Infrastructure and Capital Investment Committee

Inquiry into the circumstances surrounding the closure of the Forth Road Bridge
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Infrastructure and Capital Investment Committee

To consider and report on infrastructure, capital investment, transport, Scottish Water and other matters falling within the responsibility of the Cabinet Secretary for Infrastructure, Investment and Cities, and matters relating to housing and digital infrastructure.

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Introduction

1. At its meeting on 16 December 2015 the Infrastructure and Capital Investment Committee agreed to hold an inquiry into the circumstances surrounding the closure of the Forth Road Bridge (FRB). This followed the closure of the FRB to all traffic on public safety grounds on 4 December due to the discovery of steelwork defects of a support beam. Specifically, the remit of the inquiry is:

   To examine the management, monitoring and maintenance of the Forth Road Bridge principally in the 10 year period prior to its closure on public safety grounds in December 2015.

2. Whilst the Committee acknowledged that the closure of the FRB brought frustration to travellers and had a significant impact upon many businesses, it agreed that its inquiry should focus on the structural defects identified and whether these could have been avoided or dealt with differently. The Committee acknowledges that these related and hugely important issues might however be investigated at a later stage.

3. This report will seek to examine the nature of the defect which led to the closure of the FRB on 3 December 2015 and consider whether it could reasonably have been foreseen. It will also look at the process of decision-making leading up to the closure, together with the repair process and staged re-opening to traffic. In the report, the Committee will also reflect on earlier proposed work related to the failed components which led to the closure and related capital funding issues.

Written and oral evidence

4. The specialist nature of this inquiry meant that the number of individuals or organisations who were able to provide evidence to the Committee was relatively low. However, as the inquiry was looking at the decisions made by the Forth Estuary Transport Authority (FETA) and Transport Scotland over a number of years, the volume of material to be considered by the Committee was particularly high.

5. In order to understand the background to some of these decisions, the Committee took oral evidence from Transport Scotland and Amey (who were appointed by Transport Scotland to manage and maintain the FRB from June 2015), representatives of the FETA (who had managed and maintained the FRB up to June 2015), independent engineering experts and the Minister for Transport and Islands.

Visits

6. On Monday 14 December 2015, prior to the Committee agreeing to hold an inquiry, a number of Committee members attended a technical briefing at the FRB
hosted by the Minister for Transport and Islands. Following the Committee’s
decision to hold an inquiry but ahead of its first evidence session, members of the
Committee visited the FRB on 19 January to see where the steelwork failure
occurred and the interim solution which had been put in place.

Acknowledgements

7. The Committee would like to take this opportunity to thank all those who provided
written and oral evidence to the inquiry, particularly those who travelled from
throughout the UK and North America to appear before the Committee. We would
also like to place on record our thanks to Alan Simpson for the expert advice and
insight he was able to provide on the FRB and suspension bridges more generally
in his role as technical adviser to this inquiry.

Image: Committee Members view the repair work at the Forth Road Bridge.
Forth Road Bridge – management responsibility

8. The construction and management of the Forth Road Bridge was originally overseen by the Forth Road Bridge Joint Board, established under the provisions of the Forth Road Bridge Order Confirmation Act 1947. The Joint Board retained responsibility for the management and maintenance of the FRB until 1 April 2002. On that date the Joint Board was dissolved.

9. On 1 April 2002, a newly created body, FETA (which came into existence under the provisions of the Forth Estuary Transport Order 2002), took on the assets, liabilities and responsibilities of the Joint Board but with a broader remit. This allowed FETA to spend money on public transport and other initiatives aimed at improving cross-Forth travel and reducing congestion on the Forth Road Bridge in addition to bridge maintenance and operation.

10. FETA was formally wound up, under the provisions of the Forth Road Bridge Act 2013, on 1 June 2015, when the assets, liabilities and responsibilities of FETA were passed to Scottish Ministers. Transport Scotland, acting on behalf of Scottish Ministers, contracted out the day-to-day management and maintenance of the FRB to Amey, which was the successful bidder for a five year long management and maintenance contract. This contract also began on 1 June 2015.

Truss end link failure and repair

11. The Committee was keen to gain an understanding of the nature and purpose of the truss end link components which failed on the FRB; how their failure was identified; the steps subsequently taken to close the bridge; and the repair process. The Committee’s adviser to the inquiry has provided detailed information and analysis in this regard.

12. It is understood that the truss end links support the ends of the main truss and connect them to the main towers. The links are in pairs with one link either side of the end post of the truss. Movement of the truss in a north-south direction is allowed by pins at each end of the truss end links. Movement takes place due to the live loads of traffic, wind and temperature. As vehicles move across the bridge, the main span moves slightly in a north-south direction; a wind blowing along the length of the bridge will also move it north or south, while temperature changes will cause the whole of the stiffening truss to expand and contract due to normal thermal expansion and contraction. On 1 December 2015 at 3.30pm the failure of one of the truss end links at the north east corner of the main span was identified by Amey staff conducting routine maintenance.
13. As soon as the failure was observed, Transport Scotland officials were informed by Amey. At 4.00pm Fairhurst, engineering consultants, were contacted to provide structural engineering support during the investigation and assessment and to design a repair system. Arup engineering consultants were also engaged at 2300hrs to provide an independent check on the assessment and design work.

14. As a precautionary measure, the southbound carriageway of the bridge was closed to traffic at 9.30pm and a contraflow installed on the northbound carriageway so that there was one lane of traffic open in each direction. The purpose of this was to reduce the load from traffic on the remaining link, first by only having two lanes of traffic open and secondly by moving the traffic as far away as possible from the failed member.

15. Following the failure, inspections were initiated on the other truss end links which included non-destructive testing as well as visual inspections. The Committee understand that, initially, it was not clear why the member had failed. Previous work carried out by Fairhurst in 2008 had shown that the vertical loads in the truss end links were well within their capacity, which suggested that they should not have failed.

16. Consideration was then given to whether the failure could have been caused by either a serious defect in the steelwork or a brittle failure that would be initiated by a possible imperfection in a weld. However, the Committee heard from Mark Arndt of Amey that when a metallurgist was brought in to inspect the fractured surface he confirmed that it had been caused by a fatigue failure. He told the Committee—
We engaged a specialist metallurgist to come out and inspect the failed member. His conclusive recommendation was that there was indeed a fatigue failure because the propagator initiated at the weld interface, which is potentially the weak interface.... That then propagated along the weld and progressed into the member itself, which led to a quick failure.²

17. Further analysis was then carried out to try to gain an understanding as to how the member could have been subjected to such fatigue loading. Attention focussed on the pin that connects the bottom of the truss end link to the bottom chord of the truss. As explained previously, the purpose of the pin is to allow free movement in a north south direction between the towers of the bridge and the main suspended span and movement occurs under traffic loads, wind loads and changes in temperature.

18. These movements cannot be stopped so, if the pin is not working correctly, they have to be accommodated by bending in the truss end link instead of by its rotation. Bending stresses would be set up every time an HGV crossed the bridge and the level of stresses combined with the frequency of their occurrence set up a fatigue induced failure.

19. The Committee heard from Richard Hornby of Arup on the mechanism as to how a fatigue failure is likely to develop. Initially it would have been a very small crack that would have been undetectable in an inspection. It would have grown gradually at first but then quicker, and would probably have taken only a matter of months to grow from a crack that was visually undetectable to something that had totally failed.

20. On 3 December a crack was identified in the other link at the north east corner of the main span which, although small, could have propagated quickly. If that member had also failed, the end of the truss would have dropped suddenly by 150mm under dead load but up to 260mm under live loads. Although the overall structural integrity of the FRB would not have been compromised, it would have caused a step in the level of the road surface and a danger to the road users. This degree of movement would also have been likely to have damaged the expansion joints which could take in excess of 3 months of road closures to repair.

21. Amey therefore wrote to Transport Scotland at 4.00pm recommending that the FRB be closed to traffic. This recommendation was supported by Arup at 5.50pm and by Fairhurst at 6.00pm. Later that day Transport Scotland held a meeting with
the First Minister at which, at around 9.00pm, it was agreed that the FRB would be closed to traffic at midnight.

