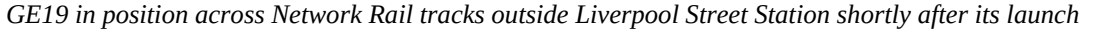
Transport for London

London Rail



GE19 in position across Network Rail tracks outside Liverpool Street Station shortly after its launch

Final Investigation Report into the incident at Bridge LTN/1-19 (generally known as GE19) that occurred on 28th May 2008.

Version 1.3

		Signature	Date
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Transport for London (TfL) – London Rail

Final Investigation Report into the incident at Bridge LTN/1-19 (generally known as GE19) that occurred on 28th May 2008.

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1 Executive Summary

1.1 Bridge GE19 was successfully moved into position above Network Rail tracks just outside Liverpool Street during the weekend of 3rd to 5th May 2008. On 28th May the bridge was in the process of being 'jacked down' into its final resting place.

1.2 Work on GE19 was completed for the day on 28th May at approximately 17.15hrs. The contractors left site about 18.00hrs having tidied up. At about 19.15hrs the temporary supports for the bridge failed at the east end. This failure resulted in the bridge dropping approximately 200mm off the temporary support plates onto the permanent bearings. As well as the temporary support material being dislodged in the vicinity of the bearing, 5 concrete planks (Omnia Planks), which had been in place on the bridge deck, were also dislodged by this movement (see Appendix A Pic.6). These planks fell onto the Network Rail tracks below.

1.3 An approaching train struck the concrete planks at slow speed. The driver stopped his train, and reported the concrete planks on the track. This report resulted in train services travelling in and out of Liverpool Street station being suspended by Network Rail control. Network Rail then instigated its emergency plans. These plans included the isolation of traction current and the detrainment of passengers from stationary trains.

1.4 Remedial works to make the bridge safe, took place through the night. This work included securing the concrete planks onto the bridge deck. Train services recommenced at 09.30hrs on 29th May.

1.5 Following the incident, TfL (London Rail) set up an Inquiry into the incident. This Inquiry Panel has concluded that the key contributory cause of this incident related to the incorrect positioning of slipper pads (metal plates covered in Polytetrafluoroethylene (PTFE)) between the base of the bridge and the top of the sloping surface of a set of taper plates, which themselves had been placed on the top of the temporary support arrangement. This incorrect positioning allowed an unplanned movement to occur (paragraph 6.1 and root cause analysis refer). The PTFE pads provide a low friction surface, and were being used to make small adjustments to the horizontal positioning of the bridge.

1.6 There are a number of contributory factors that are associated with this incident, and these are also discussed in detail later in the report.

2 Introduction

2.1 On the 28th May 2008, bridge GE19 was being lowered into its final position having been successfully launched three weeks earlier. Works had been completed for the day, and the bridge secured. However, in the early evening the east end of the bridge dropped by approximately 200mm from its temporary support packing onto the final fixed bearings. Subsequent investigations have determined that there was no structural damage either to the bridge or the bridge abutments. However, when the bridge structure dropped, 5 concrete planks were dislodged from the bridge deck, and fell onto the track below. TfL have received no substantiated reports of injuries from this incident (but see also paragraph 4.3.3). The whole incident had a high potential for injury, even fatality, to passengers using the Great Eastern Lines, and as a consequence, the Chief Operating Officer, London Rail, commissioned a report into the incident in accordance with London Rail's procedure for Incident Reporting and Investigation (RfL-MS-02-09).

2.2 As well as the TfL investigation, Balfour Beatty - Carillion Joint Venture (BB-CJV) the Principal Contractor for the project, and Network Rail, have been undertaking investigations, as has the Rail Accident Investigation Branch (RAIB). Throughout this inquiry London Rail has engaged fully with these investigation teams. It should be noted that this investigation has not considered Network Rail's management of the incident, nor the procedures for detraining passengers following the incident.

2.3 An interim report was published on 12th June 2008, setting out the background information associated with the incident. This interim report, provided a sequence of events, describing the Inquiry Panel's initial findings, and listing the main areas where the Panel were focusing their future investigations.

2.4 This document is TfL London Rail's final report into the incident. The primary aim of this report is not to allocate blame to individuals or organisations, but to understand the causes of the incident so that we can better ensure that, as far as possible, incidents such as this are not repeated. All parties involved in the investigation have been generally supportive and open. One of the principles of this investigation has been that TfL would not repeat the work carried out by the BB-CJV Inquiry, subject to being satisfied that all issues were covered to its satisfaction. Therefore TfL only spoke to Fairfield Mabey and their contractors following the issue of TfL's draft report when the need for clarification and additional information became clear.

3 Background

3.1 The installation of Bridge LTN/1-19 (generally known as GE19) is part of the East London Line Project (ELLP).

3.2 London Rail is the mode within TfL that has overall responsibility for the delivery of the ELLP. The project extends the former London Underground (LU) East London Line both north and south, to link it into the suburban rail network. The first phase of construction, Enabling Works 2, began in May

2005 with the Main Works starting in December 2007, when the LU East London Line closed; it is scheduled for completion in 2010. When the railway reopens London Overground rail services will operate from Dalton Junction to West Croydon and Crystal Palace. Phase 1a, opening in 2011, will extend services from Dalston Junction to Highbury and Islington.

3.3 The diagram below (Figure 1) shows the scope of TfL's ELLP. Bridge GE19 is located between Shoreditch High Street and Whitechapel stations.

