SECTION 19: BRIDGE DECK JOINT SEALS

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BRIDGE DECK JOINT SEALS

19.1—GENERAL

This work shall consist of the furnishing and installing of joint sealing systems in bridge decks of the types used where significant movements are expected across the joint.

Joint seals specified in the contract documents as poured joint seals shall conform to the requirement of Article 8.9, "Expansion and Contraction Joints."

The type and dimensions or movement rating for bridge deck joint seals at each location shall be as shown in the contract documents or as ordered by the Engineer.

All joint seals shall prevent the intrusion of material and water through the joint system.

C19.1

Bridge deck joint seals include compression seal joints consisting of preformed elastomeric material compressed and installed in specially prepared joints and joint seal assemblies consisting of assemblies of metal and elastomeric materials installed in recesses in the deck surface.

19.2—WORKING DRAWINGS

19.2.1—General

If not given in the contract documents, calculations showing the joint settings for their installation shall be required before approval to install joints in any bridge deck can be given. The Contractor shall submit working drawings to the Engineer showing the installation procedure and joint assembly for bridge decks using proprietary joint systems. Shop drawings shall be submitted to the Engineer for approval for joints having a total movement of more than 1.75 in.

No work on the deck joint seal shall be performed prior to approval of working drawings by the Engineer. Such approval shall not relieve the Contractor of any responsibility under the contract documents for the successful completion of the work.

19.2.2—Special Contract-Document Requirements for Modular Bridge Joint Systems (MBJS)

The MBJS axis shall be defined as any axis paralleled to the axes of the edgebeams and seals of the MBJS. The skew angle shall be defined as the angle between the longitudinal axis of the support bars and a line perpendicular to the MBJS axis. Movements parallel to the longitudinal axis of the support bars shall be referred to as longitudinal movements. The longitudinal axis of the support bars is typically coincident with the direction of the net expected thermal movement. Movements perpendicular to the longitudinal axis of the support bars will be referred to as transverse movements.

C19.2.2

Close cooperation is required between the Designer, Contractor, and joint Manufacturer to ensure a quality joint installation. For example, Designers should work with the Manufacturers when detailing blockout reinforcement. By working together, experienced Designers (typically more familiar with reinforcement needs or details of the adjacent structural elements) and Manufacturers (often more familiar with installation problems and factors affecting MBJS durability) will likely develop good details that reduce placement problems during construction. Unfortunately, it is difficult to anticipate reinforcement requirements during design because the joint system and Manufacturer are not known until after contract award.

Many MBJS durability problems are a result of poor detailing. Problems with poor detail design include improper detailing of superstructure elements and reinforcement steel, reflective cracking in the concrete cover directly above support boxes, and lack of access to the underside of the MBJS for inspection and maintenance.

Reflective cracking in the concrete deck directly above support boxes has been noted at almost every MBJS. These cracks permit water intrusion that may eventually cause delamination of the concrete cover over the support-bar boxes. Reflective cracking is most significant in a region of the deck which has transverse negative moment causing transverse tension stress in the top of the deck. An example of one such region is where the deck is continuous over a girder in a direction transverse to the longitudinal axis of the bridge.

Among the factors believed to affect reflective cracking are:

- the discontinuity in the slab thickness caused by the support box,
- the relative flexibility of the thin plates used to construct the top of the support boxes, and
- the slump of the concrete mixture.

In any case, it seems that the solution may be to provide adequate concrete cover and transverse reinforcement over the support boxes to minimize the crack widths.

Blockouts are used for modular joints to facilitate placement and adjustment. The support boxes of MBJS are typically 7.5 in. or more in depth and extend 12.5 in. or more beyond the edge of the gap. Therefore, a blockout that is 15.0 in. deep that extends 27.0 in. beyond the edge of the gap may be required. The blockout must be designed to support the weight of the joint, particularly on deck overhangs. Sometimes the ends of steel girders are notched to accommodate the joint. The possible fatigue problem at these notches should be considered. Careful installation of the joint and placement of blockout concrete are critical to ensure a durable joint.

