Expansion joint renewal with 'zero' impact on traffic - an optimal solution for urban bridges

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Summary

A solution to the demands to be addressed in the specification, design, installation and replacement of expansion joints on urban bridges is presented: the Tensa®Flex Sliding Finger expansion joint and the associated traffic management system Mini-Fly-Over. The expansion joint type is quiet and durable, with long-term benefits for local residents, while the traffic management system was developed to minimise the difficulties and traffic disruption associated with its installation as a replacement for an existing expansion joint. The successful implementation of the traffic management system to install the sliding finger joints on a major highway bridge with almost no impact on traffic is described, proving that clever solutions which take account of the needs of modern urban society can always be developed.

Keywords: Expansion joint, replacement, renewal, traffic management, low noise

1. Introduction

Bridges in urban settings may often be subjected to particular demands that do not apply to bridges in remote areas. For instance, noise from traffic passing over the bridge should be kept to a minimum in order to reduce the impact on nearby residential areas. And the impact on traffic during installation and maintenance or refurbishment work on the bridge should also be minimised, as bridges in and around cities tend to cater for much larger volumes of traffic which would be inconvenienced by the congestion such works would cause.

Fig. 1: A Tensa®Flex expansion joint

These topics are especially relevant in the case of the expansion joints which serve such an important role in providing a driving surface for traffic while also facilitating bridge movements due to temperature variations, wind, traffic loading and so on. Expansion joints have the potential to be a significant source of noise on a bridge, so their design should limit noise emissions as appropriate. In addition, since expansion joints are less robust and more highly stressed than the main structure, it must be recognised that they will need to be replaced several times during the lifetime of the bridge, with a correspondingly higher potential to impact on traffic during installation or replacement works. A clever solution to these twin demands is described below.

2. The Sliding Finger Expansion Joint

2.1 General description

The Tensa®Flex Sliding Finger joint, as illustrated in Figure 2, is a flexible metal-elastomeric bonded system which consists of two asymmetric parts. The lower part has fingers which are welded to a base plate, and is anchored to one side of the gap that is to be bridged. The upper part has cantilever fingers which slide between the fingers of the lower part, allowing the bridge deck to expand and contract.

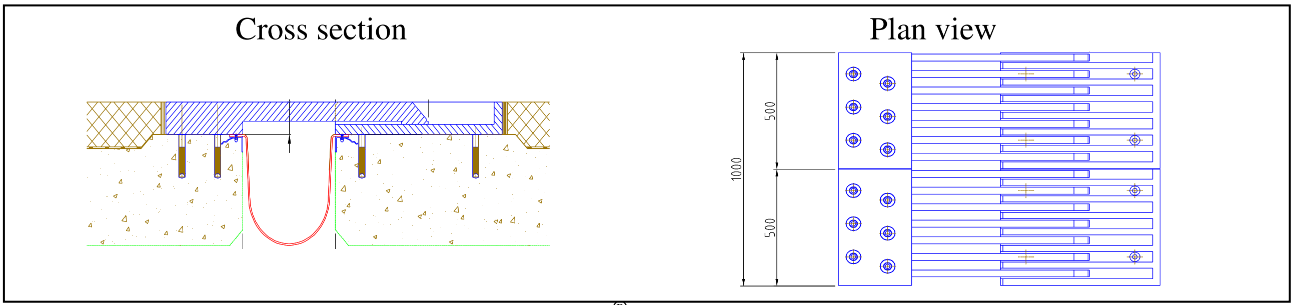

Figure 2: Cross Section and Plan View of Tensa®Flex Sliding Finger Joint

The fingers of the upper part are pre-tensioned downwards and therefore apply a permanent pressure to the opposing sliding surface of the lower part. The system is anchored to a specially prepared concrete subsurface, and is therefore easily replaceable. This expansion joint can facilitate expansion / contraction movements of up to 800mm.