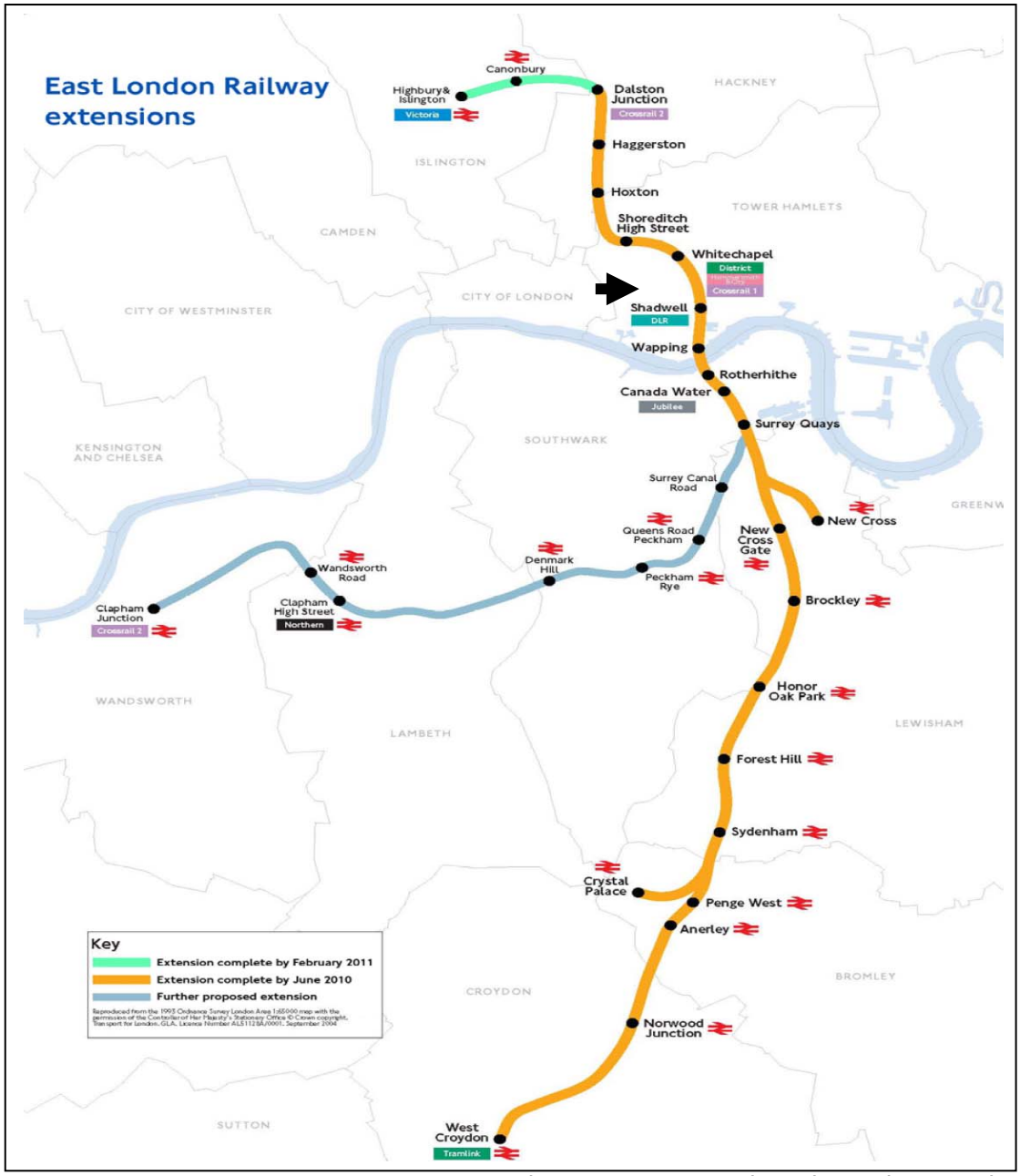

Figure 1 ELLP Extension Plan and Proposals

3.4 The original bridge GE19 was disused, in poor repair and not to current standards. It was successfully demolished during Christmas 2007 to make way for a new bridge. The new bridge will carry a new section of railway across Network Rail's existing infrastructure, and will link with the former LU East London Line to a disused British Rail railway viaduct. The new bridge

was successfully launched as a whole structure under possession arrangements over the weekend of 3rd to 5th May 2008 (see Appendix A Pic.1&2). The final installation, including jacking the bridge down into its final position, was programmed to be finished by 30th May 2008.

3.5 The new bridge is a steel Warren truss girder design. It weighs approximately 1300 tons at launch, is 84 metres long and is on a 1:30 incline with the gradient falling west to east (see Appendix A Pic. 3).

4 The Incident

4.1 Parties Involved

4.1.1 TfL appointed Balfour Beatty - Carillon Joint Venture (BB-CJV) as Principal Contractor for the ELLP works. BB-CJV is responsible for all aspects of the design and construction of these works, including bridge GE19. BB-CJV subcontracted the design of the bridge to Scott Wilson and Benaim, and the design of the temporary works, manufacture and installation of the bridge steelwork to Fairfield Mabey (excluding the deck and track way which BB-CJV remained responsible for). Fairfield Mabey employed a specialist steel erection company MJ Hughes to assist in the installation.

4.1.2 Fairfield Mabey engaged Chris Booth Associates to create the detailed temporary design for jacking down, based on concepts prepared by Fairfield Mabey. Chris Adams Limited was responsible for checking the temporary works design. On the day of the incident Fairfield Mabey and M J Hughes personnel had been on site, and were directly involved in the jacking down process. TfL ELLP site engineers and site inspectors were also on site, and had visited the jacking down operation on the day of the incident.