Problems can occur when the reinforcing bars are too close to the edgebeams or anchorages, preventing the flow of aggregate under the edgebeam. Part of the problem is that the MBJS is a bid item and there are usually several qualified Manufacturers. Therefore, the configuration of the MBJS is not known at the time the reinforcement is designed. However, some aspects of the MBJS configuration may be anticipated and allowances made in the reinforcement. This should be accomplished through appropriate details and/or Contractor submittal of revised reinforcement details.

In steel superstructures, it is acceptable to attach the MBJS directly to the end diaphragm, a bulkhead plate, or the girders, although these attachments and the supporting members must be designed for strength and fatigue to resist the repeated large impact forces imparted to the MBJS. Any possible differential movements of the deck and the attachment points should also be considered. Short-term differential movements of the deck and the attachment points could cause a fatigue failure and long-term differential movement can cause distortion or a strength failure.

Usually, the abutment shelf or the pier caps provide an adequate work surface for inspection and maintenance.

The contract documents shall include the following:

- A cross-section of the deck at every unique MBJS configuration shall be shown. The MBJS shall be shown near midrange of its movement capacity. The total gap dimension between a reference vertical plane near the inside surfaces of the edgebeams and the bridge temperature corresponding to this position shall be clearly noted.
- If the support boxes are supported by the deck or abutment, there shall be adequate space, a minimum of 2.0 in., between the bottom surfaces of the MBJS and the deck blockouts to allow easy placement of concrete and allow for adequate consolidation of concrete under and around all parts of the MBJS, especially under any horizontal surfaces such as the bottom of support boxes. If a 2.0-in. space cannot be provided, the support boxes shall be set on a grout pad.
- There shall be at least 6.0 in. of clear space between the support boxes or anchorages on the ends of support boxes and the periphery of the blockout to permit placing of concrete around the MBJS.
- A detail showing how the MBJS is to be configured at the curbs and/or parapets.

- A unique configuration of MBJS may represent many essentially similar MBJS at various locations in a project. Minor variations in dimensions and location or of nonstructural details such as the support boxes, curb upturn, or slider plates at barriers are permitted for a given configuration and may be covered by special details and/or notes. Variation in the gap opening not requiring a different size or number of seals may be covered in a special note.
- This provision is only applicable when the wheel-load reactions of the support box are not transferred directly through positive attachment to superstructure elements other than the deck or abutment. It has been suggested that 2.0 in. has been sufficient in the past (especially if aggregate size is limited), however, 3.0 in. is recommended, if possible. Grout pads increase costs and should only be used when adequate space cannot be provided.

The Contractor shall submit details of the MBJS to be used together with installation and waterproofing plans to the Engineer for approval prior to fabrication of the MBJS. The shop plans shall include, but not be limited to the following:

- Plan and section views of the MBJS for each movement rating and roadway width, showing dimensions and tolerances.
- All welded and bolted centerbeam/support bar joints and all shop and field splices shall be shown.
- Complete details of all components and sections showing all material incorporated into the MBJS.
- All ASTM, AASHTO, or other material designations.
- Corrosion protection system.
- Lifting locations and lifting mechanisms shall be shown as part of an integral installation plan.
- Temperature adjustment devices and opening dimensions relative to temperature.