22. The closure of the FRB caused severe disruption to travellers between Edinburgh and Fife, exacerbated by the increased traffic in the build up to Christmas. Additional buses and trains were scheduled to take people from Fife into Edinburgh but the Kincardine and Clackmannan Bridges remained extremely congested with long delays encountered throughout the day. To alleviate some of the difficulties for commercial traffic, a temporary relaxation to the EU rules on drivers' hours was negotiated with the EU.

23. An intensive programme of inspection at the other three similar locations on the main span and four on the side spans was started and a load test was carried out to try to check whether the pins connecting the lower ends of the truss end links were rotating correctly. The results of this test were inconclusive. However, an analysis of the truss end links to the side spans showed that, even if the pins were completely seized, the link members could accommodate the movement by bending without becoming overstressed. Work was then able to be concentrated on the main span links.

24. By 8 December the design of the repair had been developed sufficiently to allow steelwork to be ordered and fabrication to start. This repair involved welding vertical steel members onto each side of the truss end link above the level of the failure. A horizontal piece of steelwork attached to the bottom of these splices formed a platform on which a jack rested. The jack would then be expanded until the two original parts of the truss end link were brought into contact again after which it would all be welded into position. Only one member had completely failed (i.e. a visible crack had opened up) so for the other truss end links the design was the same except that there was no need to use a jack to bring the two parts together. The design relied on the assumption that the pin was able to rotate although a high friction coefficient was assumed.

25. Meanwhile, the design of the temporary works to allow access to the lower ends of all the main span truss end links was underway. The failed member would be accessed from scaffolding built up from the pier heads at the bottom of the tower while the other locations would be accessed from hanging scaffolding.
26. During December 2015, periods of high winds seriously hampered work on the FRB and, on many occasions, work on site had to be suspended until the wind abated. However, work thereafter was progressed as quickly as possible. Mark Arndt of Amey said —

> Lighting was used so that the work could progress day and night. The teams had to stand down regularly because the winds got so high that it was unsafe to work, but they just got off the scaffolding and waited until the control room indicated that the wind speed had dropped sufficiently to allow them to return.

27. Notwithstanding the bad weather, the repair of the failed member was completed on site on 18 December and a load test was carried out on 19 December by using twenty 20-tonne vehicles at selected positions on the bridge. The purpose of the load test was to check the amount of rotation in the pin. Strain gauges and other monitoring devices had been installed on the link and end post to check the effects of the loads. Although some rotation was observed, detailed analysis was required to check whether the rotation was sufficient to allow the bridge to be opened to all classes of vehicles.

28. The analysis showed that the friction around the pin was excessively high and attempts to reduce it by forcing lubricant into the joint were unsuccessful. It was therefore concluded that the FRB could not take the full level of traffic loading. A decision was therefore taken to reopen the FRB to all traffic except HGVs at 5.00pm on 23 December. The completion of this work constituted the Phase 1 stage of the works at this location.

29. By 23 December, when the bridge was reopened to most traffic, a Phase 1 splice repair had also been completed on the three other pairs of truss end links to the main span as well as the connections of the side spans to the north-east, north-west and south-west towers. By 30 December the remaining links on the side span at the south-east tower had been completed.

30. Witnesses appearing before the Committee commented favourably on the fact that the FRB had been repaired and reopened to most traffic in a relatively short timescale. For example, John Evans, an engineering consultant with Flint & Neil stated—

> I am amazed at how much has been accomplished in such a short time. I know that a huge amount of resource was put in, but it was still a major effort and all involved are to be congratulated.

31. A Phase 2 stage of the works was developed which would see the installation of additional brackets on the main towers with strand jacks to support the ends of the trusses, thus allowing HGVs to use the FRB unrestricted. This phase of the works would see the load taken from the top of the trusses which would then allow Phase 3, involving the complete replacement of the truss end links, to be implemented. The design of Phase 2 was completed by 23 December and the
installation at the north-east of the main span was originally anticipated to be completed by the middle of February 2016.

32. The plan was to open the FRB to HGVs once the Phase 2 works had been installed at the north-east of the main span but it was dependent on whether the other pins supporting the main span were operating correctly. If the other pins were found to be not operating correctly then the Phase 2 works would have to be installed wherever this was the case. In the worst case scenario of Phase 2 works being required at all four locations on the main span then the anticipated date for completing them and opening the bridge to HGVs was mid-March.

33. In an attempt to mitigate the delays to HGVs a system was introduced on 4 February on a trial basis which allowed one HGV to cross the bridge in a northbound direction every 30 seconds between the hours of 11.00pm and 4.00am. This created the opportunity for up to 600 HGVs to cross. By controlling the crossing by HGVs in this manner when there was very little other traffic on the bridge, the load on the bridge was kept to an acceptable level. On 15 February, the controlled period was extended by an hour and a half to 5.30am which potentially allowed for a further 180 HGVs to cross the bridge northbound.

34. While the strengthening work was proceeding at the north-east corner of the main span, inspection work continued on the other links and strain gauges and monitors were installed to check how the pins at these other locations were moving. On 5 February it was announced by Transport Scotland that two other pins, those at the southwest and southeast corners of the main span were not operating correctly. Because of this it became necessary to install Phase 2 works at both of these locations before the bridge could reopen to HGVs. At the time of this announcement, it was stated by Transport Scotland that the completion date for these works was expected to be mid-March.

35. As a result of the knowledge gained by installing the Phase 2 works at one location, the programme was able to be rescheduled, more work was carried out in the workshops and the operation continued 24 hours a day 7 days a week. The weather was also more favourable than it had been through December and, as a result of this, the completion was brought forward from the middle of March to Saturday 20 February at 11.00pm.

36. The Phase 2 works to the side spans were not required to be completed before the bridge was opened to HGVs. This work will therefore be completed as part of a planned programme of work during financial year 2016/17 so that any disruption to traffic will be minimised.

37. The Committee has been advised that Phase 3 works have not yet been fully designed but it is anticipated that they will involve the installation of new truss end links with a different detail for the pin. The current arrangement has the pin fixed to the truss end links so that it rotates within the end post of the truss. It is likely that this will be reversed so that it rotates within the truss end link which will make it easier to inspect and maintain. It is proposed that the Phase 3 works at the four
main span areas will be undertaken first and it is understood that these will be programmed so that there will be minimal disruption to traffic.

38. The approximate costs of the different phases of work are given below. It should be noted that costs for the Phase 3 works are estimates only as these have not yet been designed or tendered. The costs of the structural health monitoring which was installed to check the movement and stresses in the truss end links amounted to between £1.0 and £1.5M and may be added to the figures below.

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<th>Phase 1</th>
<th>Immediate repairs (spint repair)</th>
<th>c £3.0M</th>
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<tr>
<td>Phase 2</td>
<td>New brackets to main span</td>
<td>c £2.65M</td>
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<tr>
<td></td>
<td>New brackets to side spans</td>
<td>c £2.65M</td>
</tr>
<tr>
<td>Phase 3</td>
<td>Main span</td>
<td>c £5.7M</td>
</tr>
<tr>
<td></td>
<td>Side spans</td>
<td>c £5.7M</td>
</tr>
<tr>
<td>Total</td>
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<td>c £19.7M</td>
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39. The Committee was advised by the Minister for Transport and Islands that whilst the bridge was closed the opportunity was taken to carry out some routine works on the bridge and its approaches. These would normally have required lane or carriageway closures. Further details of these additional works were provided by email by Transport Scotland on 24 February and these included detailed inspections of the road surface; patching of the A90 south of the bridge; landscaping north of the bridge; replacing lane markings and studs; and general sweeping and gully cleaning.

40. In addition to work on the FRB, the contractors on the Queensferry Crossing brought forward a number of activities that would have required lane or carriageway closures. These included the construction of crossovers on the A90 south of the FRB; the removal of an overhead gantry; the construction of a foundation for a new gantry and various works to the carriageway on the north side of the bridge.

