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Memorandum

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Subject: Guidance for Choosing and Detailing Bridge Expansion Joints to Increase Durability and Resiliency.

Overview

Over the past few years there have been numerous premature expansion joint header or seal failures on expansion joints installed on new or rehabilitated bridges. Many times, these failures can be attributed to construction related issues. This memo is intended to serve as a guide to help choose the best options for joint types and to give suggestions on enhancing the design details to add some durability and resiliency against the joint installation issues that occasionally occur during construction.

Choosing a Joint Type or System

There are seemingly infinite choices for joint systems to choose from when designing a new bridge or rehab project. All joint types have their pros and cons, and it will be difficult to address in this memo all joint system types available and their use on the many varying scenarios that are encountered in bridge design or rehab. This section will focus on the low movement joint types that are most commonly considered by bridge design Engineers in Montana, how they relate to our most common design and performance scenarios, and what has and hasn't proven to work in Montana.

The following discussions on joint types and their use are general guidelines and each scenario may have unique circumstances that must be considered.

"Contraction" or "Crack Control" Joints:

"Contraction" or "crack control" joints, that mainly experience rotational effects and no thermal expansion or contraction movements, require the selection of a relatively resilient material. This applies for a new design or when replacing existing polyurethane or silicone seals in an open "joint". Durable options will include a single component Polyurethane or a compressible dense foam or rubber seal that can be "glued" into the opening. There are many specific options that meet these properties; however, silicone is not recommended and should be avoided since it is extremely soft, its durability is relatively low, and QA of installation is difficult.

Polyurethane seals have limitations that must be considered when considering their use:

1. The "joint" must not see any thermal contraction or expansion movement. It is best used for crack control over a bent or at an abutment (do not place polyurethane against an asphalt header) that only sees rotation. If there are expansion bearings under the "joint", it is not an appropriate use of this joint type.
2. Depending on the specific product, the joint opening during application must be less than 1" wide. Some products may specify larger or smaller allowable maximum joint openings, however, durability on bridge joints will be maximized if this is only used in joint opening of 1" or less. Consider the expected specific joint opening that is being designed and modify specifications accordingly.
3. Polyurethane comes in 2 varieties. The self-leveling variety is the most efficient to install but should generally be restricted to use on transverse grades that are 2% or less. A non-sag option is available for transverse grades greater than 2% or vertical applications (such as in a curb or rail). The non-sag variety takes extra work and tooling to install and is best limited to shorter installation lengths (curbs or rails).

Pourable Silicone Type Joints:

Pourable silicone joints are typically called out as bid item "Joint Seals – Silicone". Generally, these joints have performed very poorly in Montana and should be avoided when possible in rehabs and never used in new construction. These joints are very soft and susceptible to poor installation, very difficult for EPM's to QA the installation, and subject to rapid failure when the joint is filled or covered with sanding material or other debris.

"Asphaltic Plug" joints:

Asphaltic plug joints are also known as rubberized asphalt plug joints and typically called out as bid item "Expansion Joint – Asphalt Plug". They are manufactured by multiple different companies and depending on the manufacturer, they can accommodate a maximum of ¾" to 1" of TOTAL movement. This generally restricts their use to short span bridges and are almost never a good option in new construction.

On rehab bridge projects where an asphalt overlay is being added, they are sometimes the best of a lot of bad options. In Montana, the extreme temperatures generally make this joint type a poor choice. They tend to get brittle at extreme cold temperatures and will "rut" in the wheel lines at extremely hot temperatures. This will typically initiate a failure and require regular maintenance within a few seasons of installation.

When considering these joints, avoid using them in new construction and generally avoid placing them where there is greater than ¾" of total movement, where they will be in place for more than 5 (or so) years, at bridge abutments where they are in direct contact with approach roadway asphalt, or in any case where other joint types can be feasibly and economically installed. They should only be considered when there are no other joint options due to economic, project development, or construction time constraints.

“Compression” Joints:

Compression joints are generally made from stiff, compressible foam material or rubber glands. There are many manufactures and variations, but one thing they all have in common is they are designed so the joint material remains in compression when the joint gap is at its widest. This “widened” joint gap condition coincides with the time of year when the highest rate of sanding material occurs on Montana roads and bridges. The sanding material can collect in the joint on top of the seal, and when it warms up and the opening is reduced, the material can bulge up and then “push” the seal down when compressed under traffic, causing premature failure.