The Contractor shall also submit the following test reports and certificates for review and approval:

- Manufacturer's certificate of compliance with the AISC Quality Certification Program. The fabricator of the joints shall be certified to and shall fabricate the items in facilities holding the AISC Certified Component Manufacturer—Bridge Certification.
- Certification that welding inspection personnel are qualified and certified as welding inspectors under AWS QC1, Standard for Qualification and Certification of Welding Inspectors. Documentation that any personnel performing nondestructive evaluation (NDE) are certified by ASNT.
- Manufacturer's certificate of compliance for the PTFE sheeting and fabric.
- Certification that MBJS passed the Prequalification Tests required in Article 19.3.2.
- Certification that the bearings, springs, and equidistant devices are of the same formulation, and conform to the same manufacturing process, fabrication procedure and configuration that were used in the Prequalification Tests required in Article 19.3.2. In each certification, the name and address of the Manufacturer of the springs, bearings, and equidistant devices shall be provided.
- Design calculations sealed by a registered Professional Engineer. The design calculations shall include a fatigue design and a strength design for all structural elements, connections, and splices.
- Plan for replacement of parts subject to wear may be allowed for in the design. The Contractor shall submit for the Engineer's approval a written maintenance and part replacement plan prepared by the joint Manufacturer. This plan shall include a list of parts and instructions for maintenance inspection, acceptable wear tolerances, methods for determining wear, and procedures for replacing worn parts.
- Method of installation, including, but not limited to: sequence, installation gap setting for various temperatures, support during placement of the concrete, and installation at curbs.
- Tightening and quality control procedures for bolted connections.
- Recommendations for storage of MBJS and details of temporary support of joint for shipping and handling.
- Welding procedure specifications.
- Any required changes to the blockout reinforcement in order to accommodate the MBJS.
- Temporary bridging plan for any MBJS for which

construction traffic is anticipated following installation.

19.3—MATERIALS

19.3.1—Bridge Deck Joint Seal Materials and Joint Seal Assemblies Other than Modular Bridge Joint Systems

Bridge deck joint seal materials and assemblies shall conform to the following specifications:

- Preformed elastomeric joint seals of multiple-web design shall conform to AASHTO M 297, (ASTM D3542).
- Lubricant-adhesive for use with preformed elastomeric seals shall conform to ASTM D4070.
- Deck joint seal assemblies shall be of an approved type for each size required and shall conform to the specifications provided by the Manufacturer at the time of approval.
- Steel and fabricated steel components shall conform to the requirements of Section 11, "Steel Structures."

19.3.2—Modular Bridge Joint Systems

MBJS shall conform to the following specifications:

- MBJS shall conform to the specifications provided by the Manufacturer at the time of approval.
- MBJS shall be prequalified by satisfying all testing requirements detailed in Appendix A19, which are designed to allow approved MBJS to be used for a limited range of applications.
- MBJS shall be designed in accordance with Article 14.5, "Bridge Joints," of the *AASHTO LRFD Bridge Design Specifications*.
- Preformed elastomeric joint seals of multiple-web design shall conform to AASHTO M 297 (ASTM D3542).
- Preformed elastomeric joint seals of the strip type shall conform to ASTM D5973.
- Seals shall be continuous and splices are not permitted unless specifically approved by the Engineer.
- Lubricant-adhesive for use with preformed elastomeric seals shall conform to ASTM D4070.

C19.3.2

Modular bridge joint systems (MBJS) are sealed joints with two or more elastomeric seals held in place by edgebeams that are anchored to the structural elements (deck, abutment, etc.) and one or more transverse centerbeams that are parallel to the edgebeams.

Large movement ranges can be accommodated by modular bridge joint systems (MBJS). Present designs for MBJS typically use one or more transverse centerbeams to separate two or more seals. Because it must accommodate larger expansion movements, an MBJS must structurally support the wheel-loads across the gap between bridge elements.

There are two basic types of support-bar MBJS: multiple- and single-support-bar systems. Multiple-support-bar (MSB) MBJS have centerbeams that are rigidly connected to support bars. Each support bar supports only one centerbeam. For the MSB system, a support box will hold as many support bars as there are centerbeams.

Single-support-bar (SSB) MBJS have transverse centerbeams that are attached to only one support bar at each support box location using steel yokes and elastomeric springs and bearings. One special type of SSB MBJS is the swivel-joist system, in which the support bar swivels as well as slides in the support boxes.

