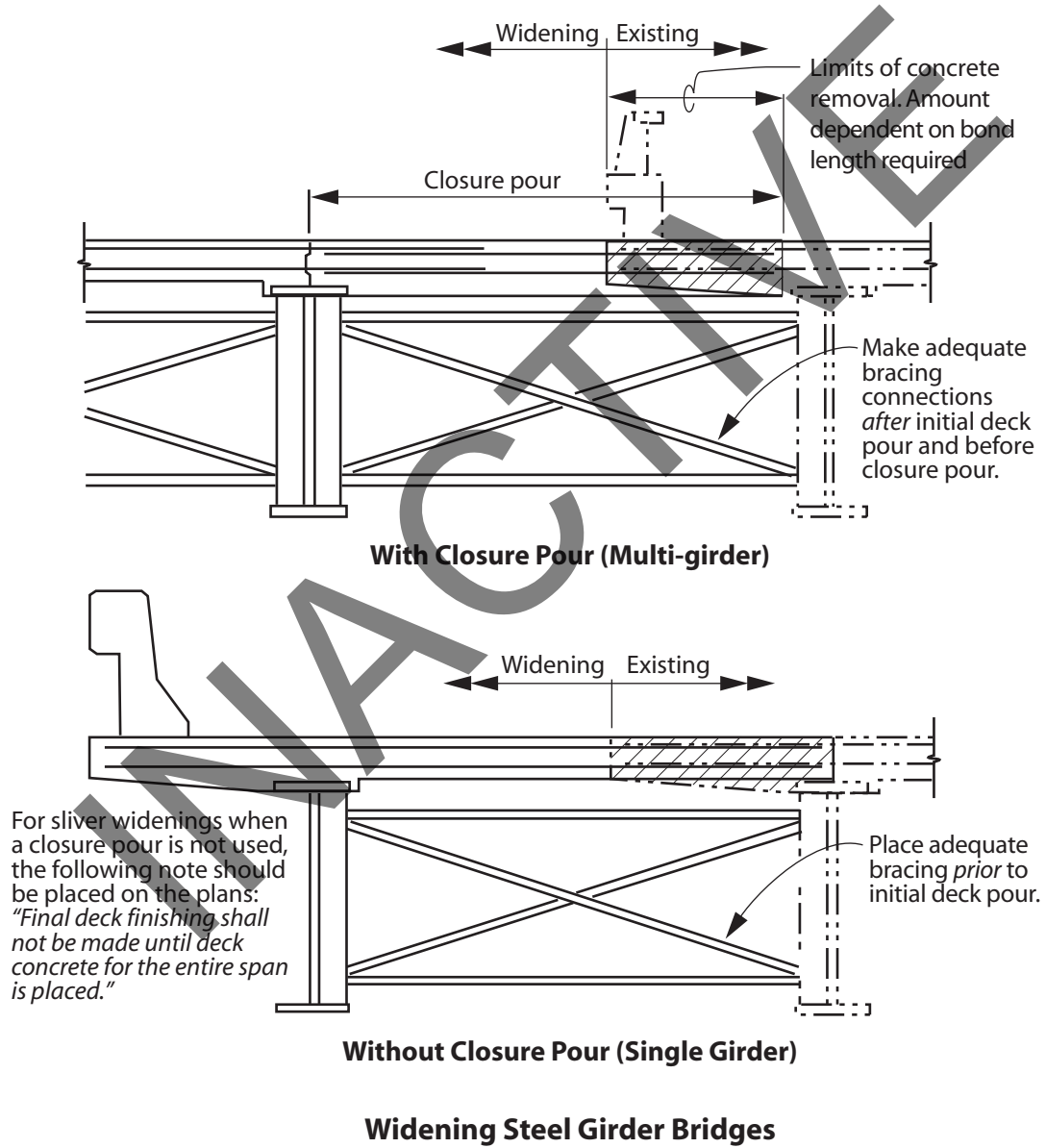
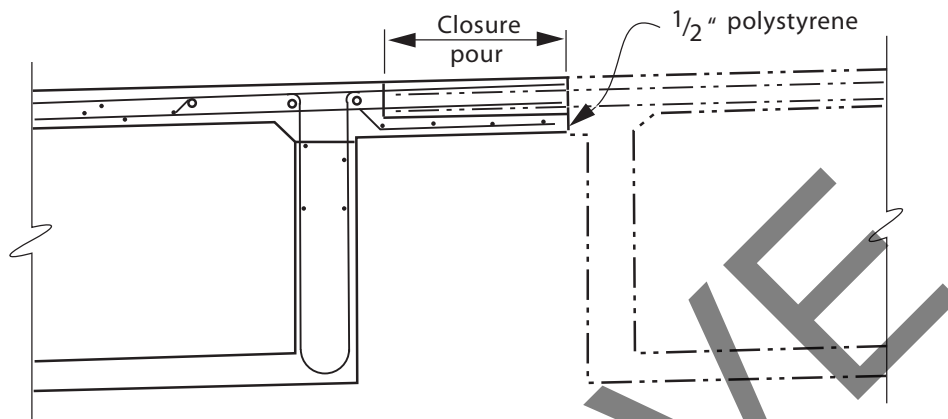
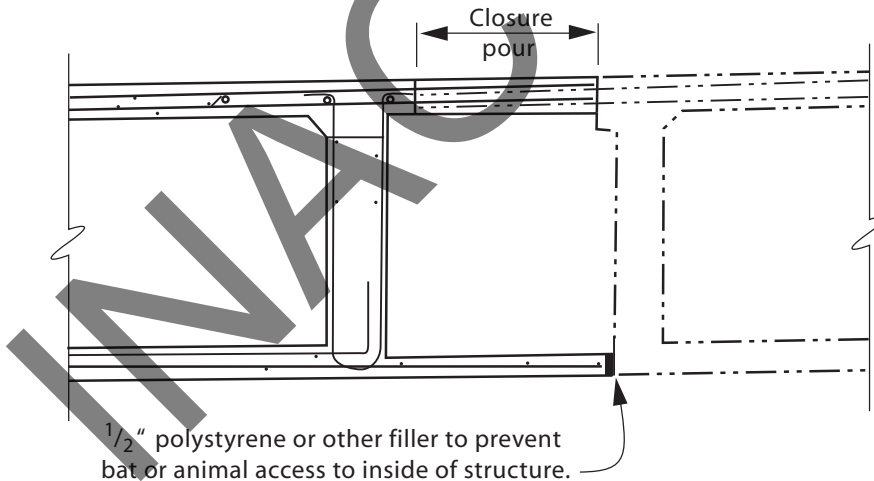