4.1.3 Below GE19 are 6 mainline railway tracks which belong to Network Rail. National Express East Anglia (NXEA) operates services in and out of Liverpool Street Station along these tracks.

4.2 Events preceding the incident

4.2.1 The process of launching bridge GE19 into position began on 3rd May, and was completed without incident by the 5th May. Between the 7th and 12th May the nose, used in the launch process, was removed from the structure. Between 12th and 21st May the temporary launch bearings were removed, and arrangements for starting the jacking down process were put in place.

4.2.2 The actual process of jacking down the bridge structure did not commence until 21st May. This delay was because of the effect of the hot weather on the bridge and the unavailability, due to leave, of the Fairfield Mabey Site Manager, who had been involved throughout the construction of the bridge.

4.2.3 ‘Jacking down’ is a normal process for gradually lowering a bridge into its final resting place. This process is staged and gradual, and takes a number

of days. The lowering is completed in approximately 100mm stages. The bridge is initially lowered onto a set of temporary steel spacer plates (sometimes referred to as support packing). Hydraulic jacks are used to initially raise the bridge, allowing removal of a controlled number of spacer plates. The bridge is then carefully lowered back onto the remaining spacer plates. These temporary spacer plates rest on the final bearing. The process is completed once the bridge rests on the four final permanent bearing. There is a second type of jacking termed 'plan jacking'. In this the end of the bridge can be moved in the horizontal plane, to locate it exactly over the centres of the bearings. Again hydraulic jacks are used, pushing against special temporary frames.

4.2.4 Bridge GE19 has been designed to be sit at an incline of 1:30, dropping west to east. For this reason, a tapered spacer plate was located between the sloping underside of the bridge and the horizontal spacer plates located above the permanent bearings. The permanent bearings are configured to allow for thermal expansion of the bridge in both of the horizontal planes, with the sole fixed permanent bearing situated at the north western corner.

4.2.5 On 28th May the jack down process began at both ends of the bridge from approximately 08.00hrs. PTFE (sometimes called Teflon) pads were inserted between the tapered spacer plates and the underside of the bridge's main beam flanges at all four bearing positions in order to facilitate plan jack activities on 28th May. PTFE pads provide an ultra low friction surface to facilitate the movement of heavy objects.

4.2.6 At the west abutment, all temporary spacer plates had been removed from above the permanent bearings. Each of these temporary taper plates is relatively small to allow them to be moved easily. These temporary plates had been replaced by a single large permanent taper plate. On the east abutment approximately 120mm of the temporary packing remained in place above the two bearings.

4.2.7 Horizontal plan jacking realignment of the bridge took place between 16.15hrs and 17.15hrs on the day of the incident. The bridge was jacked 38mm east to west.

4.2.8 Workers left site at approximately 18.00hrs after the realignment had taken place, they had checked lateral and longitudinal restraints, and had tidied the site. The PTFE plates were not removed, although they were not required for the activities planned for 29th May.

4.2.9 Figure 2 below shows the bearing arrangements on the bridge, and the movement that the bearings allow.

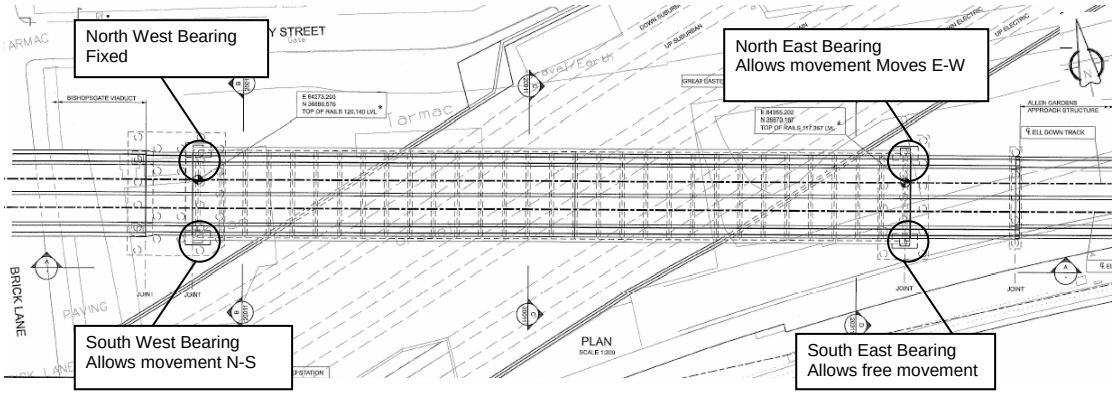

Figure 2 GE19 Bearing Orientations

Figure 3 below shows the packing arrangement at both the north and south bearings on the east abutment, on the evening of the incident. PTFE slipper pads are in place (see appendix A). It should be noted that the diagram is exaggerated: on site the slope of the tapered plate is barely noticeable.