While some owners prefer joint seals of multiple web design (box seals), compared to strip seals the box seals tend to exhibit lesser performance under seal push-out test and in the field. In the event the top surface of a box seal is broken, water is collected inside the seal, increasing the possibility of seal rupture under freeze condition. In

- Springs, bearings, and equidistant devices (sometimes referred to as control springs) shall be the same material composition and formulation, and conform to the same manufacturing process, fabrication procedure, and configuration as the ones used in the prequalification test and are as per the specifications provided by the Manufacturer at the time of approval. Urethane foam shall conform to ASTM D3574.
- Polytetrafluorethylene (PTFE) shall be 100-percent virgin Teflon®, woven PTFE fabric, or dimpled PTFE conforming to the requirements of Article 18.8, "Polytetrafluorethylene (PTFE) Surfaces for Bearings," and shall be provided on every sliding surface.
- Stainless steel sheets conforming to ASTM A240/A240M, Type 304, shall be provided on sliding surfaces. ASTM A240/A240M, Type 316 is recommended for a severe environment.
- Steel and fabricated steel components shall conform to the applicable requirements of Section 11, "Steel Structures."
- Aluminum components shall not be used.

addition, ensuring accurate installation of the box seals is difficult.

The MSB and SSB types of MBJS are the most common and, therefore, will be the focus of these Specifications. Certain parts of these Specifications may not be applicable to alternative types of MBJS. These Specifications permit alternative designs that meet the prequalification tests requirements in Article 19.3.2, "Modular Bridge Joint Systems."

In MBJS that use a support bar to allow sliding movement, the support bar usually has thin, stainless steel cover plates joined to the top and bottom of the support bar to provide smooth sliding surfaces. The support bars slide between elastomeric bearings and springs that are fixed in the support boxes, usually by a round boss or protrusion that fits into a hole in the steel plate of the support box. In SSB type MBJS, the centerbeams also slide over the support bars enabled by the elastomeric and/or polymeric springs and bearings within the yokes: the bearings and springs are usually held in position by a round boss or protrusion attached to a steel plate and the yoke that fits into a hole in the bearings and the springs. The bearings and springs typically have low-friction polytetrafluorethylene (PTFE) pads bonded to the sliding surface of the spring or bearing.

The elastomeric and/or polymeric bearings and springs are both precompressed and located atop and below the support bar, with the bearing on the bottom and the spring on top inside the support box for all MBJS, and with the bearing on the top and the spring on the bottom within the centerbeam yokes for SSB type MBJS. The springs exert compression to keep the bearing in place. The vertical component of each wheel-load applied to the centerbeam and transmitted through the support bar compresses the bearings within the support box, and reacts against the support box and the deck. There is a significant upward rebound of each wheel-load cycle that compresses the springs and reacts on the top plate of the support box, imposing an upward load on the deck. At the centerbeam-to-support bar connection of the SSB type MBJS, the vertical component of each wheel load applied to the centerbeam is transmitted to the support bar through the bearing. The upward rebound of each wheel load cycle, however, compresses the spring reacting between the yoke and the support bar, reducing the precompression in the bearing.

The wheel-load may also impart a horizontal force to the centerbeam and an associated rebound. The horizontal load is transmitted through the centerbeam, into the support bar, and into the springs and bearings through friction. In SSB type MBJS, the horizontal force is transmitted between centerbeams by equidistant devices and between the centerbeams and the support bars by friction. Ultimately, the horizontal force is transmitted by the small bosses in the springs and bearings on to the support box and the deck. These small bosses are subjected to millions of cycles of this reversible shearing action. Failure of the bosses leads to systemic failure of the MBJS and therefore the bosses should be included in the fatigue testing of MBJS. The movements of bridge elements provide the necessary forces to open and close the MBJS. An equidistant device is typically required to maintain an approximately equal gap between centerbeams and between centerbeam and edgebeam. A common equidistant device used in WSB type MBJS is comprised of a series of horizontal elastomeric springs sometimes called control springs. For SSB type MBJS the equidistant device can either consist of axial springs or shear springs connected between centerbeams. In some MBJS, the equidistant devices tend to close the gap, while in other MBJS, the equidistant devices tend to open the gap between centerbeams.