2.2 The main benefits of the system's design

The cantilevering steel fingers of the upper plates of this expansion joint extend from a rubber/steel composite block (a block with alternating layers of steel and elastomer), the elasticity of which provides a downward pre-tensioning to the fingers. This design results in the following benefits:

- Vertical movement of one side of the joint relative to the other is facilitated, as the pre-tensioning downwards of the fingers ensures that they will remain in contact with the sliding surface below at all times, and hazards to over-rolling traffic are avoided.
- The joint may be installed on bridges which have both a longitudinal gradient and horizontally placed sliding bearings, where horizontal movement of the end of the bridge deck would tend to cause the fingers (if not pre-tensioned downwards) to protrude above the carriageway surface or to be subjected to excessive force. This is illustrated in Figure 3.
- The fingers of the joint will not spring up under over-rolling traffic.
- The joint does not require major anchoring to the structure. The "simply supported" design of the fingers which span the bridge gap means that no significant moment loading on the support structures results from the anchorage of the joint.
- The flexible and shock-absorbing design protects the bridge structure underneath from fatigue-related problems.
- Noise emissions are reduced to an absolute minimum.

Furthermore, the simple but very effective waterproofing and drainage design of the joint system guarantees 100% watertightness throughout the lifetime of the joint.

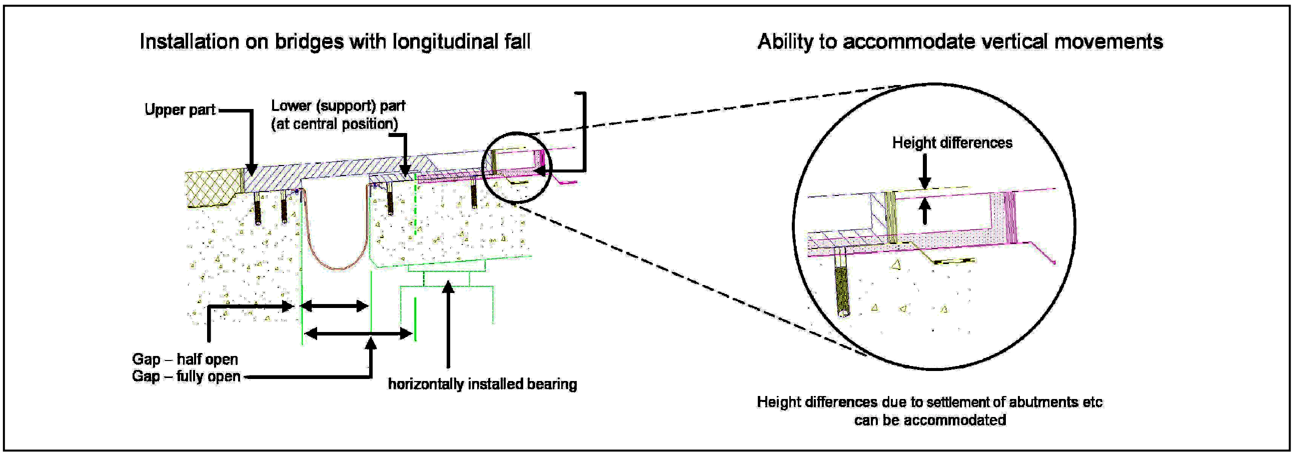

Figure 3: Installation on bridges with longitudinal gradient and horizontal sliding bearings

Perhaps most significantly, the modular design of the system allows the individual elements of the joint to be replaced in a very short period of time (for example, in one night) on a lane-by-lane basis. It is also possible to only replace the joint under the lane with heaviest traffic, should this section of joint require replacement earlier than the rest.

The features of the Tensa®Flex Finger system therefore make it particularly suitable for densely populated and heavily trafficked areas.

2.3 Clever anchoring systems

There are two possibilities for connecting the Tensa®Flex Sliding Finger to a structure, depending on the surface to which it is anchored.

For connection directly to concrete, a plugged anchoring system is suitable (as illustrated in Figure 2). The concrete subsurface must be smoothed with a tolerance of ±1mm, in order to allow installation of the joint without further preparation. The completed concrete subsurface has to match the joint's predefined inclination. This method of installation does not require a steel substructure which may be susceptible to corrosion. Furthermore, the development of rock pockets and trapped air in the concrete beneath the joint is prevented.