These joints can perform well when installed and sized properly, however the larger the total movements (i.e., wider joint gap), the less durable they are, and the more likely the seal is to fail. These joints are best used on openings with smaller total joint movements on rehab projects. It is generally a better practice to use a different joint system on new construction projects or on rehabs where the total joint movements are in the middle to upper range of typical joint movements.

Recommendations based on observations of best performance:

1. Use with total movements up to 2”. Larger movements may be accommodated but consider other joint types if possible.
2. Maximum joint opening should be less than 3.5 inches.
3. On new design or on rehabs where new joint headers will be installed, a “keeper” seat on each side of the header that the bottom of the seal rests on is highly recommended. This detail will help prevent the seal from getting pushed down into the joint opening and failing.

“Strip Seal” Type Joints:

Strip seal type joints are typically called out by bid item as “Expansion Joint Strip Seal” and are one of the most common types of joints for small to moderate total joint movements. There are multiple manufacturers with varying header design types and have generally performed well in Montana when installed properly. These are some of the best options for new construction and bridge rehabs when their installation is economically feasible within a project, and the project development and construction timeline allow for their use.

On rehabs, where the strip seal has failed and the joint headers are heavily corroded but still anchored soundly, the headers may be repurposed by removing the rubber strip seal, “cleaning” the existing steel headers and filling the strip steal header cavity with epoxy and then utilizing a compression seal in place of the old rubber strip seal.

Other Joint Types:

The joint types discussed above are not the only options for low to moderate total joint movement installations; nevertheless, they are the most commonly used joint types in the past couple of decades in Montana. There may be other good joint options available for a certain scenario and this guideline does not preclude the use of other joint types where appropriate.

Large movement joints are not used as commonly in Montana as the ones discussed above and the choices are much more limited (Finger, Modular, Sliding Plate, etc…). Their use is very dependent on the specific project details and scenario and are not part of the joint selection discussion in this memo.

Skewed Joint Considerations – Snowplow Deflector Tabs

Ideally, skewed bridges and joints should be avoided when possible. However, in many design scenarios and during rehabs, avoiding skews is not possible. Accommodating snowplows are among the many challenges that a skewed bridge presents. One way to minimize the risk of damage to the bridge joint and the snowplow (and operator) is through the use of deflector tabs placed over the skewed joint so the plow rides over the joint and doesn't fall into the joint opening or impact the header.

Joints with a skew of between 30 and 40 degrees are especially vulnerable, but these plow deflector tabs may also be appropriate for skews down to 25 degrees or less, depending on the joint opening width (the snow plow angle that the plows use most often is around 35 degrees, but the blade angle is adjustable on the fly, and will vary depending on the situation, such as operator preference, plow speed, snow type, etc…).

Consider on a case-by-case basis, with the input of the District Maintenance personnel, whether using snowplow deflector tabs on a skewed bridge joint opening is appropriate and/or desired.

Deflector tabs have been installed by Maintenance, and in some cases have been installed by others during construction projects. Therefore, several observations have been documented and recommendations for snowplow deflector tabs are as follows:

1. A spacing of 4.0 feet max (measured along the joint) between tabs.
2. In new construction and if possible in rehabs, the deflector tabs should be recessed down so the top of the deflector tabs are not sticking up above the deck surface. This may require that the joint header assemblies be recessed slightly lower than in a normal design.
3. If recessing the joint tabs is not possible, such as in a rehab, a heavy bevel is required on the leading edge to prevent the snowplow blade from catching the tab.
4. The tabs should always be welded on the approach edge to prevent plow blades from catching the unwelded end of the tab. If a bridge has 2-way traffic, the weld should be placed on the approach edge of the tab for each respective lane.
5. Steel tabs should be at least 3" wide and 5/16" thick, with 3/8" preferred (especially for wider joint gaps) if enough recess is available. ¼" thick plate should be avoided as it tends to eventually distort and bow up under the weight of traffic and plow blades, no matter how narrow the joint opening.

See MDT Drawing # 23532A for structures 05331 and 05332 (on US-12, Toston) for an example of this Snowplow Deflector Tab detail.