19.4—MANUFACTURE AND FABRICATION

19.4.1—Compression Seal Joints

Preformed elastomeric joint seals shall not be field-spliced, except when specifically permitted by the Engineer.

19.4.2—Joint Seal Assemblies Other than Modular Bridge Joint Systems

Expansion joint assemblies shall be fabricated by the Manufacturer and delivered to the bridge site completely assembled, unless otherwise specified in the contract documents.

19.4.3—Modular Bridge Joint Systems

19.4.3.1—General

The following requirements apply to both shop welds and field welds (if any) unless specifically noted otherwise. The MBJS shall be fabricated in accordance with the dimensions, shapes, details, material specifications, and procedures shown in the approved shop plans. Fillet welds shall be continuous. Intermittent fillet welds are not permitted.

Field splices should be avoided if at all possible and the entire MBJS shipped and installed as one unit. If field splices cannot be avoided, it is recommended that the splices be located away from potential wheel paths and preferred that splices be located under the median traffic barrier. Only field-splice details that have been fatigue-tested in accordance with the prequalification tests in Article 19.3.2 may be used for MBJS. Typically, the fatigue design will dictate that the span of the centerbeam with the splice must be smaller than the continuous spans; generally, it is best to make this span as small as possible.

A full-penetration field weld can sometimes be made from the deck when there is only one centerbeam and it can be lifted out enough to access the bottom of the centerbeam. Care must be taken to avoid weld metal getting into the seal retainer grooves, which can lead to seal pullout

C19.4.3.1

Whenever possible, fillet welds should be on both sides of an attachment. The MBJS should be shipped and installed in one piece, wherever possible, to avoid field splicing.

If it can be assured that a splice will remain under a median barrier and it can be assured that water cannot get to this area, it may be permitted to butt the ends of the two segments of MBJS together, but not splice them.

and leaking. Fillet or partial penetration welds are not permitted for centerbeam splices. Edgebeam profiles may be field-spliced with fillet welds across only part of the profile.

If bolted field splices are used, the bolts shall be locked in position after tightening to prevent loosening in service. Techniques to avoid loosening of the bolts include using adhesives, welding the outer surface of the nut to the exposed threads, or galling the threads.

Lifting devices shall be provided, and devices to maintain the preset opening of the joint shall be provided at a uniform spacing not greater than 15.0 ft along the length of the MBJS. At least three devices shall be used per segment of MBJS.

When the fabrication is completed, the Manufacturer shall perform the preinstallation inspection described in Article 19.5.4.2 to assure that the MBJS will pass this inspection.

19.4.3.2—Edgebeam Profile and Anchorage

The edgebeams shall be fabricated from structural steel. If a horizontal element is used, it shall have 0.75-in. diameter air holes spaced every 18.0 in. to improve consolidation of the concrete under the horizontal element. The top of the profile shall be located between 0 and 0.25 in. below the top of the wearing surface of the deck. The web of the edgebeam cross-section shall be at least 0.375 in. thick. At least the same cross-section must be used that was used in the prequalification test. Shop splices in the edgebeam profile shall be all around welds ensuring water tightness. The edgebeam shall be continuously welded to the support boxes.

The anchorage shall be designed in accordance with Article 14.5.6.9, "Modular Bridge Joint Systems (MBJS)," of the *AASHTO LRFD Bridge Design Specifications*. If there is a horizontal element in the edgebeam cross-section, the horizontal element shall also be anchored to resist the full value of the wheel-load with impact acting upward (from rebound).

C19.4.3.2

The use of a horizontal element in the edgebeam cross-section is not recommended due to difficulty with consolidating concrete under the horizontal flanges.