Figure 6



Note:

This option provides a support surface to place the closure pour concrete, but will require special design and careful attention to details. The contractor will have to provide extra effort to place and finish the closure support since new and existing reinforcement will likely be in the way. This reinforcement will also require extra effort to clean. Camber requirements for the widened portion may require a thicker closure pour to avoid conflicts between the closure support and existing reinforcement. Stay in place forms may be a better option.



Note:

This option provides a platform for support of closure pour falsework, and concealment for falsework that remains in place.

Closures that do not require Falsework Removal

Figure 7



Table 1 Widening Specification Selection Guidelines for Original BDS - Designed Structures

Component		Specification	
		BDS	LRFD
Superstructure			
Barrier	connection to deck		X
Deck	overhang widened only; i.e. no new girders **	X	
Deck	on new girders, stand-alone, connected by closure pour		X
Deck	on new girders, support cantilevered **	X	
Slab bridge	cantilevered from existing structure	X	
Slab Bridge	stand-alone or connected by closure pour		X
Closure pour		X	
Girders	new PS, steel, or box girder(s) on stand-alone substructure		X
Girders	new PS, steel, or box girders(s) on cantilevered substructure	X	
Substructure			
Abutment*	seat-type or framed; widening from existing	X	Loads
Wingwalls, retaining walls*		X	October 2010
Abutment footing or pilecap*		X	Loads
Bent cap	widened from existing w/o new support**	X	
Bent cap	stand-alone; connected to existing by deck closure pour		X
Bent cap	widened from existing; supported on new column(s), piers, or pile extension(s)		X
Pile extension from stand-alone superstructure (closure pour ok)			X
Columns, piers walls, footings, pile caps	same methodology as that used above for bent cap design	See bent cap design	See bent cap design
CIDH; driven piles		tips	Loads

* LRFD starting in 2010; currently Service I limit state load combination is used for abutment design.
 ** Existing structure must have adequate capacity to support the widening.



General Notes

See MTD 1-47 and the Preface to California Amendments.

Original signed by Kevin J. Thompson

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