Details for Enhancing the Durability and Resiliency of Expansion Joint Headers

In most of the recent failures in “new” (1 to 5 years) joints and even many of the older joints that have failed in the past, a common condition is often observed. That condition is the lack of transverse or longitudinal reinforcement near the joint or the joint concrete anchors. When there is misplaced or inadequate reinforcement in this area, and if the concrete deteriorates or if it was not consolidated properly under the joint header, there is little to prevent the entire joint from quickly getting loose, potentially cracking the steel, and presenting a safety hazard to traffic, along with causing an unnecessary strain on Maintenance resources.

This lack of reinforcement may sometimes result from the normal process of installing transverse deck rebar at specified intervals and longitudinal rebar at specified laps. If installation is started at one end of a bridge deck and works to the other end where a joint is located, an error of fractions of an inch of each transverse spacing or lap can result in a reinforcement void at the far end of the deck at the joint. Regardless of the cause, an unreinforced anchorage zone of the joint header is not an uncommon condition.

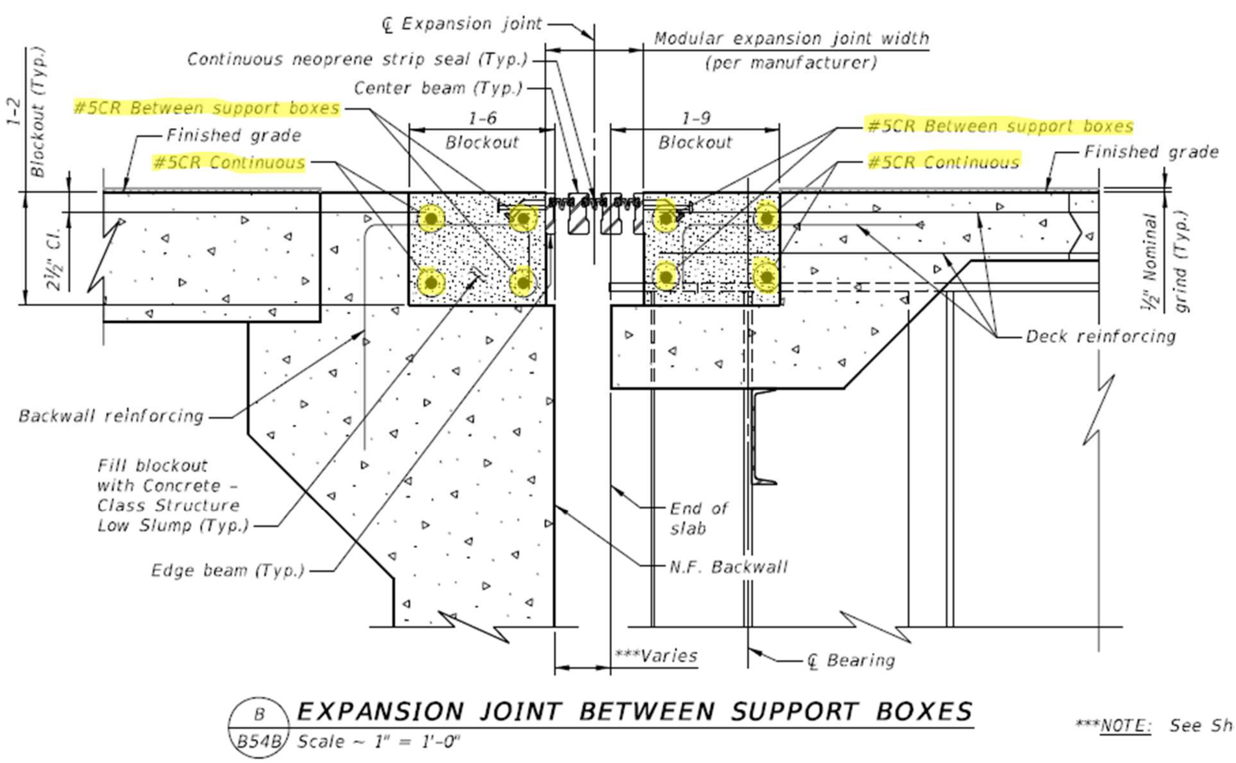
Getting rebar into this section of the deck near the joint is important for the durability of the joint header in the long run. However, it is also critical in the short run if there is some issue with the deck concrete or it is not consolidated properly under the joint header. This properly placed rebar will not prevent a failure when concrete is not consolidated properly during construction, but it will add some resiliency and likely give more of a “ductile” type failure where the joint gives some audible warning and slows the ”unzipping” failure effect of the entire joint. This gives Maintenance time to find and repair the joint before it becomes an urgent safety issue.

