# Expansion joint replacement using the *Mini-Fly-Over* system to minimise impacts on traffic

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## Abstract

The *Mini-Fly-Over* approach to expansion joint replacement in road bridges can help minimise the impact on traffic of such work. It involves the construction of a temporary sliding plate expansion joint across the expansion joint location, which enables traffic to cross the worksite when required due to high traffic volumes but allows demolition, reconstruction and installation work to proceed at other times – e.g. at night-time or weekends. The use of the approach in the replacement of various types of expansion joint is presented, demonstrating its versatility and usefulness as a highly effective method of traffic management.

**Keywords:** expansion joint; replacement; renewal; traffic disruption; traffic management.

## 1 Introduction

When a bridge's expansion joints require to be replaced at the end of their service life, the potential disruption to traffic during the work is enormous. Demolition, deck reconstruction, curing of concrete and joint installation can result in significant delays or diversions to thousands of bridge users, every hour that traffic on the bridge is impeded by the work. The costs associated with such delays and diversions can include not only great financial costs due to the loss of productivity of those affected and indirect consequences of that, but also significant environmental costs (wasted fuel, exhaust fumes, increased vehicle wear and tear, etc.) – not to mention the frustration suffered by bridge users and the resulting damage to the bridge owner's reputation. Indeed, the overall costs of expansion joint replacement works are typically many times the original supply and installation costs [1]. Therefore, approaches to replacing expansion joints which minimise impacts on traffic must generally be worthy of serious consideration. One such approach, which has been tried and tested in replacing various types of expansion joint, utilises the *Mini-Fly-Over* system (Figure 1).

*Figure 1. Placing of Mini-Fly-Over plates to allow traffic to cross an expansion joint replacement worksite during peak traffic periods*

## 2 The *Mini-Fly-Over* approach to traffic management during expansion joint replacement

If an existing expansion joint is to be replaced when it reaches the end of its lifetime, the *Mini-Fly-Over* system can be used to allow traffic to cross the site during the daytime, while the construction works to install a new expansion joint are carried out at night-time / weekends, on a lane-by-lane basis if necessary. In this way, unhindered traffic flow during peak times can always be facilitated.

The *Mini-Fly-Over* system consists of steel plates which are anchored at one side of the bridge gap and span across to the other where they receive sliding support. These plates have fingers which interlock with opposing finger plates. At both sides of the bridge gap, the finger plates are supported by a flat surface formed from quick-drying polymer concrete. Once installed, the sliding plates which span the gap can be removed when traffic permits and when necessary to enable demolition or construction work to proceed, and then replaced to allow traffic to pass over again.

The standard use of the *Mini-Fly-Over* approach is summarised by the following four steps.

<u>Step 1: Saw-cutting and removal of existing joint</u>

First, the old expansion joint is removed – initially, just to the extent necessary to allow the *Mini-Fly-Over* to be installed.

<u>Step 2: Placing of *Mini-Fly-Over* plates</u>

The wearing course is then cut back at each side and surfaces of quick-drying *Robo®Flex* polymer concrete prepared to support the *Mini-Fly-Over* sliding plates. The *Mini-Fly-Over* plates are then positioned and anchored in place. Traffic can then be allowed to pass over the joint (Figure 2).

<u>Step 3: Preparations for installation of the new expansion joint during lane closures</u>

When the lane can be closed to traffic (e.g. during night-time or weekend closures), the *Mini-Fly-Over* is removed to allow the work to progress – e.g. with reinforcement installed, formwork positioned and concrete placed as may be required. At the end of each lane closure, the *Mini-Fly-Over* is put back in place to facilitate traffic as necessary.

<u>Step 4: Installation of expansion joint</u>

When the preparatory works have been completed, the *Mini-Fly-Over* is removed for the last time during a suitable road or lane closure and the new expansion joint is lifted in and fully installed.

*Figure 2. Traffic can flow freely during peak hours, with Mini-Fly-Over (in this case raised above normal surface) spanning the construction area*

The use of the system in installing various types of expansion joint (three different finger-type joints) is described in the following three sections.