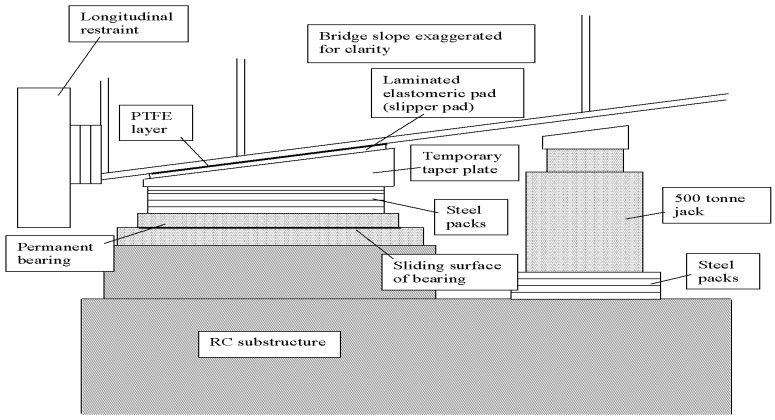

Figure 3 : Bearing arrangements at east abutment on the night of the incident

On the night of 27th May, the west abutment bearings had been left with the spacer plates between the tapered plate and the sloping surface of the bridge.

4.2.10 The deck of the bridge had been partially completed by BB-CJV. To assist with the launch process the eastern section of the bridge had been concreted (so as to provide balance and counterweight). The remaining western part of the deck had permanent formwork only. This formwork comprised of pre cast concrete planks (Omnia Planks). These planks are 2.5 metre lengths of reinforced concrete and each weigh over 100kg (see Appendix A Pic. 6); they were laid between the cross girders and fixed to the cross girders using Compriband strips laid between steel studs. Adjacent to each of the planks was either another plank or a plastic spacer strip. This part of the deck had also been sealed with grouting and mastic in preparation for concreting once the bridge was lowered.

4.3 Events during the incident

4.3.1 At approximately 19.15hrs the site security guard was alerted to a noise, which he later found out was the sound made by the bridge dropping. The north east temporary support arrangement (see Appendix A) had been ejected; this was followed almost immediately by the same thing happening at the south east bearing. The ejected material hit the vertical jack located adjacent to the northeast bearing and knocked the jack over. The result of these movements was that the bridge dropped approximately 200mm at the east end.

4.3.2 The motion of the bridge dropping caused 5 Omnia Planks to be displaced and dislodged from the bridge deck. The loss of the planks allowed water that had accumulated on the surface of the bridge to pour through the bridge deck onto overhead cables located directly beneath the bridge. Witnesses commented on plumes of ‘smoke’ coming from the cables when the water came into contact with them.

4.3.3 The Omnia Planks, along with some of the plastic spacer strips and the accumulated water, landed on the railway below. Some of the debris was hit by an approaching train. The driver had seen it on the tracks and was in the process of braking. The train suffered minor damage to its body work. Nine trains in the vicinity of bridge GE19 were halted and traction power supplies were discharged. The passengers from these trains were detrained and walked back to Liverpool Street Station. There is one report of an injury to a women evacuated along the track who claims to have fallen and hit her head. This report is yet to be substantiated by Network Rail. A letter received by the London Mayor’s office concerning this incident has been passed to Network Rail.

4.4 Events after the incident

4.4.1 The site security guard initiated emergency procedures by contacting his company’s office at approximately 19.25hrs. The security company’s offices in turn contacted BB-CJV personnel at 19.51hrs.

4.4.2 B-CJV made immediate arrangements to attend site and to advise the TfL ELLP project managers of the situation.

4.4.3 Network Rail and the British Transport Police separately advised TfL project staff at 19.40hrs and 19.55hrs respectively of a problem with GE19, and that services in and out of Liverpool Street had been suspended. London Rail’s incident escalation procedures were initiated, although at this time it was not yet clear as to the precise nature of the problem with GE19.

4.4.4 London Rail’s Director London Overground Infrastructure (LOI) was advised by his project team at approximately 19.45hrs that there was a problem at Bridge GE19. After receiving further updates he escalated the incident to the London Rail Chief Operating Officer (COO).

4.4.5 From 20.10hrs the COO started coordinating activities within TfL at a senior manager level. This included, confirming that the LOI Head of Programme Management was going to site, and briefing London Rail's Managing Director and the TfL Press Office.

4.4.6 London Underground and London Bus control centres were both advised of an incident involving GE19 from various sources. Initial reports were inaccurate and prompted the dissemination of some incorrect information, although this was relatively quickly corrected as the details of the incident became clearer.

4.4.7 London Underground and London Buses adapted their services to deal with customers who were unable to travel from Liverpool Street National Rail Station, and disseminated information from their control centres to advise passengers of the disruption at Liverpool Street.

4.4.8 The BB-CJV Senior Works Manager was the first senior manager on site at approximately 20.00hrs. Fairfield Mabey staff arrived on site at approximately 20.30hrs.

4.4.9 One of TfL's ELLP Delivery Site Engineers was the first TfL member of staff on site at 21.10hrs. After a briefing by the emergency services he immediately undertook a survey of the bridge deck and the east abutment with BB-CJV and Fairfield Mabey. He was joined by other representatives of the ELLP who arrived at 21.45hrs – they then joined BB-CJV staff for a briefing at their command post, and after that at the emergency services mobile command post.

4.4.10 The emergency services dealt with detraining passengers, whilst BB-CJV concentrated on recovering the debris from the track and agreeing methods for securing the bridge and providing the necessary levels of assurance for Network Rail.

4.4.11 The track area was handed over to the Railway Accident Investigation Branch (RAIB) by the emergency services at 22.15hrs – hand over time had been delayed due to the police having to deal with a potential 'grenade' found on the track; the 'grenade' subsequently turned out to be a child's toy.