Detail Suggestions for Enhanced Joint Header Durability:

- Avoid unreinforced areas of concrete above the joint assembly concrete anchors. Add additional joint specific transverse reinforcement separate and in addition to the existing deck reinforcement where necessary.
- Call out the specific locations (i.e., attached to top of concrete anchors) or maximum edge or joint element clearances to ensure that the additional rebar is placed properly.
- Call out maximum clearances of the longitudinal deck reinforcement to ensure that it extends into the joint anchorage influence zone, where applicable.
- Confirm that air/vent holes are called out near the top corner, in the horizontal plates of joint assemblies to aid in concrete consolidation and inspection QA. These vent holes are typically included in new joint installations, however, existing joints that are being left in place during a rehab may need new vent holes to be called out during construction (or existing ones cleaned out). Suggested size and spacing is ½” diameter vent holes at 12” on-center, as close as possible to the vertical leg. Additional vent holes may be needed for joints with very wide horizontal legs (such as finger joints or sliding plate joints).
- To prevent cutting or damaging joint seals, add a plan note to ensure that transverse deck grooving operations are either, 1) performed prior to installing pourable seals (Polyurethane) or installing compression joint seals or, 2) if they are installed prior to grooving, that the transverse deck grooving operation does not cross the joint.

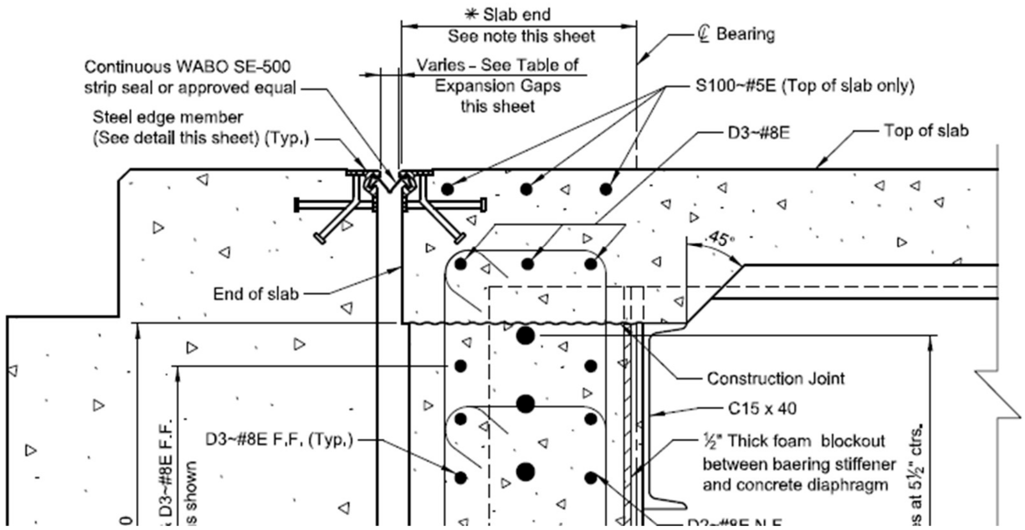
Included on the following pagers are some examples of suggested notes, minimum dimensions, and additional reinforcing bars that can be added to most types of joint header details. These are just examples, as each individual joint can vary, especially in rehabilitation projects. However, applying the suggested concept and notes universally to all joints will likely result in more durable and resilient joint installations:

Modular Joint Headers:

