Section 7 - BRIDGE SEISMIC

<table>
<thead>
<tr>
<th>XS Sheet Numbers</th>
<th>XS7-010</th>
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<td>Description of Component</td>
<td>Column Casing - Steel</td>
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Column Casing - Steel

Seismic retrofit of existing concrete columns is mainly due to deficiency in flexural confinement, lap splices in plastic hinge regions, or lack of seismic shear capacity. Jacketing outside perimeter of existing concrete columns with strong materials has been shown substantial improvement in ductile response of concrete columns in many experimental programs.

Compression region of plastic hinge regions has lateral dilation due to Poisson's effect of column axial compression. Spalling of concrete cover in the compression region results in buckling of main column reinforcement limiting ductile response of concrete columns. When lap splices are located in plastic hinge regions, jacketing method provides adequate clamping pressure to prevent lap splice slipping. Lateral dilation of concrete cross-section due to dead loads already occurred in existing concrete columns. Thus, additional dilation induced by seismic moment will be restrained by passive jacketing method.

There are few different proposed methods to estimate required thickness of steel casing. The simple approach to maintain minimum confining pressure in casing based on column dimensions in BDA 14-2 was used to develop this XS sheet. Hydrostatic pressure of grout during construction is also considered in BDA 14-2.

Jacketing also enhances seismic shear capacity of existing concrete columns because the additional clamping pressure induced by jacketing acts similar to that of column hoops. However, the required thickness of steel casing to enhance column shear capacity must be engineered based on overstrength plastic moment of column and shear capacity of existing concrete columns.
Standard Drawing Features

XS7-010 provides details for fixed-fixed (Type F) and fixed-pinned (Type P/F) column casings. It includes instructions for fabricating, welding, placing, and grouting a Steel Column Casing.

Design/General Notes

Steel Casing Type: Bridge Standard Detail sheet, xs7-010 shows two different types of steel column casings. Type "F" achieves fixity at both top and bottom ends of existing column to superstructure and footing. Type "P/F" achieves fixity at "F" end and pin behavior at "P" end. Typically Type "P/F" is used if existing column is pinned to the footing, or existing footing has “starter bars” 30” to 36” long, which are lap spliced with column longitudinal reinforcement. For multi-column bridges "P" casing at base of column is appropriate to prevent damage to the footings. For single-column bents fixity at the base of column is absolutely essential, therefore "P casing cannot be used.

Casing Thickness: Designers must determine the required thickness of steel casing and show it on Contract Plans. For circular column of 4'-4" in diameter or less, the casing must be at least 1/4" thick. For larger circular columns and for elliptical jackets, the casing must be at least 3/8" thick. For confinement purposes (as controlled by plastic hinge region), the casing thickness is specified in BDA 14-2. If steel casing is used to increase seismic shear capacity of existing column, designer should perform seismic shear demand and capacity analysis per SDC 3.6. The deficient shear capacity must be provided by steel casing considered as equivalent hoop reinforcement per unit length. The required jacket thicknesses due to flexural confinement, lap splices, and shear strength enhancement are not additive. The largest thickness shall control as the required thickness.

Welded Field Splice: Optional welded field splice is allowed for long columns. Welded horizontal splice must not be located where moment demand exceeds 0.75M_p.

Casing Opening: If existing bridge column has drainage pipe or conduit for utility line at steel casing location, the pipe/conduit should be extended outside of casing minimum of 3" from the face of column casing. Designer should check the condition of existing drainage or utility in columns. For existing pipes provide a pipe extender of the same diameter. For steel pipes, the pipe
extender must be connected by butt weld or steel pipe sleeve. If existing pipe is PVC, sleeve connection in Std. Plans B7-6 must be used. Steel pipe extender is shown on the plans, however, the designer must modify the details based on the existing condition.

Limit of Polyethylene (Type "P/F"): Polyethylene must be extended from top of footing to end of starter bars in existing columns. The limit must be shown on Contract Plans.

### Additional Drawings Needed to Complete PS&E
- Columns with flares, tapers, and other non-prismatic shapes require an additional drawing(s) to show how the steel casing will confine it.
- Tall columns require an additional drawing(s) showing supports and other details to prevent buckling during lifting and grouting.
- XS7-020 is for a minimum 3/8" and maximum 1” steel casing. Other steel casing thicknesses require an additional drawing(s).
- When the long cross-section dimension is over four times the small cross-section dimension, the steel casing becomes much less effective. In this case the designer should consider an alternative. Similarly, steel casing for columns with large cross-section areas may not be effective.

### Contract Specifications
- Caltrans Standard Specifications Section 60 Existing Structures; Section 60-40.06 Steel Column Casings.

