Section 20 – Communication Conduit Attached to Structures

Middle-Mile Broadband Network Detail Sheets

XS Sheet Numbers

Design with multiple 2-inch conduits:

- xs20-010-1, xs20-010-2, xs20-010-3, xs20-010-4, and xs20-010-5

Design with a single 4-inch or 5-inch conduit:

- xs20-020-1, xs20-020-2, xs20-020-3, xs20-020-4, and xs20-020-5

Description of Component

The following plans are for bridge-mounted communication conduits for Middle-Mile Broadband Network (MMBN). The sheets show acceptable locations for mounting conduits on structures.

Prior to the development of these detail sheets, Structures Maintenance and Investigations (SM&I) established guidance that should not be overlooked. The Project Engineer shall consider alternative methods for every bridge crossing prior to the approval of encroachment permits based on risks that could result in the disruption of services.

The table provided below will assist the designer in evaluating the various installation locations and methods and risks associated with them:

Location/Installation Method:	**Comments:**
Underground/off bridge (at least 5-feet from bridge foundations)	None or low risk, fully protected from damage and vandalism. Discuss directional boring with District.
Utilizing existing bridge utility openings inside box girder bridges between girders, or existing utility openings in sidewalk(s) or in bridge rail(s) District personnel are responsible for reviewing as-built plans from BIRIS to determine the availability of any utility openings in bridges.	Minimal risk as conduit is usually surrounded by concrete and not accessible to vandalism, However, because bridge railings are susceptible to vehicular impact, the conduit may be damaged causing service disruption. Consider the need to remove the bridge railing for bridge widening projects.
Attached to an exterior surface of concrete bridge rail or underside of bridge deck overhangs.	Moderate/high risk as conduit will be accessible to vandalism. Conduits may be damaged by vehicular impact or may need to be relocated if bridge railing is replaced.

Section 20 – Communication Conduit Attached to Structures

Middle-Mile Broadband Network Detail Sheets

Conduit attachment is not allowed on bridge rails rated as “poor” in the Bridge Inspection Reports. The list of bridges with bridge railing classified as poor can also be requested from the asset management groups in each District.

Conduit attachment to bridges or culverts over waterways have addition requirements when the conduit is attached to an exterior surface. For concrete slab bridges or culverts, conduits shall be attached to the vertical surface of the concrete slab or culvert on the downstream side. Installation at the upstream side assumes a higher risk to service disruption from potential debris impact in a high flood event. Conduits installed over waterways should be placed as high as practical to minimize potential damage from debris impact.

Standard Drawing Features

The Middle-Mile Broadband Network Program has determined that the design used for the State’s broadband infrastructure will be to install 3 – 2” conduits mounted on structures. These communication conduits are in addition to any other specified utilities carried across structures.

An alternative design will be to install a single 4” or 5” conduit (preferably a 4” conduit) with a 4-cell fabric innerduct in lieu of the multiple 2-inch conduits. Similarly, this single communication conduit is in addition to any other specified utilities carried across structures. Deviation from the use of 3 – 2” conduits or the single 4” or 5” conduit must be approved by the District and the California Department of Technology.

Design/General Notes

All broadband mounting installations on bridges shall conform to the Caltrans Standard Specifications. Concrete anchors shall conform to the requirements of Section 75-3. Additionally, for concrete anchors, existing reinforcement must be located by nondestructive means before installing holes for anchors. Rotary drills are to be used; impact drills or coring is not allowed. If reinforcement is encountered, the anchor hole shall be abandoned, patched, and a new hole installed. Anchors must be on Caltrans’ Authorized Materials List for Concrete Anchorage Devices (https://dot.ca.gov/programs/engineering-services/authorized-materials-lists) and installed per recommendations by the manufacturer.

Section 20 – Communication Conduit Attached to Structures

Middle-Mile Broadband Network Detail Sheets

The table below lists anchors found on the Authorized Materials List. Minimum effective embedment shown in the table below are for concrete with a smooth surface. For a complete list of approved MEA's see the AML website Stud Type Mechanical Expansion Anchors (MEA) | Caltrans.