41. The Committee notes that the design and installation of the repairs to the FRB was carried out with remarkable speed during a period of very poor weather conditions with regular bouts of exceptionally high winds. The response from all of the staff onsite to the discovery of the failure of the truss end link was exemplary in its implementation of measures to protect the safety of FRB users and the structural integrity of the bridge. The Committee wishes to commend all of those involved for their professionalism.
Decision-making on closure of the Forth Road Bridge

42. When discussing events and circumstances related to the closure of the FRB in December 2015, the Committee noted with interest the apparent differences in the processes of decision-making which related to weather-related and emergency bridge closures.

43. When FETA had full management and operational responsibility for the FRB, it had the power to close the bridge for any reason. In the case of high winds, the most common cause of a closure, they received predictions of wind from weather forecasters and had access to readings from an anemometer in the centre of the main span. Clear procedures were set out in which the bridge was closed to high sided vehicles by FETA officials when the wind reached a certain speed and to all vehicles at a higher speed threshold.

44. When planned work was carried out on the FRB that would require a lane or carriageway closure, notices were published in the same way as occurs in respect of local authority road closures.

45. In emergency conditions, the Bridgemaster could shut a lane, a carriageway or the whole bridge at his discretion if he felt that it was necessary for safety. In such circumstances, he would contact Transport Scotland and Traffic Scotland to put in place all the contingency arrangements to notify the travelling public and put in place diversion routes. The Committee heard how Peter Hill, the Bridgemaster at the Humber Bridge, had closed that bridge fully two days before he gave evidence, due to an overturned lorry.

46. Since FETA was dissolved, the operating procedures in relation to weather-related restrictions and closures at the FRB have continued. For example, in the event of high winds, the decision to close the bridge is taken by Amey at the location on the basis of the established written procedures. However, from information provided in relation to events surrounding the December 2015 closure, it appears to the Committee that the decision making process in an emergency is less clear. As discussed earlier in this report, Amey, the operating company, submitted a written recommendation to Transport Scotland officials at 4.00pm on Thursday 3 December to recommend full closure of the bridge. This recommendation had stemmed from the results taken from tests on the outer truss end link adjacent to the failed NE tower truss end link where a crack had been identified that could propagate. It appears that Transport Scotland officials then notified the Minister for Transport and Islands and a meeting was then held at 8.30pm which was attended by the First Minister, the Cabinet Secretary and the Minister at which the unanimous decision to close the FRB at midnight was taken at around 9.00pm.
47. Transport Scotland has a policy in place to manage a variety of incidents on the trunk road network. These cover routine, critical and major incidents. A major incident will also generate a strategic response dependent on the circumstances. This will involve mobilisation of the Multi Action Response Team (MART). Furthermore, the following action is taken in relation to more significant events—

Where the incident has a wider impact for the country the Scottish Government Resilience Division is mobilised to consider the impact and along with partners develop a strategic response in partnership with all relevant stakeholders and responders to mitigate the risks of the major incident.

48. The Committee notes that Amey has prepared an Incident Response Plan for the Forth Bridge Unit. Part of it is concerned with the arrangements for dealing with structures in an unsafe or potentially unsafe condition. This document states that the operating company will—

(i) assess the safety and stability of a damaged structure

(ii) assess whether there is a risk that public safety is endangered

(iii) assess whether a structure can continue in use with or without restrictions

(iv) assess whether the use or stability of a structure is at risk

49. If, after undertaking these assessments, they subsequently reach a view that a closure of the FRB is required; the operating company will then install traffic barriers to prevent vehicular access to and across Structures following a Critical or Major Incident that renders the Structure potentially unsafe.

50. The Committee acknowledges that when situations arise which require the emergency closure of major pieces of transport infrastructure which could result in significant travel and, potentially, economic disruption, there will be a need to ensure the relevant Scottish Ministers are quickly made fully aware of the relevant circumstances.

51. The Committee notes that on 3 December there was a time delay of five hours between the recommendation by Amey that the FRB should be closed and the decision taken at a meeting with ministers to close it. Whilst it recognises that this delay did not present any danger to users, the Committee is of the view that there is a lack of clarity as to who is ultimately responsible for closing the FRB and what protocol exists for making such decisions.

52. It considers that, in circumstances in which senior engineers in the operating company reach a view that the FRB needs to be closed on public safety or other emergency grounds, it should be possible for closure to be implemented by senior engineers without delay, under the terms of the operating company’s Incident Response Plan, without a requirement to seek authority from Transport Scotland or Scottish Ministers.
53. The Committee therefore requests that the Scottish Government confirm who is ultimately responsible for making a decision to close the bridge and provide details of the protocol followed in circumstances where a closure is required. It also calls on the Scottish Government to consider whether a clearer and more immediate decision making procedure is required to deal with emergency events which arise on the Forth Road Bridge.

Inspection regime at the Forth Road Bridge

54. In addition to considering issues related to the closure of the bridge and its subsequent repair, the Committee was keen to establish how maintenance inspections were carried out by FETA and currently by Amey.

55. Bridge owners and operators are responsible for carrying out inspections on their bridges to check for any deterioration in the structure. The Design Manual for Roads and Bridges is the UK standard that has been adopted by Transport Scotland and it sets out the normal inspection requirements for motorway and trunk road bridges. There are different types of inspections that are included in the Design Manual maintenance programme for bridges and they include:

- Safety inspections which are carried out at an appropriate frequency to ensure the timely identification of a defect that might have a safety implication. These are normally carried out from road or other easily accessed part of the bridge.

- General inspections which are carried out at not more than two year intervals and comprise a visual inspection of all parts of the structure that can be inspected without special access equipment.

- Principal inspections which are carried out at six year intervals and require a close examination within touching distance of all parts of the structure that can be inspected. This will require special access systems as appropriate.

56. However, instead of following the standard approach, the Committee heard how the FETA Bridgemaster and Chief Engineer had considered that the standard approach was not sufficiently focussed and robust for a major structure such as the FRB. They had therefore developed a risk based inspection regime, within which the frequency of inspections of a member was dependent on its criticality and vulnerability. Critical components such as the truss end links were inspected every 6 months. The same inspection regime was adopted by Transport Scotland when they took over responsibility for the FRB. The most recent inspection of that area had been undertaken on 19 May 2015 and there have been 23 inspections at that location since 2001, with no defects noted on any of those inspections.
57. The Committee was informed that the most recent inspection, in May 2015, was carried out by an inspector with more than 20 years’ experience. The truss end links are one of the most inaccessible part of the bridge and they require the inspector to access it from the bottom chord of the truss and make a visual and hand inspection assisted by mirrors attached to the end of wooden poles. This is a tried and tested method that has picked up defects in the past such as those on the cable band bolts.  

58. The other major suspension bridges in UK (Humber, Severn and Tamar) now use a risk based approach to inspections so that critical elements are inspected more frequently than the standard two and six year cycles. A frequency of six to twelve months for the truss end links was considered by all of the independent witnesses to be a very high standard of inspection. Richard Fish, who had been the Bridgemaster at the Tamar Bridge, believed that, in general, the truss end links and their equivalents on other bridges were often overlooked, but this had not been the case at the FRB. He was aware that as soon as the failure at the FRB was in the news, the equivalent detail at the Tamar Bridge was immediately inspected. He said—

"I spoke to the bridge manager at Tamar the other day and he said that as soon as the news about Forth came out, the first thing that he went to look at was the pintles on Tamar."

59. All of the independent witnesses confirmed that it was extremely difficult to check that movement was occurring correctly in the pins. The detail of the pins at the FRB has the pins fixed to the truss end links and rotating in the end posts of the truss, which makes it impossible to see any movement taking place. John Evans explained how a partially seized pin usually makes a noise when it moves. The noise is loud because it reverberates through the steelwork of the bridge and gives an indication that something is wrong but this did not occur at the FRB.

60. The detail of the connection between the main towers and main suspended span is not always the same as at the FRB, but many bridges have a link which moves with a pin. At the Humber Bridge, there are elements that move in the same way. They are not truss end links, but they are structural elements that rotate on a bearing point. They have very recently replaced them. However, the problem at the Humber Bridge was excessive wear, which becomes quite apparent over time. There is a similar issue with elements at the Tamar Bridge, which is again being observed through wear.