## 3 Use of *Mini-Fly-Over* in installing *Tensa®Flex* sliding finger joints

The *Tensa®Flex* (Type RC) expansion joint (Figures 3 and 4, [2]) is a sliding finger joint, with the fingers of steel/elastomer finger plates extending across the main structure's movement gap from one side and receiving sliding support at the other. The finger plates are pre-tensioned downwards as a result of a slight downwards inclination of the fingers of each plate relative to the anchored part of the plate, and the tips of their fingers thus maintain constant contact with the sliding surface beneath, even following abutment settlements or deck rotations. It offers very low noise under traffic and very high driver comfort, and since the finger plates are, in effect, simply supported, traffic loading is efficiently transferred to the supporting structure with minimal moment effect. Beneath the expansion joint, a watertight drainage channel of EPDM, soft PVC or stainless steel is attached.

*Figure 3. A Tensa®Flex expansion joint, as installed at the end of a road bridge*

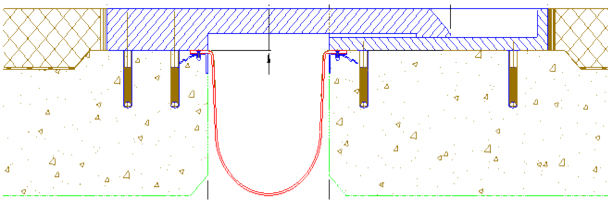

*Figure 4. Cross section of a Tensa®Flex joint*

The *Tensa®Flex* joint requires less installation depth than other comparable expansion joint types, considerably simplifying its installation on an existing structure. And such installation works can be carried out in phases, one traffic lane at a time, to minimise also the impact on traffic.

When installed on an existing structure, use of the *Mini-Fly-Over* approach can enable concreting works etc. to be carried out during road/lane closures, while allowing traffic to cross the site during peak hours when the *Mini-Fly-Over* plates are in position.

### 3.1 Case study: Felsenau Viaduct, Berne

The use of the *Mini-Fly-Over* installation method on a busy six-lane highway is described below. The Felsenau Viaduct (Figure 5), built in 1973, crosses the river Aare in Berne, Switzerland, and carries approximately 100,000 vehicles per day.

*Figure 5. The Felsenau Viaduct, Berne*

The design brief for the expansion joint replacement project had four key requirements:

- Avoid any impact on traffic during the daytime, Monday to Friday
- Only one lane could be closed during the night-time and at weekends
- The new joint should be quiet under traffic
- Short overall construction time.

Selection of the *Tensa®Flex* joint to replace the existing one, and the use of *Mini-Fly-Over,* enabled all of these demands to be met. The total duration of the work was seven weeks, with the work being carried out lane-by-lane, one week per lane, plus one week preparation. The work in one lane (one week) is illustrated by Figures 6 to 18.

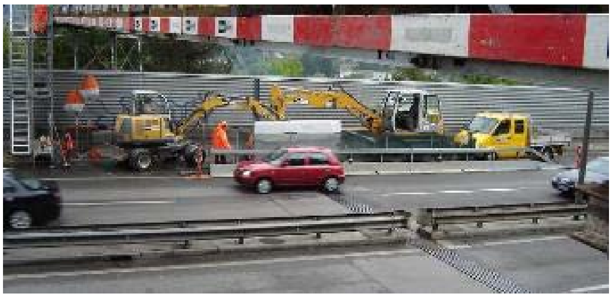

*Figure 6. Start of work on first Friday evening, with one lane closed until Monday morning*

*Figure 7. Recess cleanly excavated and subsoil compacted*

*Figure 8. Robo®Flex support surface placed at each side of the joint for the Mini-Fly-Over plates, with dowels to secure them*

*Figure 9. Robo®Flex support surfaces, dowels and shuttering in place*

*Figure 10. Mini-Fly-Over elements positioned and anchored in place at both sides of movement gap*

*Figure 11. Early on Monday morning, site cleared to allow lane to be re-opened to traffic*

*Figure 12. On Monday night, lane closed to traffic again, Mini-Fly-Over removed and concrete placed*

*Figure 13. By Wednesday evening, concrete cured sufficiently to drill anchor holes and place dowels*

*Figure 14. Drainage channel then placed and glued in position*

*Figure 15. On Thursday night, Mini-Fly-Over removed for the last time*

*Figure 16. Tensa®Flex finger plates precisely positioned (by hand), element by element*

*Figure 17. Finger plates anchored to dowels*

*Figure 18. After one week, with road newly asphalted, first phase finished and joint in service*

With all work carried out at night and weekends, the replacement of the expansion joints had very little impact on traffic on this busy highway.