### Restrictions on Use of Standard Drawings
- Tall and non-prismatic columns require special details. Very wide, tall, or non-prismatic columns may require special details and the project specific design criteria per Memo to Designers 20.11.

### Special Considerations
- The Office of Bridge Architecture and Aesthetics shall be consulted to obtain a workable and aesthetically pleasing solution when different plate thicknesses are joined, exterior stiffeners are attached, or through bolts are installed.
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The designer of an existing hinge retrofit shall choose one of the three available XS sheets depending on the structural needs. The seismic displacement demand is the primary design parameter. The XS sheet should be chosen that best matches the expected hinge opening from the seismic analysis. The three drawings are stand alone and represent different allowable hinge dead weight loads with associated allowable hinge opening values. It is encouraged to use the least amount of pipes necessary to avoid excessive damage to the existing hinge diaphragms. A minimum of two pipe seat extenders is needed. The dead load weight is the load that the pipes will see should the existing hinge seat become completely unseated. The three XS sheets have an unseating load capacity of 300 kip, 200 kip or 135 kip per pipe. The only other difference of the three XS sheets, besides the dead load capacity, is the allowable hinge opening distance to prevent bending failure of the 8” XX-Strong pipes due to excessive moment demand.

This retrofit of existing bridge expansion hinges is primarily for hinges that have seats of 14 inches or less. The bottom of cored hole shall be placed 6 inches above the existing hinge seat to avoid damage to support and to take advantage of the thicker deck section. The deck incorporates more reinforcement than the soffit thus providing better bearing capacity. The 6 inch clearance should be above any elastomeric bearing pads, stirrups, main transverse steel and the cover concrete. The box girder seat height can be measured from the outside the bridge on both sides. With this distance and knowing the soffit thickness from the access opening the bottom of the cored hole can be accurately determined inside the box girder. This design can also be used for structures that have no soffit. Some of the existing hinge shear reinforcement will be cut by the 10” dia. Cored hole and the new added bolster will help replace this lost reinforcement.

<table>
<thead>
<tr>
<th>XS Sheet Numbers</th>
<th>XS7-081, XS7-082, XS7-083</th>
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<tbody>
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<tr>
<td>Standard Drawing Features</td>
<td>Sheet Name</td>
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<tr>
<td>-----------------------------</td>
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</tr>
<tr>
<td>XS7-081</td>
<td>300 kip</td>
</tr>
<tr>
<td>XS7-082</td>
<td>200 kip</td>
</tr>
<tr>
<td>XS7-083</td>
<td>135 kip</td>
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The designer can choose which drawing to use that works best for the particular hinge being retrofit taking into account the expected hinge opening distance. The 1-1/2” dia. HS rods will create a “hard stop” for the seat extenders so as not to allow any further opening of the hinge. The 1-1/2” dia. HS rods are designed to take a large force as they are engaged but for larger structures alternative seat extenders may be needed to meet the expected hinge opening.

### Design/General Notes

**Pipe Shear Capacity**

\[ V_{cap} = 0.6 \times (\text{Pipe Area}) \times (f_{ye}) \]  
\[ f_{ye} = F_{y} \times R_{y} = 35 \times (1.6) = 56 \text{ ksi} \]

Area of Pipe = 21.3 sq. in. (Use ½ cross sectional area as effective)

\[ V_{cap} = 0.9 \times (0.6) \times (21.3/2) \times 56 = 322 \text{ kip} \]

**Pipe Bending Capacity (12” opening example)**

\[ M_{p} = Z \times f_{ue} \]

\[ M_{p} = \text{Max Allowable Moment, } Z = \text{Plastic Section Modulus, } f_{ue} = \text{Expected Ultimate Stress} \]

\[ f_{ue} = f_{y} \times R_{y} \text{ (from Steel Committee: } R_{y} = 1.6) \text{ Note: assume no tensile forces acting} \]

\[ M_{p} = 52.8 \text{ in}^3 \times (35 \text{ ksi} \times 1.6) = 2957 \text{ kip-in} \]

Available cantilever distance

Moment Capacity = \( X \times (200 \text{ kip}) = 2957 \text{ kip-in} \)

\[ X = 14.8 \text{ inch} \quad \text{Use 12”} \]

**Case Study**

**Number of Pipes needed for typical Hinges**

**American River Bridge (24-88L/R)**

6’ deep box girder bridge, Frame 2R – 78’ wide, 10 girders, bent to hinge 98’