61. The detail at the Severn Bridge is slightly different again. During the assessment for the new loadings, it was discovered that the original end props from the 1960s design were both overloaded and suffering from wear. By 1990 they had been completely renovated with new props installed.

62. When the FRB was owned and operated by FETA, the Bridgemaster was a member of the International Cable Supported Bridge Operators Association. This
body shared experiences and best practice in the inspection, maintenance and repair of major cable bridges, including suspension bridges. Knowledge was also shared between the operators of the major suspension bridges in UK.

63. Since FETA was dissolved, the responsibility for the FRB has transferred to Transport Scotland and the inspection and maintenance is carried out on their behalf by Amey. The Chief Bridges Engineer at Transport Scotland now sets the standards for inspection and he is a member of many forums that meet to share best practice in UK and internationally, such as the Bridgeowners Forum, IABSE and the Long Span Bridges Group.

64. The contract with Amey is set up with flexibility to allow for changes to be introduced. Amey are paid a lump sum for undertaking a predefined programme of inspections and maintenance. If anything is found during those inspections that requires further work such as a repair or a special inspection, then that is paid for as an addition to the contract. In this way, developments in best practice can be introduced.

65. The Committee is content that a comprehensive and robust risk-based inspection regime was in place when FETA had responsibility for the maintenance of the FRB. It notes that this went beyond the standard UK inspection requirements for motorway and trunk road bridges. The Committee further notes that this regime has been adopted by Amey and forms part of the current maintenance arrangements.

66. The Committee also acknowledges the importance of information exchange and sharing of good practice on maintenance issues between the operators of suspension bridges across the world. It is reassured that Transport Scotland’s Chief Bridges Engineer will continue to attend meetings of UK and international bridge operators’ groups, as the former Bridgemaster did previously. It notes that the nature of the defect which caused the closure of the FRB and the experience of engineers in responding to it is likely to be of significant interest to the international bridge community.

67. As part of its considerations, the Committee was keen to obtain views from witnesses as to whether, based on available information since the specific defect on the FRB was identified, it could have been identified at an earlier stage. The former Bridgemaster, Barry Colford, was clear in his view that it could not have been, explaining to the Committee—

"I have obviously thought about that for quite some time, and my answer is no—I do not think that it could have been foreseen. We carried out our inspections, and the problem was not foreseeable. We spent a lot of time looking at the truss end links, and we had many consulting engineers assisting us in that. We did not foresee the issue with the pin sticking, if that is indeed what the mechanism for failure was."
68. The independent expert witnesses who appeared before the Committee, all believed that everything reasonable had been done to inspect the truss end links and the pins at the FRB, but that the failure had been unforeseen and unforeseeable. John Evans told the Committee—

> I do not know of any system that checks whether the pins are moving. There are systems that check the movement of the bridge by checking the whole link. However, I do not know of anything that checks whether the pins are turning. As the committee has discovered, we cannot see the pins.

69. The Committee was advised that one difficulty in finding this particular problem during an inspection was that the pins rotated in the end post of the truss and not in the truss end links, so that rotation would not have been visible.

70. The method of failure was a fatigue failure which is caused by a large number of cyclic loadings at a level lower than the ultimate strength of the material. The failure is initiated at a very small defect and it can initially propagate very slowly but then accelerate quickly until failure is reached.

71. Other similar bridges have suffered problems with their truss end links or their equivalent members and many have been replaced. However, the problems have related to excessive wear with the holes becoming elongated which allows too much movement. This is exactly the opposite problem to that which occurred at the FRB. In spite of sharing best practice with Bridgemasters at other suspension bridges around the world, there was no knowledge of this happening elsewhere except possibly on an interstate bridge in US where the inspection regime is unlikely to be comparable.

72. The Committee notes from the evidence presented to it that, even with a robust inspection regime which FETA had in place at the time, it would have been almost impossible for engineers to have identified the failure of the pin in the truss end link which is now known to be the primary cause of the defect which led to the closure of the FRB in December 2015. It notes that there are no other examples of a similar failure occurring on suspension bridges elsewhere in the world which might have informed engineers and led to enhanced checking of the pins. The committee is therefore satisfied that the defect could not have been foreseen.

**Structural health monitoring**

73. The Committee inquired as to whether some form of structural health monitoring should have been installed that would have supplemented the visual inspections and given prior warning of the failure. It heard how structural health monitoring is being installed on the new Queensferry Crossing at a cost of between £5 million and £10 million. However, it was also advised that this is an evolving technology
that has seldom been installed on existing bridges. When it has been installed it has generally been to investigate known problems.

74. Barry Colford explained that the FRB already has some structural health monitoring; for instance the acoustic monitors that check for wire breaks in the main cables, monitoring of the dehumidification system and a global navigation satellite system to look for movement of the deck. However, to install monitors to find problems that are not anticipated would be very expensive, first to install on the bridge and then to analyse all of the data that gets collected. Richard Fish told the Committee—

>> The big issue with what is got out of structural health monitoring concerns the translation from data to information. People can get bombarded with millions and millions of bits of data, but they have to be interpreted.14

75. Had it been known that a failure along the lines of that which occurred in December 2015 was a possibility, then it would have been practical to install monitors such as movement detectors and strain gauges to check whether the pins were moving and what stresses were set up if they were not. However, without any indication that there was a problem in this area, devising a monitoring system previously would not have been practical or cost effective.

76. During the course of its inquiry, Scottish Government officials advised the Committee that a sophisticated structural monitoring system consisting of movement detectors, strain gauges and thermometers has now been fitted on the FRB. Officials indicated that it will cost circa £1.0m to £1.5m to install the system on all 8 pin joints.15

77. The Minister for Transport and Islands explained to the Committee some of the benefits that the installation of this monitoring equipment can deliver—

>> The new equipment has been helpful and has given us the confidence to assess what can be allowed over the bridge, which is now fully operational. We can know in good time what the stresses are on individual members. Metallurgists have suggested that the fault, or crack, was down to metal fatigue. The stress on the member can now be assessed by the new equipment, which is information that we did not have previously.16

78. The Committee welcomes the fact that structural health monitoring equipment has now been installed on the FRB and notes that this will, in future, assist engineers in identifying stresses on bridge components. It recognises, however, that this is relatively new technology and the most effective means of interpreting the data from such equipment has still to be developed.
Capital funding issues

Abolition of tolls on the Forth Road Bridge

79. A hugely significant change in the funding arrangements for the maintenance and operation of the FRB was the abolition of the bridge tolls which had been levied on users since the bridge was opened in 1964. The tolls were discontinued on 11 February 2008 under the provisions of the Abolition of Bridge Tolls (Scotland) Act 2008.

80. The Committee acknowledges that its predecessor committee, the Transport, Infrastructure and Climate Change Committee, scrutinised the Abolition of Bridge Tolls (Scotland) Bill at Stage 1. An important element of the consideration of the then legislative proposals was to look at the Scottish Government’s intention to support the running and maintenance of the both the FRB and Tay Road Bridge by replacing lost tolling revenue with central government funding.

81. The Committee notes that in evidence to the TICC Committee, when discussing future funding mechanisms following the removal of toll income, FETA stated that its strong preference was for these to be flexible, particularly in relation to capital funding—

“It is the capital programme that possibly gives us the greatest concern because, by definition, it is irregular, which is why we are pleading for a flexible approach to be taken… At the moment, we simply invest our income, and we can smooth out the peaks and troughs in spending. We are hoping for a similar robust funding mechanism.”

82. FETA further stated to the TICC Committee—

“We are aware that the Executive’s spending review covers a three-year period. That is one of the problems that we are trying to resolve in our present discussions. Some of our contracts are for more than three years, so we must have commitments for such periods.”