Best results have been obtained with rolled or built-up shapes with welded plate attachments or solid shapes with machine-cut grooves in the side to retain the seals. One design that satisfies the load requirements and has been designed according to ACI requirements is a 1.5-in. thick edgebeam with no horizontal element and Grade 50 (345), 0.5-in. diameter welded, headed concrete anchor studs 6.0 in. long, spaced at 12.0 in. on center. This design requires at least 3.0 in. of cover above the anchors (measured from the centerline of the anchor to the surface of the concrete). There is no need to bend the studs, unless the anchor stud falls at an overlay/ structural slab interface.

19.4.3.3—Centerbeam and Support Bar

The centerbeams, support bars, and connection details shall be the same type as were used in the prequalification tests. Shop splices in the centerbeam profile shall be two-sided, complete-joint-penetration groove welds.

Centerbeams and support bars shall be straightened prior to assembly. Both heat and cold straightening methods are permitted as approved by the Engineer. For cold straightening, the bending pressure shall be introduced in a controlled fashion and the maximum inelastic strain at a section shall not exceed five times the yield strain of the material.

In welded multiple-support-bar MBJS, the weld joint between the centerbeam and support bar shall be a full-penetration groove weld. After welding, the centerbeam/support bar assembly shall be placed on a flat surface and it shall be verified that the support bars lie in a single plane, with no part of the bottom of any support bars exceeding 0.25 in. off the surface. The subassembly may be straightened. No more than three attempts may be made to heat-straighten the subassembly.

For SSB type MBJS, the centerbeam to support bar connection shall be achieved by precompressing the sliding bearing and springs within the yoke and bolting or welding it to the centerbeam.

In bolted SSB type MBJS, the connection between the yoke and the centerbeam shall be designed as slip critical and the bolts shall be pretensioned per Section 11, "Steel Structures" and Table 11.5.5.4.1-1 and locked to prevent loosening in service.

Bolted equidistant devices shall be designed as slip critical and the bolts shall be pretensioned per Section 11, "Steel Structures" and Table 11.5.5.4.1-1 and locked to prevent loosening in service.

Techniques to avoid loosening of the bolts include using adhesives, welding the outer surface of the nut to the exposed threads, or galling the threads.

19.4.3.4—Seals

Seals shall be installed by the Manufacturer before shipping unless centerbeam field splices are used. If field splices are necessary, continuous seals (without splices) shall be installed in the field after the construction is complete. In either case, the same lubricant-adhesive that was used in the prequalification tests shall be used when installing the seals. The seals shall extend out from the ends of the edgebeams and centerbeams by at least 2.0 in.

C19.4.3.4

Movement joint seals usually have a maximum movement range of 3.0 in. Seals up to 5.0 in. have been used successfully. However, the maximum opening for seals is set by AASHTO requirements. Seals used for in-service MBJS must be the size that was tested in the prequalification tests required in Article 19.3.2.

The ASTM specifications for the seal material appear to be sufficient to assure adequate durability under normal wear and tear and environmental exposure. Some agencies do not allow the seal to be installed in the field because of the potential for detachment. However, if the MBJS is installed in stages, for the rehabilitation of an existing bridge or new installations on wide bridges, a seal field splice will be required if the seal is installed in the shop. Field splices of the seals should be avoided. The performance of spliced seals is not adequate in protecting the bridge superstructure from deck drainage. Therefore, in the case of staged construction, seals should be installed in the field in one continuous piece.

Another common problem is that the seals fill with debris. Traffic passing over the joint can work the seal from its anchorage by pushing on this debris. Manufacturers contend that MBJS systems are self-cleaning because as the joint approaches its full, open position, debris is expelled from the joint. However, many Designers conservatively oversize the MBJS, thus preventing the joint from being self-cleaning. Debris has been observed to be the cause of damage to many MBJS. Debris has been reported in the expansion gap that reduced the effective movement range. When the bridge expands, debris trapped in the seal gaps is compacted and can cause additional stresses and associated damage in both the joint and the structure.