4.4.12 RAIB allowed BB-CJV access to the bridge at 00.30hrs after their initial investigations had been completed.

4.4.13 Works to secure the bridge and reopen the main line railway continued to a position considered acceptable by BB-CJV and TfL. This work was completed at approximately 04.00hrs. The track was re-energized to allow stranded rolling stock to be moved. However, at approximately 05.00hrs the Network Rail bridge team arrived on site, and requested a second isolation, so that additional works could be carried out to further secure the bridge. This further work took some time to both agree and carry out. This additional work was all completed to Network Rail's requirements by 08.45hrs. Train services in and out of Liverpool Street recommenced at approximately 09.30hrs.

5 The Investigation

5.1 Evidence was mainly drawn from the following:

- Inquiry Panel site visit with ELLP engineers
- Examination of documentation
- Statements and interviews from experts and those involved
- Inquiry Panel site visit with an independent bridge expert
- Independent bridge experts report
- Review of RAIB' s preliminary report and BB-CJV's final incident report
- Comments from Fairfield Mabey, Chris Booth Associates and Chris Adams Ltd following issue of the TfL draft report.
- Discussions with Fairfield Mabey

6 Factual Information

6.1 Engineering

6.1.1 The installation of bridge GE19 can be clearly divided into two distinct areas of work – the bridge launch itself and the subsequent lowering of the bridge into its final resting place. The Inquiry Panel have concentrated their review of evidence on the temporary works arrangements and specifically the lowering process.

6.1.2 The Network Rail (NR) standard 'Technical Approval of Design – Construction and Maintenance of Civil Engineering Infrastructure' requires that a Form C (certificate of design and checking of temporary works) be produced. The Form C was completed and was signed by BB-CJV, the ELLP and Network Rail. This design underwent a Category III check. This is a check, undertaken on a design, by an organisation completely separate from the Designer. The detailed design for the jacking down process was carried out by Chris Booth Associates and was checked by Chris Adams Limited.

6.1.3 In association with the Form C, a method statement (and Work Action Plan) and a risk assessment were produced for the jacking down. A number of risk assessment workshops took place with representatives from BB-CJV, the bridge designers, the temporary works designers, the ELLP and Network Rail to consider the overall bridge launch and installation process. Initially NR did not require a possession for the launch, but BB-CJV decided that a possession would be necessary, and this was arranged. NR did not require a possession for the jacking down activities.

6.1.4 While there was significant liaison between the permanent works and temporary works designers, there is some evidence that the design of the temporary works was constrained by the permanent works, so for example there was not much space available for lifting the packing plates in and out due to the final location of bridge and bearing.

6.1.5 The Temporary Works Designers did not consider in their design for temporary works, the potential need for realignment of the bridge, (plan

jacking), during the lowering process; the bridge launch had been engineered such that the bridge would be in its correct longitudinal and lateral position after the launch. Therefore the bridge was planned to be lowered without need for horizontal realignment on to its final bearing. In fact, after the launch the bridge was initially in its correct location. However, the bridge moved slightly between May 5th and May 21st, as the dead weight friction was insufficient to hold it in place, and Fairfield Mabey felt plan jacking was necessary to return the bridge to the original location.

6.1.6 Therefore no method statements or risk assessment were prepared for horizontal realignment (plan jacking), as it was not envisaged that it would be required.

6.1.7 The jacking down method statements incorporated consideration of thermal expansion and contraction of the bridge. During the jack down process at (say) the East end of the bridge, the West end would be fixed, and then vice versa. The method statement required that the fixity of the bridge was always transferred from one end of the bridge to the other at the same temperature, i.e. 13°C.

6.1.8 The risk assessments also considered the possibility of the bridge becoming unstable during the jacking down, and therefore restraints were fitted. These restraints worked, as during the incident the bridge moved only vertically. However the risk assessments did not specifically consider the possibility of the bridge dropping from the temporary supports, nor the potential effects of this (although in the risk assessment for earlier stages of the work (i.e. the launch) this had been considered), nor how it could be mitigated.

6.1.9 Small unplanned bridge movements occurred after the bridge launch and before the jacking down process started. The unplanned movement was known to Fairfield Mabey and MJ Hughes, but not reported formally. A Non Conformance Report (NCR) was raised but was not issued. However, neither the Fairfield Mabey nor BB-CJV procedures for the issue of NCRs give a deadline for the issue of these documents.

6.1.10 As a result of the movement, remedial works to realign the bridge via plan jacking were undertaken, but were neither planned by Fairfield Mabey with, nor approved by BB-CJV. Staff from Fairfield Mabey and MJ Hughes had also noticed that transit bolts located in the bearing plates at the east abutment had bent or were broken, but did not consider this significant, so no further action regarding this issue was taken by either of them; they felt that such bolts often break or distort during routine thermal movements.

6.1.11 The jacking down works were taking place without close supervision from BB-CJV site engineers, and on the day when realignment was taking place, Fairfield Mabey's Senior Site Manager was not present on site. This was however normal practice and within the remit of the jacking down method statement.

6.1.12 On 28th May MJ Hughes personnel, under supervision from the Fairfield Mabey's Site Manager, inserted PTFE covered plates between the sloping face of the taper plates and the base of the bridge frame. Those involved can provide no explanation, as to why they left the PTFE plates in situ; there was no need to have left it there, nor any benefit in terms of the following day's work. The bridge was left without any secondary means of vertical support. If the jack left in position close to the bearings had been locked out close to the underneath of the bridge deck, it might have supported the bridge after the first bearing shed its load on 28th May.

6.2 Recovery

6.2.1 Network Rail handled the passenger facing aspects of this incident, and the Inquiry Panel has not looked at this aspect. Attendance on the project site by BB-CJV, their sub contractors and senior ELLP staff was swift. On-site coordination between the emergency services, BB-CJV and ELLP staff in relation to the construction site was good.

