# Forth Bridge

# Comb Joint Options Report

## February 2008



### Notice



### Document History

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# Executive Summary

The initial proposal to replace or refurbish the existing comb expansion joints took advantage of the full carriageway closure in place whilst the existing roller shutter expansion joints were replaced. The replacement of these roller shutter joints would require at least eight continuous weeks closure of each carriageway and it was considered that the opportunity should be taken to replace the comb expansion joints at the same time, minimising future disruption to road users.

Various alternative options for the roller shutter expansion joint replacement have been considered including the use of temporary over-bridges to allow the carriageways to remain open for the maximum duration possible. The feasibility of this option is described in full in the *Feasibility Study of Over-bridging Option* document ref: 5057541/304/001 Rev A. This option has reduced the road closure requirements from approximately eight weeks per carriageway to an estimated one week for the erection of the over-bridges on each carriageway. Due to this likely reduction, it will not be possible to carry out the comb joint replacement without further extensions to the planned carriageway closures.

Having assessed the condition of the existing comb joints, and pending further inspections, it is believed that the condition of the joints is not critical and replacement works are not deemed urgent. Since installation, the wear of the joints has been gradual and sudden failure of the plates is considered unlikely. In the event of failure of any joints, the effects are likely to be localised and temporary measures can be implemented to allow traffic flows to be maintained.

It is recommended that the comb joints are continued to be inspected to ensure their safe operation. Subject to inspection, replacement works should be carried out in conjunction with future re-surfacing works in approximately five years time, thus reducing the inconvenience caused to the travelling public.

# 1. Introduction

Cantilever comb expansion joints are located between the approach viaduct and the side suspended span on the north side of the bridge and at Pier S3 of the south approach viaduct. They were commissioned in 1964 and remain in their original condition with the exception of the holding down system which was modified in 1970. The joints are currently showing signs of wear in the running plates and the supporting arrangement. The spring loaded bolt system, which holds down the removable comb plates, has been replaced and modified to make it accessible from below for maintenance and repair.

Each comb joint comprises bolted comb plates and a fixed comb plate at carriageway level. The fixed comb plate forms one unit across the entire carriageway width and is integral with the bridge deck. The bolted comb plates are smaller in width and are readily removable with eight plates in each carriageway. The bolted comb plates span from one side of the joint to rest on a support bar attached to the end of the fixed comb plate. The bolted plates are showing signs of distortion in the comb fingers and overall displacement due to wear of the supporting bar on the fixed comb plate.

# 2. Causes of Deterioration

The existing comb joint system is showing wear and distortion, primarily of the bolted plates. Movement of the bolted comb plates across the support bar attached to the fixed comb plates has resulted in wear to both the support bar and the underside of the fingers of the bolted comb plates. This wear has caused the fingers of the bolted comb plates to deflect downwards so there is now a difference in level across the joint. The supporting rib at the rear of the bolted plates has also worn, resulting in an overall drop in level across all plates.

Due to the drop in height of the bolted comb plates, the fixed comb plate fingers now protrude up above the bolted comb plates. This has resulted in direct vehicle run over at the exposed ends, causing some wear on top of the fingers.

The drainage system at the joint underside has suffered damage over the years, possibly as a result of the difficult access for maintenance and the system now requires replacement.