**Weights**

Hinge diaphragm = 73.6 kip  Girders = 236.7 kip  Deck = 318.5 kip

Soffit = 269.5 kip  Barrier rail = 29.4 kip  Overlay = 69.6 kip

Int. diaphragm = 14.3 kip  Bolster = 30.5 kip

**Total Wt. on hinge seat = 1042 kip**

Number of pipes needed at 135 kip per pipe = 8

Number of pipes needed at 200 kip per pipe = 6

Number of pipes needed at 300 kip per pipe = 4
**Airport Drive OC (50-266)**
6’ deep box girder bridge, 39’ - 8” wide, 5 girders, bent to hinge 92’

**Weights**
- Hinge diaphragm = 38.3 kip
- Girders = 112.5 kip
- Deck = 154.1 kip
- Soffit = 107.5 kip
- Barrier rail = 27.6 kip
- Overlay = 33.8 kip
- Int. diaphragm = 7.7 kip
- Bolster = 20.0 kip

**Total Wt. on hinge seat = 502 kip**
Number of pipes needed at 135 kip per pipe = 4
Number of pipes needed at 200 kip per pipe = 3
Number of pipes needed at 300 kip per pipe = 2

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<tr>
<th>Additional Drawings Needed to Complete PS&amp;E</th>
<th>N/A</th>
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<tr>
<td><strong>Contract Specifications</strong></td>
<td>Caltrans Standard Specification Section 60 Existing Structures and Section 51 Concrete Structures</td>
</tr>
<tr>
<td><strong>Restrictions on Use of Standard Drawings</strong></td>
<td>If the bridge superstructure is less than 48 inches in depth then a special design may be considered for the pipe placement.</td>
</tr>
<tr>
<td><strong>Special Considerations</strong></td>
<td></td>
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# Section 7 - BRIDGE SEISMIC

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<th>XS Sheet Numbers</th>
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<tbody>
<tr>
<td><strong>Description of Component</strong></td>
<td><strong>Cable Restrainer Hardware Details</strong></td>
</tr>
<tr>
<td><img src="image" alt="Cable Restrainer Hardware" /></td>
<td>A minimum of two restrainer units (Type 1 or Type 2 for box girder bridges) are required at the hinges for new bridges. Existing bridges with inadequate seats should be retrofitted with the combined pipe extender/cable restrainer units detailed in XS7-071. Cable Restrainer Hardware is used to securely attach each end of the cable to the facing girders at hinges and expansion joints and also to adjust the cables so they are effective during earthquakes. A Cable Yield Indicator is also required so that the ABME can determine if the cable needs to be replaced.</td>
</tr>
<tr>
<td><strong>Standard Drawing Features</strong></td>
<td>XS7-090 shows all the hardware required to securely attach restrainer cables to the girders at hinges and expansion joints. The arrangement of the hardware is important and should be carefully followed.</td>
</tr>
<tr>
<td><strong>Design/General Notes</strong></td>
<td>For new bridges the designer should follow Caltrans Seismic Design Criteria which requires that two restrainer units should be placed at every hinge. For existing bridges the designer can follow Memo to Designers (MTD) 20-4 Seismic Retrofit Guidelines for Bridges in California. Bridge Design Aids 14-1 Hinge Restrainer Design Method has some good information but should no longer be used for design because Caltrans no longer relies on restrainers to reduce bridge displacement during earthquakes. Similarly MTD 20-3 Restrainers at Support Joints should be used with caution since many of the restrainers shown are no longer considered effective.</td>
</tr>
<tr>
<td><strong>Additional Drawings Needed to Complete PS&amp;E</strong></td>
<td>XS7-090 Cable Restrainer Hardware Details must be accompanied by the cable restrainer XS Sheets: XS7-040, XS7-041, XS7-50-1, XS7-050-2, XS7-070, and/or XS7-071. Alternatively, the designer can provide their own restrainer plan sheet(s), but because retrofits need to be as standard as possible any significant deviations should follow the project specific criteria per Memo to Designers 20-11.</td>
</tr>
<tr>
<td><strong>Contract Specifications</strong></td>
<td>Caltrans Standard Specifications Section 60 Existing Structures; Section 60-40.09 Bridge Joint Restraint.</td>
</tr>
<tr>
<td><strong>Restrictions on Use of Standard Drawings</strong></td>
<td>XS7-090 should be suitable when using the cable restrainer sheets shown in XS7. Other cable restrainer details will require special connections and project specific design criteria per Memo to Designers 20-11.</td>
</tr>
<tr>
<td><strong>Special Considerations</strong></td>
<td>The Cable Restrainer Hardware Details should be effective with Type 1 and Type 2 Restrainer Units in concrete box girder, T girder, and I girder bridges. However, they have also been used effectively for other restrainer arrangements on a variety of different types of bridges.</td>
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