For anchoring to a steel substructure (such as the two-part steel trough shown on the concrete bridge in Figure 4), the joint can be delivered together with the steel substructure, as a pre-assembled unit. The entire system is positioned, aligned, welded to reinforcement, and set in concrete. Such a substructure facilitates particularly easy replacement of finger plates (approx. 3-4 hours for 15m of joint). It is also possible to make the substructures from stainless steel.

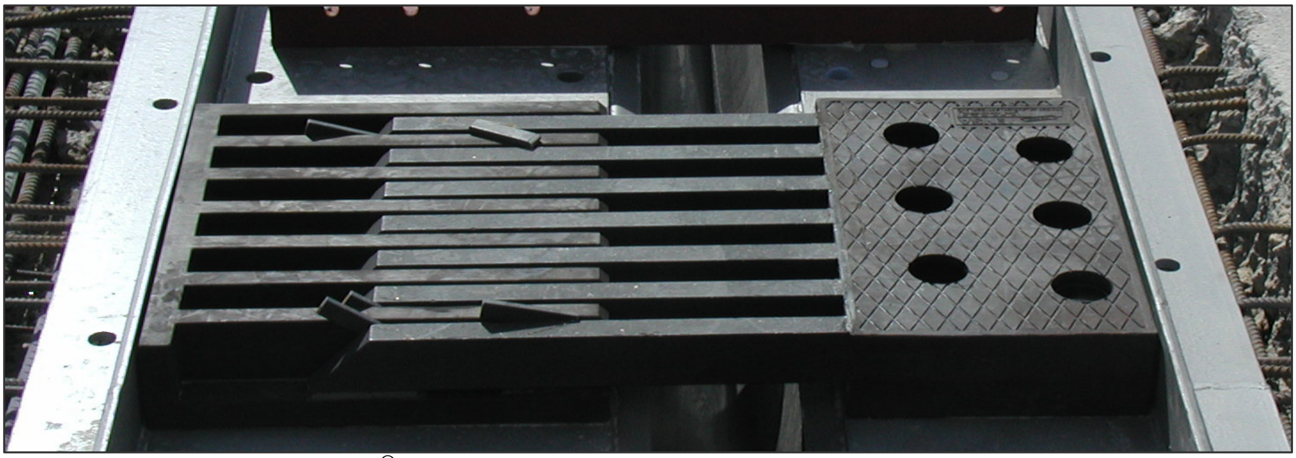

Figure 4: Anchoring of Tensa®Flex Fingers on steel substructure

2.4 Low noise emission

As the joint has, on the one hand, no impact areas and, on the other, no mechanically moving parts, the system has a very low noise level. Measurements carried out during the bridge renovation of the Seez Viaduct on the A3 motorway at Walenstadt (St Gallen, Switzerland) showed that noise levels were reduced by up to 18dBA compared to conventional expansion joint systems.

2.5 Renewal of existing expansion joints with new Sliding Finger Expansion Joints using revolutionary traffic management system

If an existing expansion joint is to be renewed when it reaches the end of its lifetime, the Mageba "Mini-Fly-Over" system can be used to allow traffic to cross the site during the daytime, while the construction works are carried out at night-time on a lane-by-lane basis. In this way, unhindered traffic flow during peak times can always be facilitated. A successful implementation of this system, which kept disruption to traffic during joint replacement to an absolute minimum, is described in Section 3 below.

3. Reference Project – Felsenau Viaduct, Bern, Switzerland

The Felsenau Viaduct, built in 1973, has a total length of 1,150m and crosses the river Aare north of the old city centre of Bern (see Figure 5). The six lane carriageway carries approximately 100,000 vehicles per day.

Figure 5: Felsenau Viaduct, Bern

Due to the high traffic volume, the existing modular expansion joint with 7 x 60mm movement capacity developed signs of fatigue and had to be replaced. The design brief for the refurbishment had four key requirements:

- Avoid any impact on traffic during the daytime
- Only one lane could be closed during the night-time and at weekends
- The new expansion joint should exhibit low noise emission characteristics
- Short overall construction time.