## 4 Use of *Mini-Fly-Over* in installing *Tensa-Finger* sliding finger joints

*Tensa-Finger* (Type GF) sliding finger joints (Figures 19 and 20) provide a safe driving surface for traffic by means of steel fingers which span the structure's movement gap, interlocking with steel fingers at the opposite side. Like *Tensa®Flex* finger joints, the fingers that span the gap receive sliding support at the opposite side, minimising moment loading and increasing movement capacity. In common with all finger-type expansion joints, this joint is characterised by the high driving comfort and low noise emissions it offers.

*Figure 19. A Tensa®Finger (Type GF) sliding finger joint in service*

A typical design for this type of joint is shown by the following image of a full-scale model. The type shown has stainless steel spiral springs to pre-tension the sliding finger plates downwards, but alternative spring types may be used.

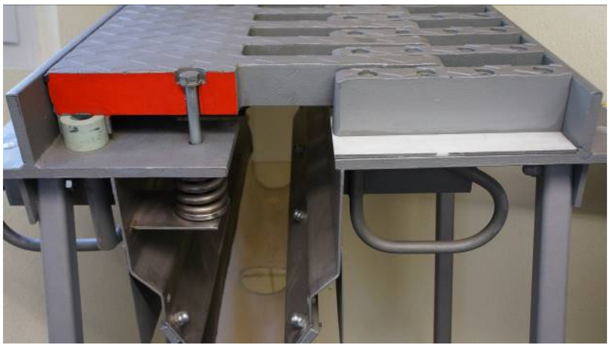

*Figure 20. Full-scale model of Tensa®Finger (Type GF) sliding finger joint, showing its construction*

### 4.1 Case study: Schiessplatz Bridge, St. Gallen

On a busy highway between the Swiss cities of Zurich and St. Gallen, the three-gap modular expansion joints at one end of the Schiessplatz Bridge needed to be replaced at the end of their service life. The bridge consists of two structures, with a three-lane carriageway on each. Two steel sliding finger joints were to be installed, each of length 12 m, and disruption to traffic had to be minimized – generally with all lanes open to traffic except at nighttime and weekends. At weekends, one lane on each structure could be closed from 9pm on Friday night until 5am on Monday morning, and a second lane could be closed for shorter periods, predominantly at night, if needed. During the week, up to two lanes could be closed to traffic at night, and one lane if necessary during the daytime. The joints at both ends of the bridge were to be replaced at the same time, to minimise construction time to just seven weeks during the summer period.

These challenging demands could be met by the use of *Tensa-Finger* (Type GF) sliding finger joints, installed in phases (three sections per joint) using the *Mini-Fly-Over* method. Thanks to the development of a detailed 14-phase programme, defining the lane closures, traffic management and construction work during each weekend and each work-week, the work on the two structures could be coordinated, with the same *Mini-Fly-Over* plates used on both structures, one after the other. Images from the installation work on one structure are presented in Figures 21 to 27.

*Figure 21. Removal of existing joint in first lane during first weekend*

*Figure 22. Mini-Fly-Over as placed in first lane at end of first weekend*

*Figure 23. Removal of joint in second lane for placing of Mini-Fly-Over during second weekend*

*Figure 24. Mini-Fly-Over in place in centre lane while outside lane closed for replacement works*

*Figure 25. Removal of Mini-Fly-Over in one lane at start of a weekend shift*

*Figure 26. Lifting in of the new finger joint in the first lane during the third weekend*

*Figure 27. Levelling of new finger joint prior to concreting and completion of connecting road surfacing*

## 5 Use of *Mini-Fly-Over* in installing *Tensa-Finger* cantilever finger joints

*Tensa®Finger* (Type RSFD) cantilever finger joints (Figures 28 and 29) provide a safe driving surface for traffic by means of steel fingers which cantilever across the structure's movement gap from each side, interlocking with the fingers from the opposite side. Contrary to sliding finger joints, of the types described previously, the fingers do not receive sliding support at the opposite side, increasing moment loading and decreasing movement capacity. Like sliding finger joints, however, this joint type offers high driving comfort and low noise emissions.