6.2.2 During the recovery process the Fairfield Mabey Senior Site Manager was in attendance, and instructed that the PTFE pads on the west abutment be relocated from between the sloping side of the taper plate and the bridge frame, to between the horizontal plane of the taper plate and the horizontal spacer plates.

6.2.3 Whilst RAIB were carrying out their initial investigations, BB-CJV discussed with Network Rail their requirements for securing the Omnia Plank decking. Initial agreement was reached to secure the Omnia Planks by tying them in a longitudinal direction using rebar (already stored on the concreted part of the bridge). In addition, plywood was used to cover the gaps left by the ejected Omnia Planks. There were several plastic spacers from the gaps between the Omnia Planks, hanging beneath the deck. These were removed, and debris from the bridge that had landed on the track was removed.

6.2.4 A statement was prepared for Network Rail and signed by representatives from BB-CJV, Fairfield Mabey, Scott Wilson Railways and Benaim (bridge Designers), to confirm that considered the bridge and its supporting structure to be in a safe condition, and that the lines below could now be reopened. At this point power was re energized to allow the movement of stranded trains.

6.2.5 At approximately 05.00hrs the Network Rail Bridge Team arrived on site. They inspected the works already carried out on the bridge. They were not content that the Omnia Plank decking was sufficiently secured and requested that the Omnia Planks were secured with additional transverse lengths of rebar. In addition, they stated that fixing the additional rebar could not start until the Overhead Line Equipment (OHLE) was isolated. Isolation of power was not confirmed until 07.15hrs and it was at this point that work on the bridge restarted. This additional lacing work was completed to Network Rail's satisfaction by 08.50hrs, when power was then restored.

6.3 Incident Escalation and Stakeholder Involvement

6.3.1 Notification of an incident occurring with GE19 was swiftly transmitted to BB-CJV and to ELLP staff and upwards to London Rail senior management. London Rail and ELLP escalation procedures were not followed precisely; this did not materially affect handling of this incident; however there were lessons which are picked up in the recommendations.

6.3.2 Whilst not affecting the overall handling of this incident, it was noted that robust arrangements for contact between TfL London Rail and its various control centres (NOC, Serco DLR, Centre Com. and Network Rail) were not in place.

6.3.3 London Rail was able to instigate their pre-arranged procedures, for dealing with the press and issuing press statements. This was in place and operating in less than an hour after London Rail received notice of the incident. Despite this, some of the information being reported on news channels and in London newspapers was not accurate. Many reports stated that the bridge had collapsed even after TfL were reporting that it had dropped by 200mm and was in a safe condition.

6.3.4 The TfL press office in association with London Rail's own Stakeholder Management team arranged all media interviews connected with the incident. This also included working with BB-CJV's communications department to make their senior personnel available for interviews.

6.3.5 There were no complaints received from local residents regarding this incident. TfL received one phone call from a local resident at 19.20hrs who was concerned that the bridge was collapsing. TfL did not issue any correspondence/letters to residents in the days following the incident, as it considered that the subsequent media coverage was by then sufficiently accurate to get the key messages across to the public.

6.3.6 London Rail deployed its stakeholder handling plan the day after the incident. A stakeholder briefing was drawn up. Personal phone calls were made by London Rail's Managing Director to advise appropriate stakeholders.

6.4 Similar Incidents/Past Safety Performance

6.4.1 The Inquiry Panel and the independent bridge expert [2] engaged by the Panel have been unable to identify any incidents similar in nature to this, either in the United Kingdom or overseas.

[2] The inquiry panel have commissioned an independent bridge expert (see evidence list) to provide advice relating to the installation of the bridge. He has reviewed all relevant documentation in relation to the installation and has been able to attend site to carry out a visual inspection of the bridge.

6.4.2 The documentation concerning competence of those involved in the installation of GE 19 was reviewed. There was no evidence to suggest that any of the people who worked on the installation of the bridge, were either insufficiently competent or experienced for this task. Clearly, the events question the depth of understanding of those involved, but the panel do not think this could have been determined ahead of the incident.

6.4.3 The independent bridge expert confirmed that the use of the process of jacking down is not an unusual operation. In addition, the use of PTFE in the support arrangement to allow plan jack realignment is an industry recognized method.

6.4.4 Safety performance of the main works contractor has been carefully monitored at a number of forums within London Rail since the start of the main works on the project. There have been no reportable dangerous occurrences prior to this (as defined in the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) 1995).

6.4.5 There have been a number of injuries to the workforce that are classified as reportable under RIDDOR. A note of interest is that a number of the incident investigations discovered that a contributory factor, in several of these incidents, was working outside the scope of authorized method statements. As such, a revised procedure was introduced to allow for short notice changes to method statements. This was not followed here.

7 Analysis and Discussion

7.1 The Inquiry Panel are satisfied that the immediate cause of this incident related to the incorrect positioning of PTFE on the sloping surface of the taper plate. Due to the fact that PTFE was placed on a slope, the vertical load of the bridge generated a horizontal force. The presence of a second slip plane within the permanent bearing plates, allowed the taper plate and the support packing materials between the PTFE surface and the fixed bearing surface to be ejected. It is believed that a small movement in the structure, perhaps 2-3mm, as the result of temperature change during the evening of 28th May, resulted in the initiating movement of the bridge, such that the coefficient of friction between the PTFE and the packing plates changed from static to dynamic. The dynamic coefficient of friction of PTFE is significantly less than that in its static state.