83. In evidence in September 2007, Scottish Government officials assured the Finance Committee that the bridge authorities would have the flexibility and confidence to plan long-term expenditure. They stated that—

“We need to ensure that everybody understands that there is a long-term commitment to funding the boards. The specifics will be dealt with in three-year chunks, but the boards have a long-term funding commitment from the Government that allows them to enter contracts that extend beyond three years.”
84. The TICC Committee took into account the report by the Finance Committee on the Financial Memorandum associated with the Abolition of Bridge Tolls (Scotland) Bill, which examined the costs associated with this commitment. It noted that the Finance Committee report considered the issue of the flexibility of these future funding mechanisms and that—

The Scottish Government does not appear to intend simply to provide grant each year equivalent to the income which would have been gathered from tolling, and allow the bridge authorities to manage this to meet fluctuations in expenditure. Rather it appears to intend to provide grant to meet the costs expected in each particular year. This means that the impact of the policy on Scottish Government spending will be subject to significant, and sometimes unpredictable, fluctuations.  

85. In its Stage 1 report on the Bill, the TICC Committee noted the assurances given to the Finance Committee by the Scottish Government that it would provide flexibility in its future funding to the bridge authorities in order for them to plan long term expenditure.

86. However, the TICC Committee agreed with the Finance Committee’s recommendation which expressed concern in relation to the lack of specific identification of the net new cost of supporting the two bridge authorities once the tolls were abolished and what they then viewed as the remaining uncertainties regarding several of the main cost headings. The TICC Committee called on the Scottish Government to provide clarification on these points as well as the specific points raised by FETA about the future funding arrangements for the bridge authorities.

87. In response, the then Minister for Transport, confirmed during the Stage 1 debate on the Bill that, the Scottish Government would replace the shortfall in FETA’s income due to abolition of bridge tolls, and that this had been confirmed as an outcome from the 2007 Spending Review. He said that—

We want to remove the power to charge and collect tolls, and the Government has given an assurance to each of the bridge boards that we will replace the toll income with direct grants. We are discussing appropriate agreements with them. The current toll income of some £13 million will be replaced. We, rather than bridge users, will provide that money. A clear announcement in yesterday’s spending review backed that up.

88. The impact of the removal of bridge tolls revenue was highlighted in evidence to the ICI Committee by Councillor Lesley Hinds, former Convener of FETA, who indicated that this had resulted in a loss of up to £12m per annum, with result that FETA either had to apply for capital funding from Transport Scotland or use its reserves and that this introduced an element of uncertainty into the capital planning process.
89. An acknowledgement of the change in the funding regime and the effect this had on FETA’s financial management was provided by Barry Colford, the former Bridgemaster, who said—

> FETA was in a position whereby we had the governance but not the funding, which is quite a difficult position for any organisation to be in. It was our responsibility to manage and maintain the Forth Road Bridge, but we had to rely on funding from the Scottish Government via Transport Scotland.  

90. In providing evidence to the Committee, the Minister for Transport and Islands confirmed the Scottish Government’s position on the approach taken with regard to the funding of FETA—

> When tolls were removed and FETA became reliant on Scottish Government funding, it was required to bid for funding through the spending review process. It is clear that FETA had to adapt to new ways of working. Notwithstanding, the Scottish Government ensured that funding was provided to meet FETA’s committed spend and that capital maintenance was delivered on a prioritised needs basis.

**FETA funding and expenditure**

91. The Committee notes the written submission from Audit Scotland which provided a detailed analysis of FETA’s grant funding and expenditure between 2010/11 and 2014/15. A supplementary written submission from Audit Scotland provided a further analysis for the years 2002/03 to 2009/10 in order to allow comparison with the period when FETA’s main source of income was from toll revenue, the surplus from which was used to fund capital expenditure.

92. The supplementary submission from Audit Scotland contains a summary table of the relevant data for the years 2002/03 to 2014/15, including the treatment of reserves, which was sourced from FETA’s annual accounts for that period. The table is reproduced at Annex A of this report.

93. The evidence provided to the Committee highlights a reduction in the capital grant funding available to FETA for the period from 2012/13 to 2014/15 in comparison to 2011/12 and earlier levels. This can be attributed in the main to the outcomes of the Scottish Government’s Spending Review in 2011. An extract from Transport Scotland’s Spending Review Finance Report from September 2011 contained the following table detailing the proposed allocations for both FETA and the Tay Bridge Board—
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| Total Forth and Tay | £k | £k | £k | £k |

94. The Committee notes that Transport Scotland’s Spending Review Finance Report also provided the following narrative confirming the reduction in capital grant and indicating that the proposed allocation would only cover essential works—

> There is a reduction in the capital grant over the period which could lead to pressure if there is an unexpected major capital works requirement. Only essential capital works are covered. During the Spending Review period Ministers will reach a decision on the future management and maintenance of the Forth Replacement Crossing and the Forth Road Bridge.

95. The proposed budget levels were subsequently formally notified to FETA by letter on 14 October 2011 and included in Scottish Government’s “Spending Review 2011 and Draft Budget 2012/13” document.

96. The level of funding available was discussed extensively during the Committee’s inquiry, principally in the context of the impact this may have had on FETA’s capital plan proposals for the FRB.

### FETA’s indicative capital plan

97. In addition to gathering information on the nature of the structural defect which led to the closure of the FRB and its subsequent repair, the Committee wanted to gain a clear understanding of previous inspection and maintenance regimes carried out by FETA. It also considered it essential that details were obtained of FETA’s capital plan proposals and, in particular, any works which related to the truss end link and related components.

98. Since the FRB opened in 1964, the volume and weight of traffic has increased beyond the expectations of those who planned and designed it. As a result, a continuous programme of works is required to many parts of the structure to allow inspections to take place, to carry out repairs and to strengthen it.
99. During the period for which FETA was responsible for the bridge, a long term programme of works was developed which set out the authority’s best estimate of what would be required to be undertaken over a period of 15 years. Approximate costs were prepared for each of the elements of work and these were then developed into an indicative capital plan that was approved by the FETA Board.

100. The indicative capital plan was a live document and was updated annually to take account of new information that came to light on the bridge. It also formed the basis for developing budgets for each year.

101. In February 2010 the FETA Board approved an indicative capital plan to cover the 15 year period from 2010/11 to 2024/25. The total cost, which covered a broad range of capital projects, amounted to £120.3M. Of this £3.1M was included for the truss end links in the years 2010/11 to 2013/14. The following year, the 15 year indicative capital plan amounted to £121.1M with a cost of £3.05M for the truss end links included in the years 2013/14 to 2015/16.

102. The indicative capital plan proposals for carrying out work on the truss end links were developed following a report received by FETA in March 2008 from Fairhurst engineering consultants. This set out the results from the assessment that they had carried out on the connections between the stiffening truss and the main and side towers. This included the truss end links. This showed that the welds connecting the bracket at the top of the truss end links to the main towers were overstressed under maximum traffic loading. It is noted that this report contained no indication that either the links or the pins – the seizing of one of which subsequently caused the defect which led to the December 2015 closure – were found to be overstressed.

103. The Committee heard in evidence from Transport Scotland officials that the estimated cost of the proposals in the indicative capital plan which, it was advised, “would see the entire truss end link assembly replaced at eight locations”, was up to £15m. The Committee explored with witnesses the status of this estimated figure. The former Bridgemaster, Barry Colford explained its origins—

> I remember that Chris Tracey and I produced the figure of £15 million, which we may then have reduced to between £10 million and £15 million. The precise cost would have depended on the contractor’s programme, how much of the work could have been done overnight and the amount of possession time that would have been needed.  

104. The Minister for Transport and Islands asserted that this estimate was not at that stage based on fully developed proposals. He said—

> It had a cost estimate with a broad range of between £10 million and £15 million for replacing the links, but it was just a cost estimate. There was no design, no work ready to go and no comprehensive capital plan design function ready to go.
105. The Committee is aware that FETA announced a tender exercise in May 2010 to identify consultants to provide advice on how the proposed work on the truss end links might be developed. This was withdrawn in March 2011 and the Committee questioned witnesses as to why this occurred. Transport Scotland officials advised the Committee that the withdrawal was “due to affordability issues”. They also suggested the reason behind the cancellation of the tender may have been that FETA had started to explore alternative solutions to their original proposals to replace the truss end linkages with Fairhurst consultants. An email exchange in September 2010 which appeared to confirm this was referred to in this regard.