Only the Tensa®Flex Sliding Finger in combination with the revolutionary mageba Mini-Fly-Over system could be used to accommodate the above-mentioned client requirements. The construction works were executed at weekends and during night shifts (see Figure 6).

Figure 6: Night-time installation of the Tensa®Flex Sliding Finger

The total duration of the construction works was seven weeks with the work being carried out lane-by-lane, in six phases. Each phase was carefully planned, ensuring that the construction works were completed on time and within budget. The construction sequence is illustrated in Figures 7 to 10 below.

<u>Step 1</u>: The old modular expansion joint is still in place in Figure 7. The construction width was 720mm at the surface and 275mm at the bottom. The modular expansion joint was cut longitudinally with a diamond saw at four locations to facilitate its removal.

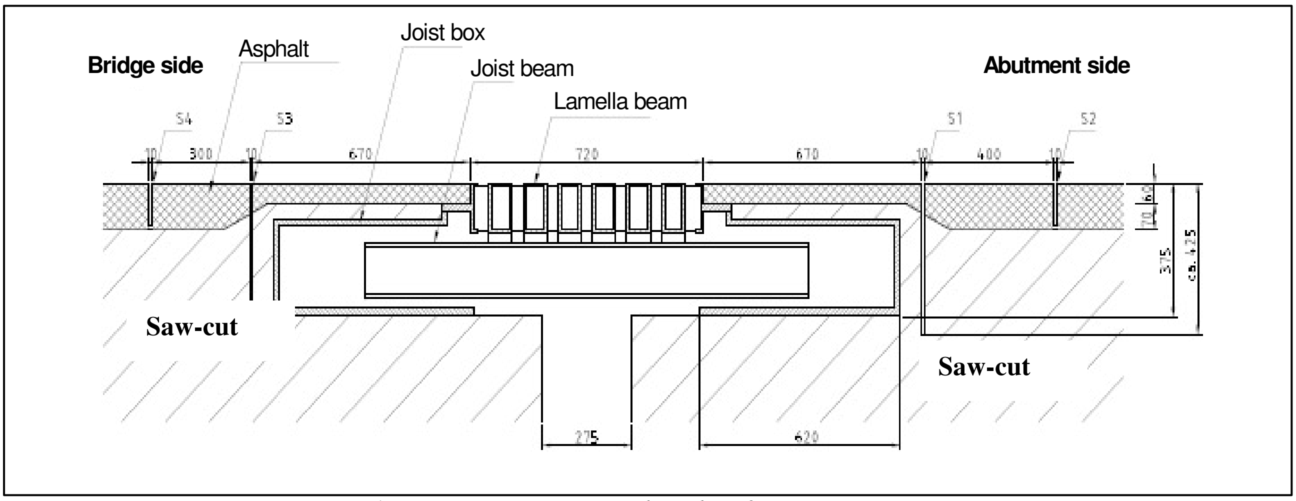

Figure 7: Construction Step 1: Saw-cutting at each side of existing joint

Step 2: After the old expansion joint was removed, the asphalt wearing course was cut away over a length of about 1.1m from the joint gap to facilitate the laying of the Mini-Fly-Over as shown in Figure 8. Then the surface was prepared using Robo®Flex, a special polymer concrete. This concrete hardens within a few hours allowing the surface to be put into service very quickly. The Mini-Fly-Over was then placed on the Robo®Flex surface, and held down by safety bolts to ensure that no uplift would take place. Traffic was then allowed to pass over the joint.