7.2 The movement appears to have happened initially at the northeast bearing and then immediately afterward at the southeast bearing, as the additional load was shed onto it from the north east bearing. The same did not occur at the west end bearings because the permanent bearing plates were fixed in the longitudinal direction. As the bearings were fixed, this effectively prevented a second slip plane forming.

7.3 The requirement to use PTFE resulted from the need to horizontally realign (or plan jack) the bridge. The reasons for the realignment are important factors in explaining contributory causes of this incident. Fairfield Mabey required the plan jack because of a small movement, which had occurred while the west abutment parking restraint had taken up the load. The

support materials relied upon friction, but this had been insufficient to hold the bridge in place in this case.

7.4 From the documentation reviewed, there is no evidence that the Designers of the temporary works arrangements envisaged that the bridge would have to be realigned for any reason during the lowering process. The launch was engineered so that the bridge could be lowered to its final resting place within a tolerance of +/-15mm.

7.5 There was no Method Statement or risk assessment for the plan jacking procedure as it was not anticipated. Work was undertaken by Fairfield Mabey in accordance with their procedure allowing mental/dynamic risk assessment. Such an assessment had been carried out for the plan jack activity by the Fairfield Mabey Senior Site Manager, and briefed to the Fairfield Mabey Site Manager. However the Senior Site Manager was not on site when the activity was undertaken.

7.6 Whilst realignment may not have been expected or intended, the Inquiry Panel believes that realignment of the bridge should have been considered as a possibility, and therefore the means of realignment should have been documented within a method statement or within a Fairfield Mabey Work Action Plan (WAP). The absence of written instructions is a contributory factor to the incident, and allows for a greater opportunity for human error, in particular in the positioning of the PTFE in the support packing arrangement.

7.7 The independent bridge expert has reviewed the method statements and work action plans, and raises a number of questions. These relate to the potential need to realign the bridge, safe systems of work for those performing the task and work site management and communication. He goes on to comment in his initial appraisal report that the WAP does not give confidence that the author has a clear plan thought through to cover every aspect of the task. He states that the author takes the view that the tasks are obvious and basic, and that it is therefore not necessary to detail how the job is to be done. He summarises by stating that: ”for a critical operation, that is not acceptable from an engineering standpoint…..”.

7.8 Following the withdrawal of Guidance document GS28 by the Health and Safety Executive, the only formal guidance on the development of method statements in steel construction is the Steel Bridge Group's Guidance Note 7.08 "Method Statements". In order to test the adequacy of the Method Statement it asks the following: "Is the Erection Method Statement, with its reference documents, complete and sufficient for a competent site manager with no previous information to implement it as a safe system of work? If challenged, can the originator and the reviewers demonstrate from the Erection Method Statement how it satisfies all the technical, safety and management requirements?" In the case of the method statements relating to the lowering process, it is the opinion of the Inquiry that given the lack of a method statement for plan jacking, the answers to these questions are ’no’.

7.9 The Inquiry Panel have reviewed the risk assessments that were carried out for the jacking down. Consideration had been given to the risk of longitudinal and lateral movement of the bridge. However, there is no

evidence that the risk of the bridge dropping had been fully assessed. Even if this had been thought of as extremely unlikely, the high consequences resulting from the operating railway below means that further consideration should have been given; such consideration may have led to the installation of a secondary means of securing the bridge and its components.

7.10 Within the original Designer's risk assessments relating to GE19, there was a proposed mitigation to partially fix reinforcement over the formwork to prevent the Omnia Planks falling onto the railway below. This was not deemed necessary in subsequent temporary works designs, as the Omnia Planks were considered to be adequately fixed. As in paragraph 7.9, the Inquiry Panel believe that if greater consideration had been given to the possibility of high consequence outcomes, different mitigation measures may have been identified.

7.11 It is also worth noting that the Benaim Designer's risk assessment used a severity classification in which '1' was the most severe outcome, whereas the risk assessments used in the temporary works design used '5' as the highest severity outcome. Whilst there is no evidence that the temporary works Designers misinterpreted the Benaim Designer's risk assessments, the potential for human error exists.

7.12 As with many serious incidents there are normally precursors to the actual incident. In this case, as mentioned in paragraph 7.2, the bridge had moved and this had not been planned for. In addition, on the day of the incident the Fairfield Mabey staff noticed bent and broken transits bolts. If these incidents had been reported to BB-CJV and ELLP staff by Fairfield Mabey, the requirement for realignment would have been known and could have been planned.

7.13 The launch of the bridge was seen as the area of greatest risk, which is why BB-CJV wanted to launch the bridge during a possession. As has been seen before, less attention is sometimes paid to the installation detail, and this appears to be true of liaison between the parties during the jacking down, following the successful high-profile and time-critical launch. The works were carried out largely without supervision/monitoring from BB-CJV, and on the day of the incident without the presence of the Fairfield Mabey's Senior Site Manager. It is possible that if BB-CJV had been actively monitoring the jack down, they may have been aware of the unplanned movements and the need for plan jacking, and thus called for a further documented risk assessment and specific method statement for plan jacking.

7.14 ELLP site inspectors had attended GE19 on the day of the incident, and in the days leading up to the incident. The TfL ELLP Principal Engineer (Civil) had also been in attendance. Neither of them had been advised of unplanned movement or the need to realign the bridge. Whilst not material to this incident, it was noted that the detail contained within the Site Inspectors' and the Site Engineers' reports, was not sufficient to provide a record of any actions/instructions taken on a day to day basis.