CONCRETE ANCHORAGE REQUIREMENTS						
Configuration	Material	Anchor Diameter (in)	Minimum Effective Embedment h_{ef} (in)	Minimum Concrete Thickness T_{conc} (in)	Minimum Edge Distance C_{min} (in)	Minimum Anchor Spacing S (in)
On Overhang	Stainless Steel	⅜	2	6	6	3
On Barrier	Stainless Steel	⅜	1 ½	6	6	3
PC I-Girder Bridge	Stainless Steel	⅜	2	6	6	3
T-Beam Bridge	Stainless Steel	½ *	2	6	4	6
			3 ¼	6	4	4
Single Conduit Clamp	Stainless Steel	½ *	2	6	4	6
			3 ¼	6	4	4

*Contractor's option to use either embedment depth for 1/2-inch anchor.

Designers using these MMBN details may find it necessary to specify a deeper effective empbedment. To accomplish this, the designer can increase the minimum effective embedment (h_{ef}) in the table shown on the XS-Sheet details. When a structure does not have a smooth concrete surface to attach the metal framing channel, it's possible to lose part of the anchor effective embedment; one example would be when there is architectural treatment. In this case, the minimum effective embedments shown in the XS-Sheet tables are not adequate and need a deeper embedment to match a Broadband Middle Mile Stud Type MEA of choice found on the Authorized Materials List.

In addition to the drawings, the Engineer must also comply with the requirements listed in Chapter 600 of the Caltrans Encroachment Permits Manual.

In some cases, the conduit may need to be painted or covered with an approved coating that must match the color of the structure.

Section 20 – Communication Conduit Attached to Structures

Middle-Mile Broadband Network Detail Sheets

All broadband utility installations on bridges shall be designed to accommodate thermal movements at bridge joints located at abutments, bents, and in-span hinges. To account for this movement, a combination of conduit expansion fittings and expansion-deflection fittings will be required (see Figure 1). Designers shall use the combination expansion-deflection fittings shown in Standard Plan ES-9B.

Figure 1 – Conduit expansion fitting and expansion-deflection fitting combined in series

During installation, the initial position setting of the expansion fittings is crucial for proper functional movement with the bridge depending on ambient temperatures. For example, a bridge joint that is fully open in the winter will require installation of the expansion fitting with the largest percent of maximum expansion range as listed below (80% of fully open fitting). Installation position table assumes no further permanent long-term prestress shortening. The position of the expansion fitting(s) during installation are provided below:

EXPANSION FITTING INSTALLATION POSITION TABLE	
Installation Period	***% of Maximum Expansion Range***
December to February	80 %
March to May and September to November	50%
June to August	20%

Expansion fittings will accommodate for most of the movement range of the bridge while expansion-deflection fittings will accommodate for transverse movement. Common individual expansion fittings are available for 4-inches or 8-inches of maximum movement. Multiple expansion fittings may be specified in series to satisfy large thermal movement requirements. A single deflection fitting is capable of providing ¾-inch transverse, vertical or longitudinal movement, or up to 30 degrees of pivot. A 1-

inch minimum separation between conduits and adjacent conduit fittings is required to prevent contact between components during transverse or vertical movement.

For questions regarding the bridge movement range, please contact the Bridge Technical Liaison:

DES Technical Liaison Engineers (for most recent contacts see Link):

Districts 1,2, & 3: Sannow Mam (acting)
District 4: Rosa Candiotti
District 5,6,9, & 10: Michael Downs
District 7 & 12: Cesar Sanchez
District 8 & 11: Tiffany Hang Tran

Additional Drawings Needed to Complete PS&E

A General Plan (GP) of the bridge or bridge length culvert shall be provided to show the location of the MMBN conduit. It is possible to develop one GP for a suitable number of locations. It is recommended to insert a table into the GP that is similar to that shown in the appendix. The table provides bridge and joint data for conduit installation, of which the Movement Range (MR) is critical data to identify.

Contract Specifications

Reference the latest Caltrans Standard Specifications – Sections 86 and 87.

Section 77 contains construction specifications related to Middle-Mile Broadband Network (MMBN) and will reference Sections 86 and 87.

Restrictions on Use of Standard Drawings

Attachment of conduit to exterior girders is not recommended. If a bridge site must consider allowing attachment to an exterior girder, the engineer must ensure there is no potential damage to the integrity of the girder (prestressing strands are a major concern). The project designer and project engineer are responsible for developing and stamping a separate detail showing the specific attachment of conduit to avoid hitting any prestressing strands.