106. The former Bridgemaster, Barry Colford, confirmed that the decision to withdraw the tender notice was made by FETA and added that “we make decisions based on funding availability”.

107. The Minister for Transport and Islands was asked whether Transport Scotland had a role in the decision by FETA to cancel the tender exercise. He stated that this was not the case—

108. It is not clear to the Committee exactly why the tender exercise was cancelled in early 2011, although it notes that both former FETA and Transport Scotland officials have indicated that it was due affordability issues. There is also at least a suggestion that it may have coincided with FETA beginning to explore alternative solutions to the replacement of the truss end links.

109. The Committee also explored with witnesses whether the work on the truss end links, as originally proposed by FETA, if it had been carried out, might have avoided the FRB closure in December 2015. Barry Colford told the Committee—

110. However, several witnesses expressed the view that there was uncertainty over whether the original FETA work proposal would have proceeded given that the consultants may have proposed an alternate approach. For example, Wayne Hindshaw of Transport Scotland said—

A consultant probably would have looked at providing best value for money as part of any optioneering. The design that came out of the workshop was conceptual and was not finalised. What has happened since has been evidenced by FETA's downsizing of the scheme. It is oversimplifying the case to consider that a full replacement would have taken place.
111. When asked to comment on this issue, the Minister for Transport and Islands said—

“It is hard to answer the what-if questions. What if FETA had proceeded with using consultants? What would a consultant have recommended? What resources would have been available at the time? When could the work have been profiled? Would the pins have seized up before that? There are so many unknowns that it would be unfair of me to make a judgment on whether FETA got it right.”

**Impact of Spending Review 2011 on FETA’s indicative capital plan**

112. FETA’s indicative capital plan was agreed by the FETA Board in February 2011 and submitted to Transport Scotland in advance of the Spending Review 2011.

113. Following the Scottish Government’s Spending Review in September 2011, Transport Scotland confirmed a capital grant of £13.8M for the three years 2012/13, 2013/14 and 2014/15. This compared to £23.9m in the indicative capital plan for the same years. There were already several committed schemes underway which required funding of some £8.9m. When an allowance for drawing down FETA’s reserves was included, there was a remainder of £7.2m available for schemes that were not yet committed.

114. In evidence to the Committee there were various views given as to the status of the indicative capital plan proposals and the impact the capital grant allocation following the Spending Review 2011 had on these. Setting out the Scottish Government’s position, Scott Lees of Transport Scotland said—

“FETA’s indicative forward capital programme was considered and funding provided to meet its contractual requirements and deliver capital maintenance on a prioritised needs basis. Transport Scotland made grant offers in line with the outcome of discussions with FETA officials and those were accepted by the FETA board.”

115. The former Bridgemaster, Barry Colford, explained to the Committee the status of the projects contained within the indicative capital plan and a recognition of the process for obtaining funding to deliver them. He said—

“The capital programme, as I described it earlier, included what we considered needed to be done on the Forth road bridge. It was not a wish list or what we wanted to do; it included what we considered needed to be done. Obviously, finances come into that, and we were in a slightly anomalous position post tolling. FETA had the governance of the bridge, but the funding came from a third party. We had to deal with that, but the capital programme included what we felt needed to be carried out.”
116. Transport Scotland officials explained their approach to assessing the capital works required for the FRB—

Our approach is different from FETA’s. It said, “Here is everything that we want”, whereas we build up from the bottom. We highlight the minimum funding requirement for maintenance to ensure the safe operation of the asset and for the works that are required to maintain the structural integrity of the bridge; we then consider the risks of not doing that work.\textsuperscript{40}

117. In providing evidence, Councillor Hinds, the authority’s former Convener, asserted that the FETA board had viewed the Transport Scotland response to the indicative capital plan as a 58 per cent cut to the level of capital expenditure which was proposed.\textsuperscript{41} Scott Lees of Transport Scotland commented on this, saying—

The 58 per cent figure related to a capital programme for the three-year period that the FETA board approved. That was done in isolation from the spending review and any outcomes from the UK settlement.\textsuperscript{42}

118. The Minister for Transport and Islands confirmed the Scottish Government’s position with regard to the consideration of FETA’s indicative capital proposals —

There would have been a two-way exchange between FETA and Transport Scotland in view of the UK spending review, which had a significant impact on the Scottish Government’s budget. I assure members that it would have been expressed to FETA at the time that there should be a degree of prioritisation and that committed projects would be seen through. Anything that was critical for the health of the bridge would have been funded, and reprioritisation would have been undertaken in that light.\textsuperscript{43}

Reprioritisation of FETA capital projects

119. With a reduced level of capital funding available, FETA was required to undertake a process of matching proposed expenditure to income. The former Bridgemaster explained to the Committee why this was necessary—

We were carrying out our capital programme prior to the spending review. Obviously, things changed after that, and we had to reprioritise capital spending. Engineering is about managing risks. When we looked at the schemes…the management team had to consider what schemes we could afford to carry out. We could not afford to carry out all the schemes in our capital plan simply because there was a spending review, and we had to accept that we needed to work within the moneys that we were granted. Therefore, we had to prioritise projects.\textsuperscript{44}

120. This process required FETA engineers to conduct a detailed assessment to inform a reprioritisation of the indicative capital plan proposals. This was carried out using a risk based approach and resulted in non-committed capital schemes being
ranked by priority. The method of prioritisation used was to rank the different projects against levels of risk in the following order:

- the safety of bridge users and staff
- the long term structural integrity of the bridge
- the potential disruption to users (operational risk)

121. The former Bridgemaster explained the background to this approach—

> Our whole ethos...was about minimising risk. We used that philosophy when we tried to prioritise projects post the spending review, and we brought that to the board. If a failure occurred in the main cable and the main cable anchorages, there would be a catastrophic failure of the bridge, so they became a priority. If the truss end link failed, there would be what we would term an operational failure. The risk of someone being killed or seriously injured would be lower than other risks but, unfortunately, a lot of disruption would be involved. When we risk assessed projects, the potential for structural damage, collapse or risk to life took priority. That is how we came up with the risks.  

122. Following the risk assessment exercise, the replacement of the truss end links came fifth in the list of ranking against other priority projects. The reasoning for this was that the engineers assessed that the failure of the truss end links would not jeopardise either the safety of bridge users or the long term integrity of the bridge. It was acknowledged by them, however, that such a failure would cause serious disruption to the bridge users and as such the project was therefore categorised as an operational risk. A recommendation that the truss end link project should be deferred was put to the FETA board as part of a reprioritised list of projects and approved on that basis.

123. Another factor that was taken into account when assessing the risks associated with each of the projects was the fact that, after 2011, FETA knew that, once the new Queensferry Crossing was completed in 2016, the majority of traffic would use the new bridge with the result that the weight of traffic on the existing bridge would be reduced significantly. Barry Colford confirmed this to the Committee—

> It affected some of our thinking on programming. Post February 2011...we knew that it was unlikely that heavy goods vehicles would be using the existing crossing. That allowed us to reduce the return period, as we call it, for loading.