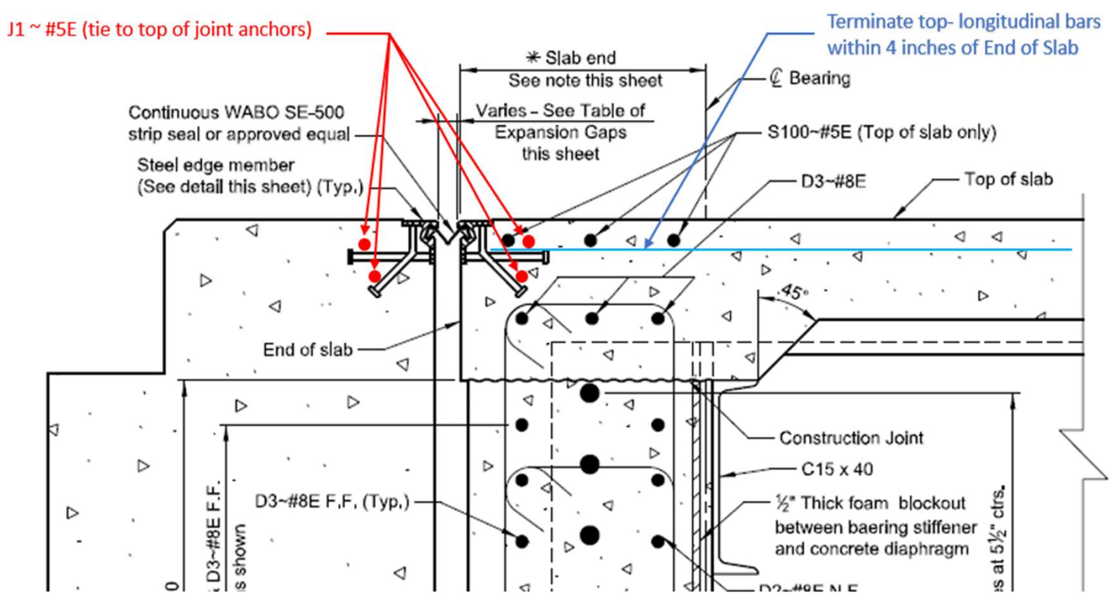


Good Example of Labeling and calling out all specific bar sizes and locations in the joint closure pours.

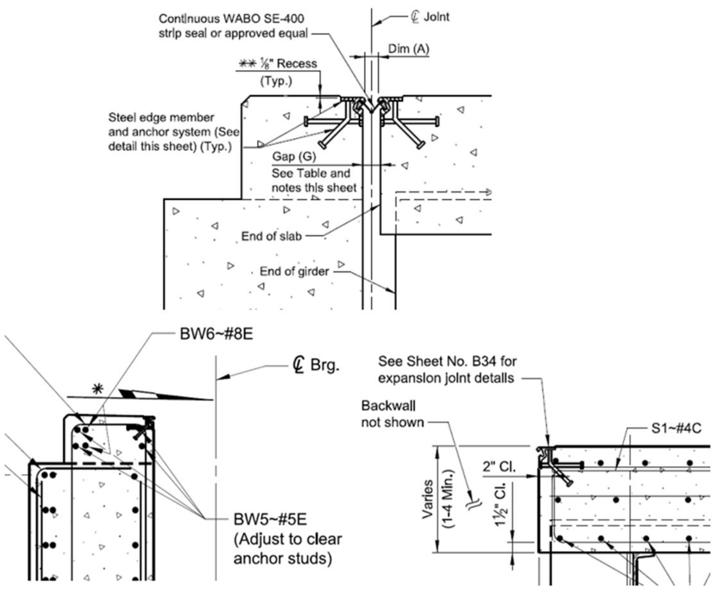
Strip Seal Joint Headers:



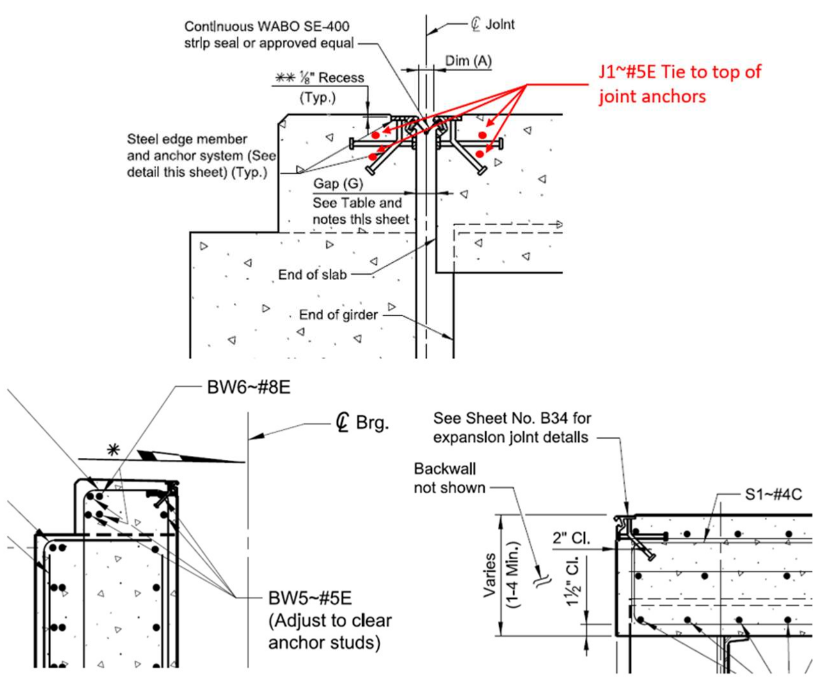
Typical Strip Seal Joint Detail without reinforcement.



Suggested Additional Joint Specific Reinforcing Called out.

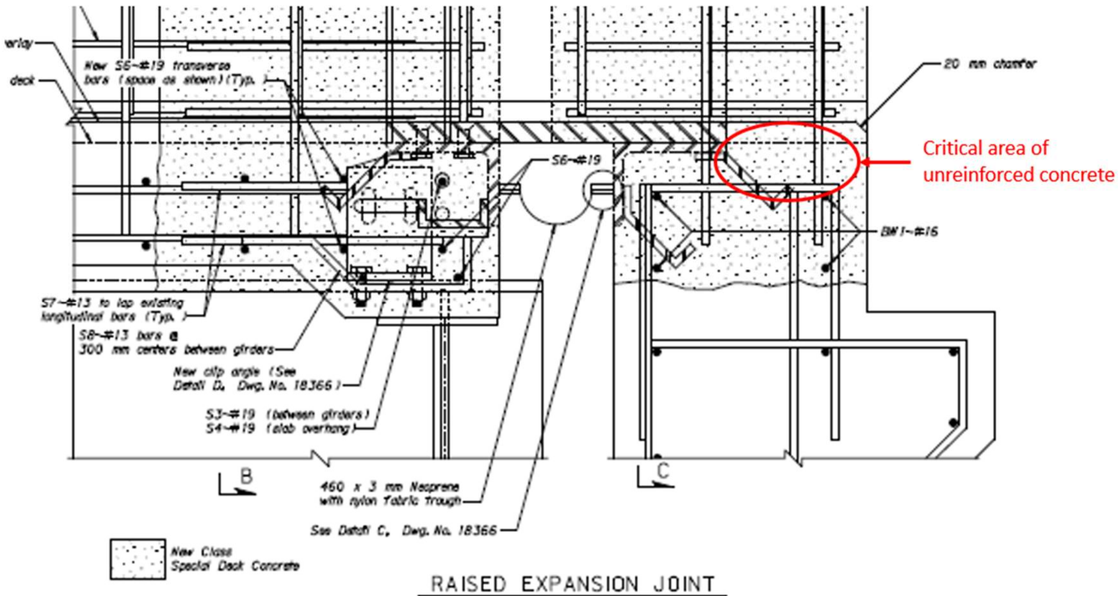


Series of Joint and Reinforcement Details for a Single Strip Seal Joint. Longitudinal Reinforcement is Adequate; However, Additional Joint Specific Transverse Reinforcement is Needed.