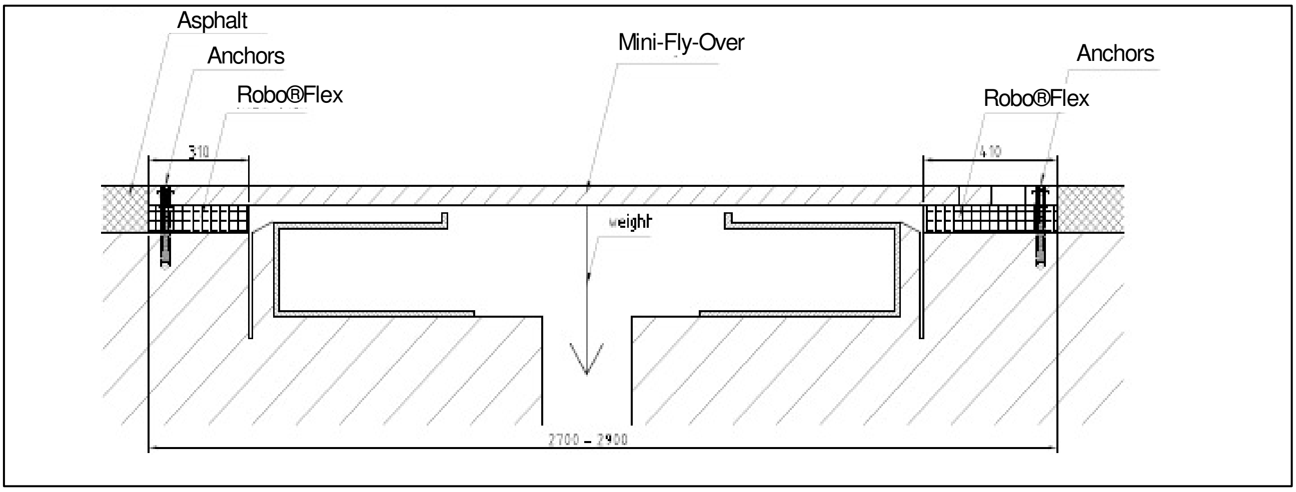

Figure 8: Construction Step 2: Removal of existing joint and installation of Mini-Fly-Over

Step 3: During the next night-time closure of the lane, the Mini-Fly-Over was removed to allow the work to progress. Reinforcement was installed, formwork and anchor dowels were positioned and concrete was placed, as shown in Figure 9. The surface of the concrete was then levelled to an accuracy of +/-1mm. The Mini-Fly-Over was put in place again to facilitate traffic the following day.