An attachment detail to a sound wall on a barrier (refer to xs20-010-4) that encases the three 2” conduits in concrete will not be allowed on bridges. The added weight of this concrete encasement will add a significant load to the bridge overhangs which they are usually not designed to handle. At locations off bridges where the encasement is considered, a structural evaluation on a case-by-case basis would be required to verify

the system has adequate capacity since the added weight of this concrete encasement will add an eccentric load to the foundation.

Special Considerations

It is required that splice vaults be placed near the ends of any bridge installation to facilitate ease of future repairs/replacement/relocations of broadband utilities mounted on the bridge. The vault also serves as a transition point from high density polyethylene (HDPE) flexible conduit installed underground to the rigid conduit installation requirement on bridges. If these vaults are within Caltrans' access-controlled right-of-way, an exception will be required.

It is critical that designers using these MMBN details for structures coordinate the location of the vaults at each end of the structure. It was noted earlier in this User Guide that a General Plan is needed to complete PS&E. Accurately locating a vault at each end of the structure will help determine the exact number of conduit bends and degrees as they cross the structure to the vault at the other end. In order to keep cable pulling tensions under 600 pounds and conduit install radii at least 20 times the cable outer diameter (which cable specifications typically require), general recommendation is to eliminate any conduit radius under 24-inches.

Specifications limit conduit run bends to no more than 180 degrees between pull points. The XS-Sheets provide multiple installation alternatives to allow designers conduit paths along bridges with the least complications. Generally speaking, placement of conduit along the underside of the overhang may provide the least amount of obstructions (e.g. luminaire pedestals at bridge railing) to limit the conduit bends. Pull boxes will be required to reset the conduit bends within allowable limits. Pull boxes will also be required for long bridges even if the conduit installation is in a straight alignment. Assuming a straight conduit run on a bridge, locate pull boxes no more than 2,400 feet apart to facilitate pulling cables for long distances without exceeding pulling tensions above 600 pounds.

Field bends are not possible for the 4-inch and 5-inch conduits. Field bends on the smaller 2-inch conduit has limitation for minimum bend radius. For the 2" conduits, a minimum bend radius of 14-inches is required if the total bend degrees between pull points does not exceed 90 degrees. For total bend degrees between 90 degrees and 180 degrees, the minimum bend radius for all bend fittings is 24-inches.

Minimum pull box sizes for attaching to structures are fairly large. MMBN Design Guidelines specify three types of fiber-optic cable: 288 strands (Type 1), 432 strands

Section 20 – Communication Conduit Attached to Structures

Middle-Mile Broadband Network Detail Sheets

(Type 2), and 864 strands (Type 3). The XS-Sheet design must be able to accommodate the larger 864 strands cable which has a minimum bend radius of 14-inches (13.82 rounded up). Acceptable pull boxes must be NEMA 4X rated with minimum dimensions as follows: 12”x12”x60”, 36”x30”x16”, and 48”x36”x16”.

Rigid steel conduit also has a minimum bend radius based on the conduit diameter. The conduit minimum bend radius varies depending on the diameter. For example, a 2-inch conduit can be bent to a 9.5-inch radius. With the assumption that we could be running 864 strands cable, we would need to satisfy this minimum bend radius of 14-inches. When allowable conduit minimum bend radius is less than the fiber-optic minimum bend radius, design the system with a bend radius of the fiber-optic cable as the governing criteria to satisfy the MMBN Design Guidelines as shown in Section 5.4.

Multi-span slab bridges often have drop bent caps that support the slab soffit. These drop bent caps typically obstruct conduit installation; therefore, it is recommended that communication conduits be attached to the end face of the slab and/or exterior face of the barrier. For bridges crossing waterways, the engineer shall also avoid attaching conduits to the soffit or the upstream edge of concrete slab bridges. The engineer shall also ensure the concrete slabs do not contain prestressing strands at locations of conduit installation.