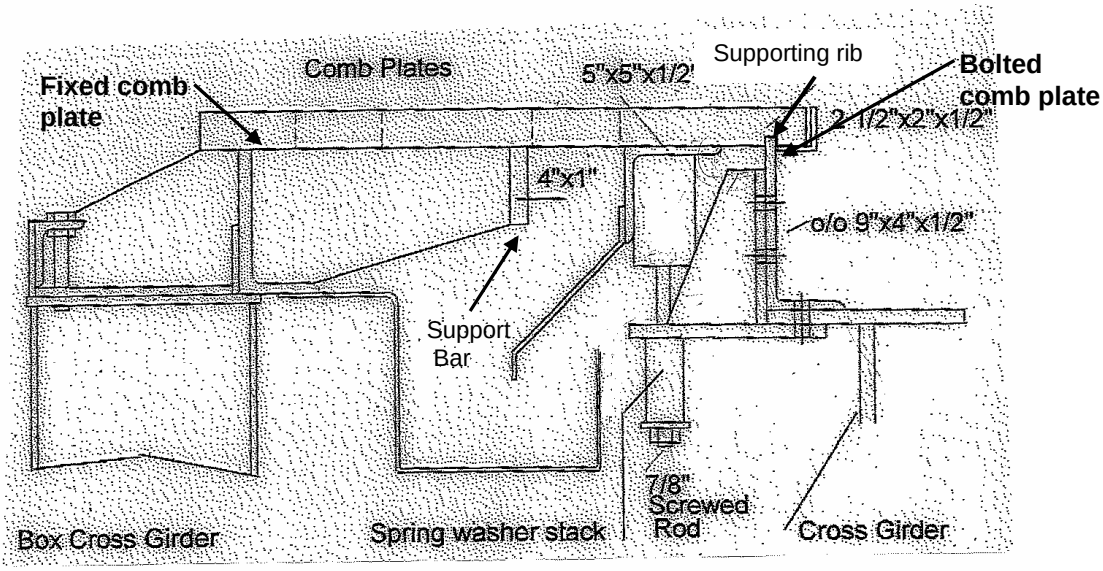


**Fig 1– Typical Section through Comb Joint**

# 3. Modes of Failure

Whilst the comb joint units are showing signs of deterioration, it is not believed that they currently pose a risk to road users. It is however necessary to carry out further investigation/inspection works to accurately establish their current condition and assess the likelihood of future failure.

Any future degradation of the units is likely to be similar to the existing wear, resulting in further lowering of the bolted comb plate, due to additional wear on the supporting beams at both ends of the comb plates. This will also give rise to further wear of the exposed fingers of the fixed comb plate, causing “rounding-off” of the top surface. Any movement and distortion is likely to be gradual and not result in any sudden failures. The overall distortion and wear to the plates is low in relation to the plate thickness. However should failure occur, it is likely to be limited to a single bolted comb plate. This would enable a temporary plate to be placed over the area, allowing the carriageway to remain open to traffic.

Due to the high number of bolts and springs within the system, failure of any of these components is unlikely to cause global failures, due to the high level of redundancy within the joints.

The fixed comb plate has shown little sign of distortion or overall movement since installation and it is believed that failure of this plate is unlikely.

# 4. Consequences of Failure

Pending further investigations of the conditions of the comb joints, it is judged that any sudden failure of the joints is improbable. Based on the existing conditions of the joints, including signs of wear evident at carriageway level, future deterioration is likely to be gradual and not cause sudden failure. As such, any problems encountered by road users are likely to be as a result of the change in height of the two corresponding plates. This may be pertinent for motorcycle users and a further visual survey should be carried out to determine the extent of this problem and the likely consequences.

Any unacceptable distortions or failures of the plates are likely to be localised due to the width of each bolted plate. As such it would be possible to place a temporary plate over the joint section in

the event of any problems, enabling the carriageway to remain open until repairs can be completed.

# 5. Proposals for Refurbishment

The refurbishment proposals include the removal and replacement of the bolted comb plates whilst the fixed comb plate remains in place. This will require the replacement of the supporting arrangement which attaches to the transverse deck beams. An additional support bar will be attached to the fixed comb plate to address the wear in the existing bar.

In addition, the drainage system on the underside of the joint requires replacement, incorporating improved access for future maintenance.

# 6. Conclusions and Recommendations

Further investigations should be carried out for the comb joints to determine their current condition and requirements for refurbishment. However it is believed that they currently pose little risk to road users and refurbishment is not deemed critical. Having assessed the deterioration since installation, sudden failure of the joint system is unlikely and any future wear is likely to continue in a gradual manner.

Should the comb joint survey highlight areas of concern and excessive wear, consideration will be given to the early replacement of the joints.

By utilising an over-bridge to carry out the roller shutter joint replacement, the overall road closure duration will decrease, which will remove the benefits of carrying out the comb joint replacement works concurrently. As such, it is recommended that the comb joint works be carried out at the next period of significant road closure which is in approximately five years, when re-surfacing works are planned. This will minimise inconvenience to the travelling public whilst not compromising the structure's safety due to the non-critical condition of the existing comb joints.