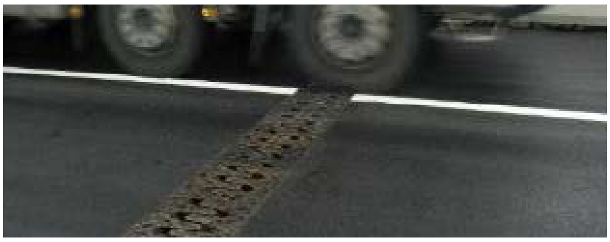

*Figure 28. A Tensa®Finger Type RSFD expansion joint in service on a bridge*

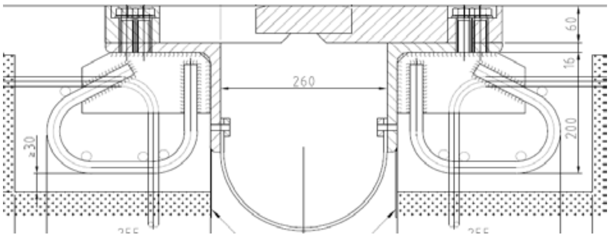


*Figure 29. Cross-section of a Tensa®Finger Type RSFD expansion joint*

### 5.1 Case study: Linden Bridge, Schwyz

The Linden Bridge (Figure 30) on the A4 highway in the Swiss canton of Schwyz opened to traffic in 1975. It has a total length of 536 m, with separate three-lane superstructures for each direction of travel. During renovation works in 2015, the existing modular expansion joints at both ends of both superstructures required to be replaced by *Tensa®Finger* (Type RSFD) cantilever finger joints with a movement capacity of 240 mm each. Disruption to traffic during the joint replacement works had to be kept to an absolute minimum, with work limited to off-peak traffic periods.

*Figure 30. The Linden Bridge in central Switzerland*

In planning the installation of the expansion joints on this bridge, it was decided to introduce a new element to the previously described *Mini-Fly-Over* installation method. By raising the level of the *Mini-Fly-Over* plates so that their top surface was raised above the expansion joint's driving surface (by an amount just exceeding the thickness of the plates), it becomes possible to complete the full installation of the new expansion joint, including setting of concrete etc., before the *Mini-Fly-Over* plates are finally removed. Otherwise, the lane in question must remain closed to traffic from the time the new expansion joint is lifted into place until the joint can be driven over by traffic.

In order to make this improved traffic management possible, it is necessary to temporarily raise the level of the road's driving surface in the vicinity of the joint, suitably tapered to avoid sudden level changes and consequent reductions in driver safety and comfort. This was achieved by the asphalting of temporary ramps at each side of the expansion joint at the time of *Mini-Fly-Over* installation, which could be removed without great difficulty when the *Mini-Fly-Over* was removed for the last time. This approach also made it possible to install the entire expansion joint as a single unit, without the need to connect sections together on site.

Images from the replacement of one of the four expansion joints are presented in Figures 31 to 37.

*Figure 31. The existing expansion joint prior to removal, with polymer concrete strips (darker colour) cast at each side to support Mini-Fly-Over*

*Figure 32. Drilling of holes (using template) in polymer concrete strips for Mini-Fly-Over anchors*

*Figure 33. Following anchoring of Mini-Fly-Over in place, road surface temporarily tapered at each side with new asphalt to suit level of plates*

*Figure 34. Removal of Mini-Fly-Over at start of a work shift to allow recess preparation to proceed*

*Figure 35. Final preparation of recess prior to lifting in of a new cantilever finger joint*

*Figure 36. Lifting in of a new cantilever finger joint*

*Figure 37. Fully installed cantilever finger joint following concreting in place, and removal of tapered ramps and re-asphalting at each side*

## 6 Conclusions

Although an uncomplicated concept, the *Mini-Fly-Over* approach to expansion joint replacement, if properly planned and implemented, can greatly reduce the impact on traffic of these essential works. The approach can be used for different types of expansion joint, and adapted to suit the particular traffic management needs of a specific structure – for example, with increased flexibility to undertake the removal and installation works during shorter road or lane closures by raising the *Mini-Fly-Over* plates above the normal driving surface and tapering the driving surface back at each side of the joint. With demands increasing to minimise traffic disruption due to road and bridge maintenance, the use of such innovative approaches to expansion joint replacement should be considered wherever appropriate.

## 7 References

[1] Spuler, T., Loehrer, R. and O'Suilleabhain, C. Life-cycle considerations in the selection and design of bridge expansion joints. *Proc. IABSE Congress on Innovative Infrastructures towards human urbanism*. Seoul, 2012.

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