124. A former Convener of FETA, Phil Wheeler, also confirmed to the Committee that the construction of the new Forth crossing influenced the authority’s approach to capital planning—

> From the time that the decision was taken to build the new bridge, I got the impression that there was always a pressure on FETA to carry out only the absolutely essential work to nurse the bridge through until the new crossing was
available. The works—on the cables and bolts—were items 1 and 2 on the list and they were our priorities. We noted that there were a lot of other things that should be seen to, but they had to be pended for that time.48

125. The Minister for Transport and Islands also stated—

My understanding from FETA is that it considered the prospect of the Forth replacement crossing and would have reordered and reprofiled works as a result, considering what was required earlier and what could be deferred until later in view of potential disruption.49

126. Witnesses who appeared before the Committee were asked to provide views on whether the decision not to attach a higher priority to the truss end link replacement project was reasonable in the circumstances faced by FETA. A former Convener of FETA, Phil Wheeler confirmed that the FETA Board accepted the engineering advice provided, saying that—

…the board was guided by all the various experts that it was acceptable to postpone the work at that time. You heard that evidence last week and we endorse that today.50

127. One of the independent expert witnesses who appeared before the Committee, Richard Fish, indicated that he felt that the reprioritisation of the proposed work seemed appropriate in the circumstances, saying that—

In any maintenance budget there will be pressures from the amount of money in the budget and from other maintenance needs and interventions that need to be carried out, which have to be balanced with one another. With hindsight, we can say that the work that has been referred to should not have been removed from the programme. However, given a reducing budget and increasing demands elsewhere, it is quite understandable that that decision was taken.51

128. Scott Lees of Transport Scotland told the Committee—

I assume, from what I have seen and from the actions thereafter that the risk was seen as acceptable. If it was not, FETA should have flagged it as safety-critical work. As I said earlier, if there was anything that was safety-critical, FETA could have used its reserves or come to Transport Scotland and asked for help. I have found no evidence of that, so I consider that the risk was deemed to be manageable.52

129. Other witnesses also commented on the suggestion that had any of the non-committed capital projects been deemed to be of sufficient priority, FETA could have taken the decision to make an approach to Transport Scotland to request addition capital funding. For example, the chief bridge engineer at Transport Scotland expressed the view that this was an important issue as another, later
request by FETA for additional funding, made on the basis that it was safety-
critical, had been granted. He said—

> It is interesting to note that FETA never brought the matter to us as a safety-
critical piece of work that urgently needed funding beyond the capital grant that
we gave it at the time. I feel that that is germane to a lot of the arguments
because, some years later, when additional funds were needed urgently to take
forward work on the cable band bolts, my predecessor was more than willing to
listen and to act on that.\(^{53}\)

130. The former Bridgemaster, Barry Colford, indicated that he would have presented a
robust case to Transport Scotland had he felt works to be necessary from an
engineering perspective. He stated—

> We had good relations with Transport Scotland once it became responsible for
our funding, and we had meetings with Transport Scotland staff. If I had gone to
Transport Scotland and said that there was a problem, my professional integrity
would have ensured that I pressed that case.\(^{54}\)

131. A former Convener of FETA, Councillor Lesley Hinds, indicated to the Committee
that she felt such an approach would have been refused by Transport Scotland.\(^{55}\)
However a former FETA Board member, Councillor Ian Chisholm, held an
alternative view. He said—

> My recollection about an issue cropping up regarding the safety of the bridge is
that we were never refused any funding from Transport Scotland to go ahead
with anything that was considered to be a vital safety issue...\(^{56}\)

132. The Minister for Transport and Islands, confirmed to the Committee that the
Scottish Government’s position was to give positive consideration to requests for
additional capital funding for critical repair work. He said—

> The dialogue between the Scottish Government, through Transport Scotland,
and FETA was around finance, with a clear understanding that FETA should do
nothing that would undermine the structural integrity of the bridge and should
approach the Government if any critical repairs were required. It did that, and I
can give you an example. In 2012, there was a request for more resources for
cable band bolts.\(^{57}\)

133. The Committee also explored with witnesses whether potential existed for FETA
to borrow money to fund any of the non-committed projects which had to be
defferred following the reprioritisation of its capital plan. The former, Bridgemaster,
Barry Colford, indicated to the Committee that this had been looked at, but was
not considered to be a practical option. He said—

> We considered borrowing. As far as I remember, FETA would have been able to
borrow. However, speaking to our treasury people from the City of Edinburgh
Council, who advised us, we ascertained that that was not a practical proposition, especially as FETA would be wound up when the new crossing opened.\textsuperscript{58}

134. Another former Convener of FETA, Phil Wheeler, cast doubt on whether lenders would have been prepared to lend directly to an organisation which did not have a revenue stream to fund the necessary repayments.\textsuperscript{59} It was also suggested to the Committee that the possibility of FETA borrowing to fund projects had been raised with Transport Scotland. The Convener of FETA in the period immediately prior to its dissolution, Councillor Lesley Hinds, explained—

\begin{quote}
I spoke yesterday to the people at the council who were responsible for the finance in supporting FETA. They said that it could still borrow in the same way. However, as I understand it from the discussions that took place, Transport Scotland was not keen for that to happen.\textsuperscript{60}
\end{quote}

135. The question of whether FETA might have been able to make use of its reserves to fund capital projects was also raised by the Committee. In response to this, Barry Colford advised the Committee that the value of available reserves was unlikely to be sufficient to cover the deferred work proposed in the capital plan.\textsuperscript{61} Phil Wheeler suggested that the use of reserves was not a feasible option, stating—

\begin{quote}
I am sure that that was theoretically possible, but we were told that as a result of the spending review we must make do with what we had unless there was a real emergency. That is my recollection of the situation at that time.\textsuperscript{62}
\end{quote}

**FETA – alternative approach to strengthening truss end links**

136. Following its decision to defer the proposals in the capital plan to repair the truss end links, FETA started a process to identify alternative methods of carrying out the necessary strengthening.

137. The area of the truss end links that had caused real concern to FETA was their connection to the main towers. The lower end of the links was not overstressed under normal loading because it was only the additional forces generated by the seized pin that caused the member to fail. FETA therefore investigated other ways of strengthening the connection of the bracket that connects the top of the links to the main towers. They were concerned that this might not prove feasible because it would involve welding onto the existing steelwork of the towers. Because the FRB is 50 years old, the quality of the steelwork is not of the same standard would be obtained today and this can cause difficulties in welding to it resulting from imperfections and laminations introduced during the manufacturing process.

138. A trial was therefore proposed at one location to test whether the strengthening proposal could, in fact, be correctly carried out on site. This trial was eventually undertaken in May 2015 just before FETA was dissolved and it was successful.
Since then the work has been taken over by Amey who have continued to strengthen the brackets at other locations using the technique applied in the trial.

139. The Committee sought the views of witnesses on whether the decision by FETA to proceed with a trial of a reduced scheme was appropriate. Wayne Hindshaw, Transport Scotland’s chief bridge engineer, felt that it was, and said—

“The scheme appeared fourth or fifth in the list of FETA’s priorities. My view is that, based on the evidence that was presented in the Fairhurst report and at the workshop, it was tolerable and appropriate for FETA to look for a more cost-effective and less disruptive solution.”^63
Conclusions

140. As stated earlier in this report, the Committee wishes to commend all Transport Scotland, Amey and engineering consultant staff who were involved both in responding to and resolving the defect which led to the closure of the Forth Road Bridge in December 2015 and in carrying out associated repair work. It considers this to be a remarkable engineering achievement, carried out during a period of adverse weather conditions.

141. The Committee agrees with the unanimous views of those witnesses, including former FETA engineers, as detailed earlier in this report, who expressed the view that the defect which caused the closure in December 2015 could not have been foreseen.

142. The Committee is clear that FETA’s decision in December 2011 to reprioritise projects within its capital plan – including work to address concerns about the efficacy of the truss end link mechanisms – was a direct consequence of a decision by the Scottish Government/Transport Scotland to reduce its capital grant allocation for the period 2012/13 to 2014/15. It is also the Committee’s view that the development of the Forth Replacement Crossing would have had an influence on decisions to reprioritise certain capital projects.

143. In the light of this, the majority of the Committee\(^i\) considers that decision by FETA to defer the proposed work on the truss end links and to subsequently develop an alternative approach was an appropriate course of action on the basis of both the prevailing financial circumstances and the engineering advice available at the time.

144. The majority of the Committee\(^ii\) is content that had FETA been of the view that it was necessary to accelerate work on the truss end links to address a matter of public safety, a route existed for it to go back to Transport Scotland to make a case for additional funding. It is also confident that, had FETA engineers felt this work to be necessary from a public safety perspective, they would have taken this route.