Some bridges with a very short overhang will not accommodate all 3 – 2” conduits under the overhang or the alternative design installing the single larger conduit. For such instances, other attachment possibilities should be considered. Although not cost-effective, when the multiple 2” conduits are installed, some of the conduits can be placed under the overhang and the rest of the conduits can be placed on the bridge railing (with the exception of a see-through barrier). A combined mounting configuration, both on the underside of the overhang and attached to the barrier rail (refer to xs20-010-2 and xs20-020-2), will increase the installation cost. Other mix-and-match configurations such as 1-conduit on barrier and a 2-conduit array on underside of overhang, or other configurations possibilities are permissible. Another option is to split some conduits on each overhang, this option will require additional District details to bring the conduits all together in a vault beyond the bridge.

Bridges with diaphragm abutments may not require expansion fittings and expansion-deflection fittings at the Beginning-of-Bridge (BB) and End-of-Bridge (EB) as shown in Figure 1. Diaphragm abutments monolythicly connect the superstructure and the substructure at the BB and EB; thus, thermal movements should be accomodated differently. At the discretion of the engineer, it may be possible to eliminate the need for

Section 20 – Communication Conduit Attached to Structures

Middle-Mile Broadband Network Detail Sheets

an expansion-deflection fitting since no transverse movement is expected between superstructure and substructure. Anticipated thermal movement for most diaphragm abutments along the length of the bridge will not exceed ½". If the location of the vaults at each end of the structure is in close proximity to the last conduit attachment on the wingwall, the designer can locate an expansion fitting near the last attachment point on the wingwall before the it is buried underground.

There may be permit requirements regarding hanging utilities on bridges where the XS-sheets may not be applicable. Bridges over railroads and over waterways where communication conduit is being installed can be expected to require additional permits.

Over jurisdictional waterways, broadband communication installations will require a USACE Section 408 Permit and/or a non-federal levee encroachment permit. Details as shown in these XS-sheets may not be consistent with the minimization and avoidance criteria with respect to USACE Section 408 permits for structures near jurisdictional areas (levees/channels). These details may only be used on non-jurisdictional waterway bridge crossings. Work with District Engineers to facilitate obtaining the permits. Refer to Appendix F in the Middle-Mile Broadband Network Design Guidelines, for an overview of 408 permit requirements and avoidance and minimization for conduit on existing structures over jurisdictional waterways.

When the optional cover plate detail is required, as shown in the Communication Conduit (Barrier) sheet, it is recommended to indicate this requirement in the Notes column of the recommended data table (see Appendix). The main reason for the District to request an optional cover plate is to hide the utility and be a deterrent against vandalism. The designer shall coordinate with the District on a particular cover plate. Details and additional notes can then be added to the XS-Sheets.

Clarification is needed for the "Limits of Structure Work" called out on xs20-010-1, xs20-010-2, xs20-020-1, xs20-020-2, and for all communication conduit attached to bridges. The XS-Sheets show the limits of structure work terminating at the end of wingwalls. As stated already, a vault is required at each end of a bridge and it serves as a transition point from high density polyethylene (HDPE) flexible conduit installed underground to the rigid conduit installation requirement on bridges. The intent it to locate the vault near the end of wingwall but the location will vary for every site. It is important to capture the quantity for Type 1 Conduit as a structural bid item for the length required to the vault. For the buried portion leading to the vaults, include "Structure Excavation (Type 1 Conduit)" and "Structure Backfill (Type 1 Conduit)" quantities. A Summary of Structure Items used for MMBN Bid Item List is listed in the references below.

Section 20 – Communication Conduit Attached to Structures

Middle-Mile Broadband Network Detail Sheets

Appendix

Recommended data table format for insertion on a General Plan.

Bridge or Structure No.	Bridge or Structure Name	Location County - Route - PM	Structure Length (ft)	Barrier Type	Joint Identifcation	MR (in)	Notes
					BB	4	
					Hinge 1	6	
					EB	2	

References

A. Caltrans Encroachment Permits Manual, July 2021
B. Memorandum: Accommodation of Wired Broadband Facilities within access-controlled state highway right-of-way, March 25, 2022
C. Guidance for Broadband Installation on Bridges, Structures Maintenance and Investigations, March 15, 2022
D. Example Single Bridge GP plus use of xs20-010-4
E. Example Multiple Bridge GP's plus use of xs20-010-3 and xs20-010-5
F. Example JOC MMBN Project
G. Summary of Structure Items used for MMBN Bid Item List