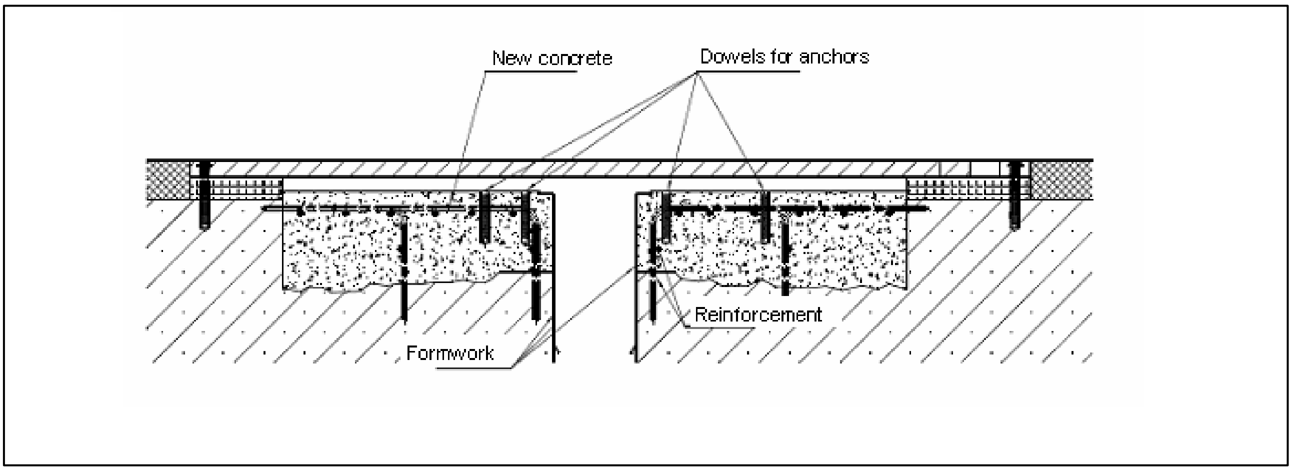

Figure 9: Construction Step 3: Placing of reinforcement and pouring of concrete

Step 4: The final stage is shown in Figure 10. When the concrete surface had hardened, the Mini-Fly-Over was removed for the last time and the drainage channel (5mm flexible EPDM) was positioned and fixed, with connection to the bridge's waterproofing membrane. Finally, the Tensa®Flex Sliding Finger was mounted on the surface. The small remaining gap between the Tensa®Flex Sliding Finger and the wearing course of the road was then sealed with Robo®Flex.

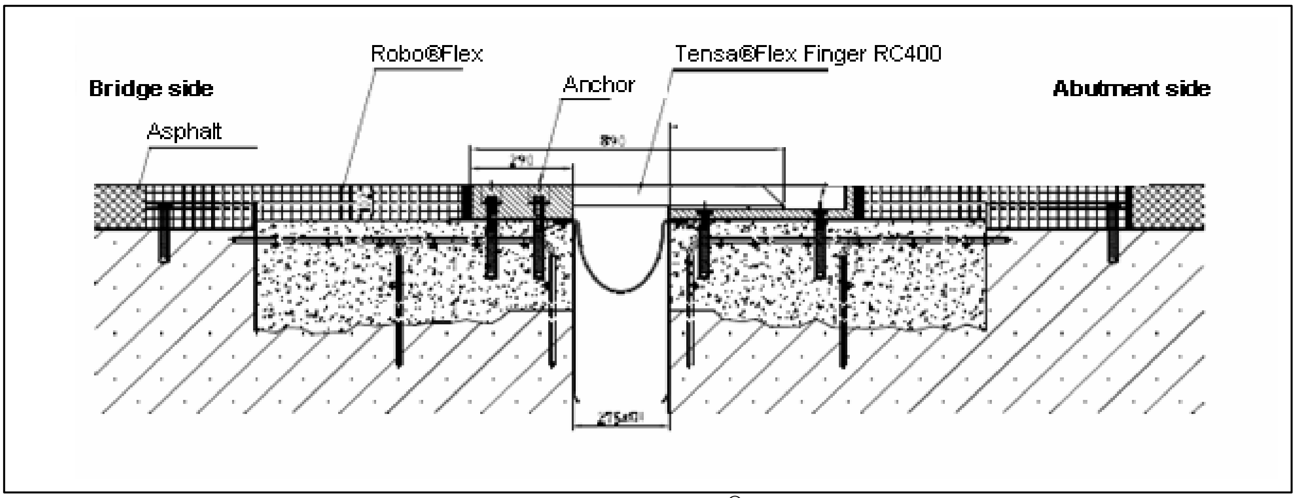

Figure 10: Construction Step 4: Installation of the Tensa®Flex Sliding Finger

Figure 11 shows a section of the bridge where Tensa®Flex Sliding Fingers are being installed. The left side of the picture shows the new sliding finger joint after installation. The centre of the picture shows the 36 year old modular expansion joint (before replacement with the new sliding finger joint). The right side of the picture shows the Mini-Fly-Over system, which permits unhindered traffic flow during the day-time while works are carried out at night.