7.15 The response to the incident in terms of project staff attendance was swift. A plan to make the bridge safe was quickly put in place. BB-CJV and

their sub contractors worked well to put in place measures, which eventually satisfied Network Rail that the bridge would be safe for train services to run underneath. It was unfortunate that Network Rail's requirements as to what was needed to make the bridge safe were not made clear to ELLP/BB-CJV earlier during the recovery operations; it was only when Network Rail's bridge team arrived at about 05.00 on 29th that the final extent of the remedial works was clarified.

7.16 The request to install further transverse lengths of rebar so that the Omnia Planks could be further secured seems excessive to the panel. This was relayed to Network Rail at the time by representatives of BB-CJV and TfL ELLP. However, the Inquiry Panel believes that requesting OHLE isolation to carry out this activity was a sound decision, although it should not have taken as long as it did to carry out the isolation.

7.17 There were a number of occasions during the planning of the temporary works, and the lowering of the bridge, when the specialist contractors could have considered the detail of the positioning of the PTFE pads. As already noted this does not appear to have occurred. An explanation may lie in the well understood human factor error mode of peer reinforcement, in which it is assumed that details which have already been signed off are correct and are therefore not challenged.

8 Conclusions

8.1 Under slightly different circumstances, if for example one of the planks had come into contact with a train as it fell, this incident may have resulted in a significantly worse outcome. The immediate cause of the incident – simply placing and leaving the PTFE pads in the wrong position – is, an error which, given the less rigorous planning for the jack down/plan jacking work, can be understood. The people placing the PTFE on the sloping face of the taper plate did not appreciate the engineering significance of their actions.

8.2 However, it is likely that this situation could have been avoided if better supervision and direction had been in place. The Fairfield Mabey Senior Site Manager was not present at the time of the incident and clear instructions in the form of a method statement or work action plan were not available for plan jacking. The production of these documents is clearly the responsibility of the skilled and expert contractors employed to carry out the task. While after the event, the temporary works designers were clear that the consequences of wrong positioning were high, with the potential for human error also high; they would not have sanctioned the approach without close supervision. They did not expect plan jacking to be necessary. However, they did not highlight the risks in advance of the event.

8.3 The Inquiry found that the Method Statements for the temporary works were planned and documented in accordance with the BB-CJV procedure, albeit that no Method Statement was prepared for plan jacking. However this incident provides an opportunity for the construction industry to take on board the messages that temporary works can have severe consequences and therefore require as much planning, documentation and attention as permanent work, and that high consequence risks require additional scrutiny.

9 Recommendations

9.1 It should be noted that BB-CJV, as a result of their own investigation, has put forward a number of recommendations, which have then been developed into an action plan, on a Company wide basis. This has been taken into account when formulating TfL London Rail's recommendations.

Recommendation 1 : London Rail to disseminate both internally (within TfL) and externally (to the wider construction industry) the lessons learnt from this high potential incident.

Recommendation 2 : London Rail to review the extent to which it assures itself of the performance of contractors. This should include a review of site inspection record keeping, a review of procedures examined on inspections (i.e. changes to Method Statements).

Recommendation 3 : London Rail to carry out a desktop exercise to further refine its emergency plans.

Recommendation 4 : London Rail to review its escalation and on call procedures including ensuring that those involved can easily communicate with each other (already partially complete).

Recommendation 5 : London Rail to review its procedures for conducting Formal Inquiries to understand and implement improvements learned from this first large scale Inquiry.

Recommendation 6 : In addition to recommendations already contained within the BB-CJV report, set out below, London Rail recommends that BB-CJV consider the following:

- BB-CJV should review their risk assessment process to ensure that it correctly captures low likelihood high impact risks.
- BB-CJV should ensure that all sub-contractors and designers within the project use the same risk assessment matrix.

9.2 The BB-CJV recommendations, reproduced with their approval, are as set out below. The term PI should be read as BB-CJV Panel of Inquiry :

1. It is the opinion of the PI that where key movements are taking place involving mental/dynamic assessment the FM Senior Site Manager should have been present on site.
2. The PI would recommend that in cases of mental/dynamic assessment these should be subject to appropriately written Risk Assessments and Method Statements suitably briefed out to the construction team.

3. The PI would recommend that a review is undertaken of those matters that may be routinely handled as mental/dynamic assessment on sites with a view to standardising them as Guidance Notes with suitable briefing to all construction supervisors and operatives.
4. It is the opinion of the PI that a change requirement for horizontal realignment after the launch should have triggered a re-evaluation resulting in written Risk Assessments and Method Statements that took into account the need to carry out manoeuvres not previously contemplated at this point in the sequence.
5. It is the opinion of the PI that there should have been provision of a Method Statement for this possibility as a contingency plan.
6. The PI is of the opinion that a closer liaison should have existed between the BBCJV and FM for all aspects of the post launch temporary works.
7. It is the opinion of the PI that key aspects of the temporary works design should have been better highlighted in the information transferred to the construction teams and to FM management timeously[3].
8. It is the opinion of the PI that this unforeseen movement should have been raised with the BBCJV Temporary Works Coordinator by the FM Temporary Works Supervisor.
9. It is the opinion of the PI that further Permits to Load should have been in place for key structural phases including completed West end and East end parking restraints.
10. It is suggested by the PI that there is close liaison between the Principal Contractor and the Supply Chain to promote structural interface awareness.

London Rail will track both sets of recommendations to conclusion, against the timescales to be agreed, once the report has been circulated.

[3] It should be noted that BBCJV are pursuing further investigations with regard to the design checkers.