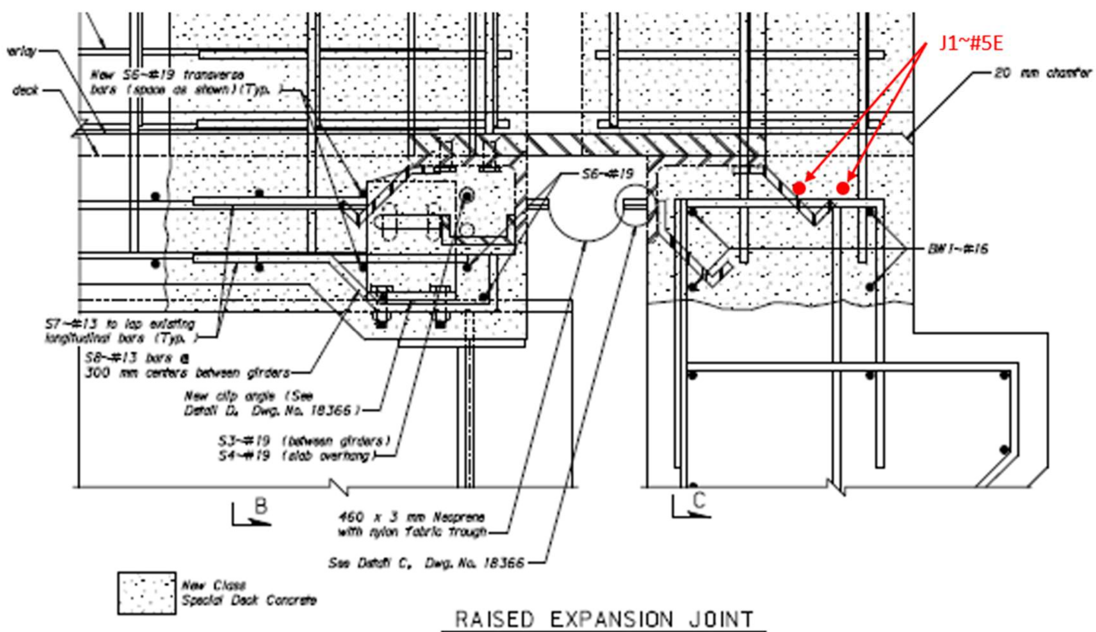


Suggested Additional Joint Specific Transverse Reinforcement.

Joint Assemblies (Finger and Plate Joints):

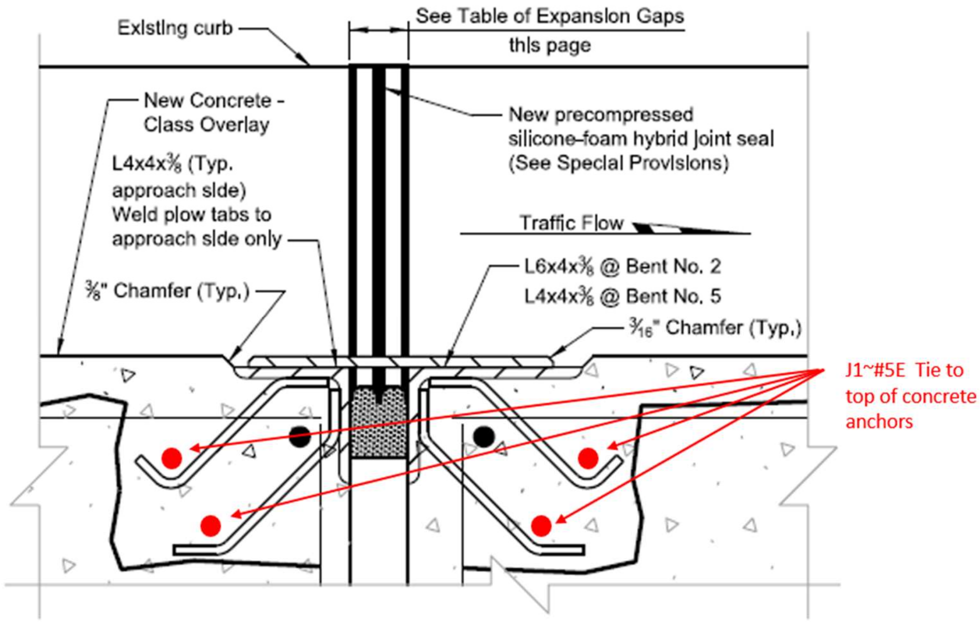


No Transverse Reinforcing in Abutment Side of the Finger Joint above the Concrete Anchors.



Suggested Additional Reinforcing Called out above Concrete Anchors.

Contraction Joint Headers (Angles or Channels), Guard Angles, or Other Steel Headers:



Steel Headers for a Compression joint with no Joint Specific Reinforcement. Suggested additional Reinforcement Shown in Red.