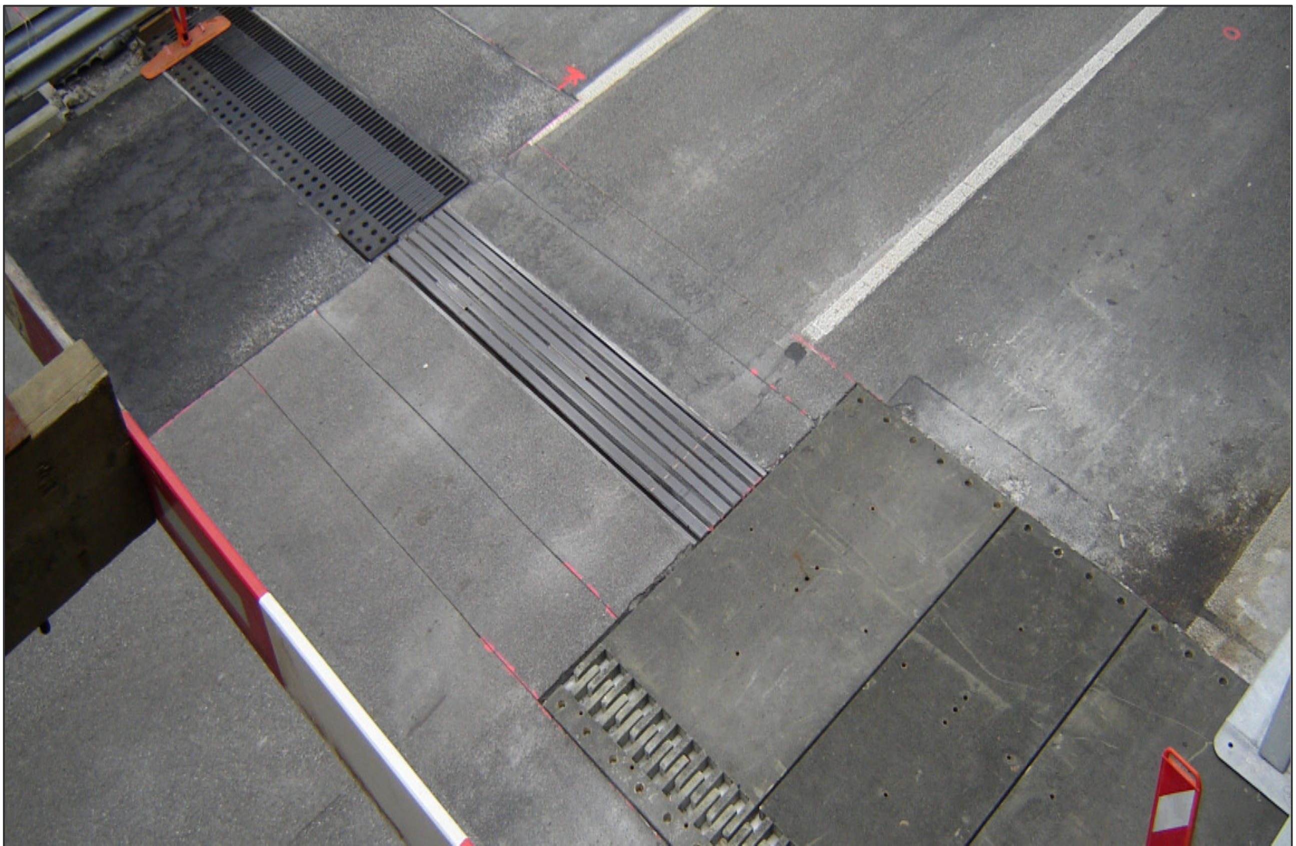

Figure 11: Replacement of expansion joint with Tensa®Flex Sliding Finger, using "Mini-Fly-Over"

With all work carried out at night and at weekends, when one lane could be temporarily closed to traffic, the replacement of the expansion joints had minimal impact on traffic flows, essentially "zero impact" due to the reduced traffic volumes at those times.

4. Conclusion

Modern society places high demands on those charged with constructing and maintaining the bridges that serve its cities and towns, with long term noise and temporary traffic disruption during the carrying out of such works to be kept to a minimum. This is of particular importance in the selection of expansion joints and the planning of their installation on busy routes, as expansion joints tend to be a source of noise on a bridge and are also likely to require replacement several times during the life of the bridge. The Tensa®Flex Sliding Finger expansion joint is ideally suited to meet society's demands, as it reduces noise to a minimum and with its modular design can be installed or replaced easily and quickly, without heavy lifting equipment. Together with Mageba's patented Mini-Fly-Over system, the joint offers a solution which minimises the impact on traffic, reducing the burden on society posed by these essential construction and maintenance works.