145. The Committee wishes to make clear its view that FETA acted entirely appropriately throughout this process. The authority’s robust maintenance inspection regimes had identified that work was required to the truss end link mechanisms. It had developed proposals to take this forward which were reconfigured following the capital plan reprioritisation in 2011, subsequently transferred to Transport Scotland/Amey and ultimately taken forward.

\(^i\) David Stewart dissented.
\(^ii\) David Stewart dissented.
146. The Committee is of the view that FETA dealt with the challenge of reprioritising its capital proposals following the 2011 Spending Review in a professional and responsible manner.

Impact of FRB closure on the public and businesses

147. The remit of the Committee’s inquiry focused on issues related to the structural defects leading to the closure of the FRB and their repair. It is conscious that it may be appropriate for further scrutiny to be carried out on the impact of the bridge closure on the travelling public and on businesses, particularly the haulage industry and their customers. The Committee therefore intends to include a recommendation in its legacy report that successor committee(s) consider whether further work on such issues should be carried out early in the new session.
The Bridge was subsequently reopened to all vehicles except Heavy Goods Vehicles (HGVs) on 23 December 2015. A trial to allow HGVs to travel northbound between 11 pm and 5.30 am was put in place in early February before the Bridge was fully open to all vehicles, including HGVs, from 20 February 2016.

Transport Scotland supplementary submission


Finance Committee Report on the Abolition of Bridge Tolls (Scotland) Bill, para 43.

Abolition of Bridge Tolls (Scotland) Bill, Stage 1 debate, 15 November 2007


Infrastructure and Capital Investment Committee, Official Report, 3 February 2016, Col 43.
### Annexe A

#### FETA Income and Expenditure 2002/03 to 2014/15

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**Revenue Income and Expenditure:**
- **Revenue from Tolls:** Yearly revenue from tolls.
- **Revenue grant:** Financial assistance from the government.
- **Revenue grant for Toll Abolition costs:** Costs related to the abolition of tolls.
- **Revenue expenditure funded from capital grant:** Costs covered by capital grants.
- **Interest on Revenue Balances and other Investments:** Income from investments related to revenue balances.
- **Rental/other income:** Income from other non-toll-related activities.

**Expenditure:**
- **Administration:** General administrative expenses.
- **Maintenance:** Costs for maintaining the infrastructure.
- **Operations:** Expenses for everyday operations.
- **Toll Collection:** Costs associated with toll collection.
- **Contribution to Capital Account:** Funds contributed to the capital account.
- **Net non-cash items:** Adjustments for non-cash transactions.
- **Additions to/(drawdowns from) reserves:** Changes in financial reserves.
### Infrastructure and Capital Investment Committee

**Inquiry into the circumstances surrounding the closure of the Forth Road Bridge, 4th Report, 2016 (Session 4)**

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Source: FETA Annual Accounts 2002/3 to 2014/15
Annexe B

Extracts from the minutes of ICI Committee Meetings

27th Meeting, 2015 (Session 4), Wednesday 16 December 2015
1. Decision on taking business in private: The Committee agreed not to take item 3 in private and to take item 4 in private.
3. Forth Road Bridge: The Committee considered and agreed its approach to an inquiry into the circumstances surrounding the recent closure of the Forth Road Bridge.

1st Meeting, 2016 (Session 4), Wednesday 6 January 2016
1. Decision on taking business in private: The Committee agreed to take item 4 in private.
4. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge: The Committee agreed its preferred candidate for appointment as adviser to its inquiry.

3rd Meeting, 2016 (Session 4), Wednesday 20 January 2016
1. Decision on taking business in private: The Committee agreed to take item 5, and future consideration of evidence on its inquiry into the circumstances surrounding the closure of the Forth Road Bridge in private.
2. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge: The Committee took evidence from—Scott Lees, Head of Network Maintenance, and Wayne Hindshaw, Chief Bridge Engineer, Transport Scotland; Mark Arndt, Operating Company Representative, Forth Bridges Unit, and John Russell, Operations Manager, Forth Bridges Unit, Amey; Colin Clark, Partner, Fairhurst; Richard Hornby, Director, Arup.
5. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge (in private): The Committee considered the evidence heard earlier in the meeting.
4th Meeting, 2016 (Session 4), Wednesday 27 January 2016
1. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge: The Committee took evidence from—Councillor Lesley Hinds, Convener, Phil Wheeler, Convener, Councillor Ian Chisholm, Board Member, Barry Colford, Chief Engineer and Bridgemaster, and Chris Tracey, Engineering Services Manager, all of the former Forth Estuary Transport Authority (FETA).
2. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge (in private): The Committee considered the evidence heard earlier in the meeting.

5th Meeting, 2016 (Session 4), Wednesday 3 February 2016
2. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge: The Committee took evidence from—John Evans, Consultant, Flint & Neill; Richard Fish, Independent Engineering Consultant; Peter Hill, General Manager and Bridgemaster, Humber Bridge Board.
4. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge (in private): The Committee considered the evidence heard earlier in the meeting.

7th Meeting, 2016 (Session 4), Wednesday 24 February 2016
3. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge: The Committee took evidence from—Derek Mackay, Minister for Transport and Islands, Scottish Government; Roy Brannen, Chief Executive, Mike Baxter, Director for Finance and Analytical Services, and Wayne Hindshaw, Chief Bridge Engineer, Transport Scotland.
5. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge (in private): The Committee considered the evidence heard to date.

8th Meeting, 2016 (Session 4), Wednesday 2 March 2016
3. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge (in private): The Committee considered a draft report. Various changes were suggested and the Committee agreed to consider a revised draft at its meeting on Wednesday 9 March.
6. Inquiry into the circumstances surrounding the closure of the Forth Road Bridge (in private): The Committee considered a draft report. Various changes were agreed to and the report was agreed for publication.

David Stewart MSP proposed that the following text be added after paragraph 141—“There was a clear statement of intent by FETA to replace the truss and links. Had this work been carried out it may have had a bearing on the closure of the bridge in December 2015.”
The proposal was disagreed to by division: For 1: (David Stewart), Against 5:(Clare Adamson, Jim Eadie, Adam Ingram, Alex Johnstone, Mike MacKenzie), Abstentions: 0.

David Stewart MSP proposed that the following text replace paragraph 143—“The Committee considers that decision by FETA to defer the proposed work on the truss end links and to subsequently develop an alternative approach was an appropriate course of action on the basis of both the prevailing financial circumstances and the engineering advice available at the time. However, FETA did not take this decision in isolation. They had the governance of the bridge but not the purse strings. It was a unanimous decision of the FETA board to replace the truss end links and appoint consultants to take forward the project. Following the 2011 Spending Review, the advert to appoint consultants was cancelled and the project was postponed.”
The proposal was disagreed to by division: For 1: (David Stewart), Against 5:(Clare Adamson, Jim Eadie, Adam Ingram, Alex Johnstone, Mike MacKenzie), Abstentions: 0.

David Stewart MSP proposed that the following text replace paragraph 144—“The post-toll regime changed FETA’s role from having a self-contained, income-generation from tolls and loans which could be spent on maintenance, to one of governance where capital spend was a matter for the Scottish Government. FETA faced a 58% cut to the indicative programme of expenditure by the Scottish Government which radically restricted its ability to carry out its capital programme, in particular the truss end links works.”
The proposal was disagreed to by division: For 1: (David Stewart), Against 5:(Clare Adamson, Jim Eadie, Adam Ingram, Alex Johnstone, Mike MacKenzie), Abstentions: 0.
Annexe C

Written evidence

- Audit Scotland
- Audit Scotland Supplementary Submission
- Bob Hopewell, Civil Engineer
- Bob Hopewell, Civil Engineer Supplementary Submission
- The Forth Estuary Transport Authority (FETA)
- Cllr Ian Chisholm, Board Member and Fife Council Elected Representative to the former Forth Estuary Transport Authority (FETA)
- Pete Wilkins
- Transform Scotland
- Transport Scotland’s written submissions can be found at: foi.forthroadbridge.org
- Transport Scotland Supplementary Submission
- Transport Scotland Additional Supplementary Submission