Rail Accident Investigation Branch

Rail Accident Report

Derailment of a freight train at Audenshaw, Greater Manchester
6 September 2024

Report 10/2025
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This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC
- the Railways and Transport Safety Act 2003
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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Preface

The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability. Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

Where RAIB has described a factor as being linked to cause and the term is unqualified, this means that RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident or incident that is being investigated. However, where RAIB is less confident about the existence of a factor, or its role in the causation of the accident or incident, RAIB will qualify its findings by use of words such as 'probable' or 'possible', as appropriate. Where there is more than one potential explanation RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident or incident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, words such as 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the accident or incident being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of RAIB, expressed with the sole purpose of improving railway safety.

Any information about casualties is based on figures provided to RAIB from various sources. Considerations of personal privacy may mean that not all of the actual effects of the event are recorded in the report. RAIB recognises that sudden unexpected events can have both short- and long-term consequences for the physical and/or mental health of people who were involved, both directly and indirectly, in what happened.

RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of any inquest or fatal accident inquiry, and all other investigations, including those carried out by the safety authority, police or railway industry.

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Derailment of a freight train at Audenshaw, Greater Manchester, 6 September 2024

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Summary

At about 11:25 on 6 September 2024, a freight train derailed as it crossed a bridge that carries the railway over a public footpath in Audenshaw, Greater Manchester. The derailment involved 9 of the train's 24 fully laden wagons and led to extensive damage to the track, the bridge and some of the wagons. No one was injured during the accident, but the railway at this location was closed for around 8 weeks, while repairs were undertaken.

The derailment occurred due to a loss of restraint of the track gauge between the rails. This caused the wagons' wheels on the right-hand side to drop from the rail into this widening space.

The railway tracks over the bridge were installed on a longitudinal bearer system (LBS). An LBS is a track support arrangement in which the rails are mounted on timber bearers that run longitudinally under the rails and not on sleepers and ballast, as is typically found on the railway. The rails are mounted using baseplates, which are screwed onto the bearers.

The spread of the track's gauge was caused by the failure of a number of the screws securing the baseplates to the longitudinal wooden bearers. Subsequent metallurgical examinations showed that these screws had sustained fatigue damage before the arrival of the train. RAIB examinations of a section of the LBS recovered from site found that there had been previous screw failures at the same locations. Records of inspection and maintenance activities confirmed that there had been at least three previous failures, with one occasion known to have been before 2020, although many of the required records were not available.

Vehicle dynamics analysis and fatigue calculations carried out by RAIB during this investigation showed that these screws were not expected to have an infinite fatigue life when installed in the configuration used on the bridge, even though the forces from trains on the track were below the maximum limits stated in Network Rail standards. The LBS was installed in 2007 and an increase in the volume of traffic over the bridge since 2015 had accelerated the rate of fatigue of the screws.

The investigation also found that those screws which had failed, or were failing before the passage of the train, had not been detected by Network Rail's inspection regime. This was because both the automated and manual inspection regimes were not capable of reliably detecting this type of failure. RAIB also found that the regular dynamic track geometry measurements were within the allowable limits in standards, so no further action was mandated. It further found that the significance of previous screw failures had not been appreciated by those responsible for inspecting and maintaining the LBS at this bridge.

There were two underlying factors. Network Rail did not have effective processes for managing LBS assets, in regard to their design assurance, installation, inspection and maintenance.

RAIB also found that the track team in the maintenance unit responsible for the LBS at this bridge had neither recorded, nor reported, previous screw failures, and this had not been identified nor corrected by Network Rail's assurance regime over a period of years.

RAIB has made eight recommendations to Network Rail. The first recommendation aims to give greater assurance of the components used in its designs of LBS. The second recommendation is to improve its management of LBSs, including design, installation and maintenance guidance, and the reporting of component failures. The third recommendation deals with the competence of staff who manage those assets.

The fourth recommendation is for Network Rail to improve the interfaces between the two disciplines responsible for the track and structures assets to better manage them. The fifth recommendation is for Network Rail to better understand the effects from the condition of the LBS supporting structure on the track's behaviour.

The sixth recommendation is for Network Rail to review the way in which it assesses the effects of changes in rail traffic on its LBS assets and to consider any subsequent necessary changes in design, inspection or maintenance activity.

The seventh recommendation is to improve its records of its LBS assets, ensuring that it knows the configurations of its LBS assets nationwide.

The eighth recommendation is for Network Rail to improve its own assurance processes for LBS assets to ensure that staff are keeping accurate records of inspection and maintenance activities.

Introduction

Definitions

1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given.

2 The report contains abbreviations and acronyms, which are explained in appendix A. Sources of evidence used in the investigation are listed in appendix B.

Acknowledgments

3 RAIB is grateful to the British Transport Police for its assistance in providing X-ray equipment and scans to support this investigation.

The accident

Summary of the accident

4 At about 11:25 on 6 September 2024, a freight train travelling at 21 mph (34 km/h) derailed as it traversed a bridge that carries the railway over a footpath (which was formerly a road) in Audenshaw, Greater Manchester (figure 1). The 11th wagon of the 24-wagon train (wagon 11) was the first to derail on the bridge, followed by the next eight wagons. The train came to a stop, due to an automatic brake application, with the last five wagons still on the approach to the bridge.

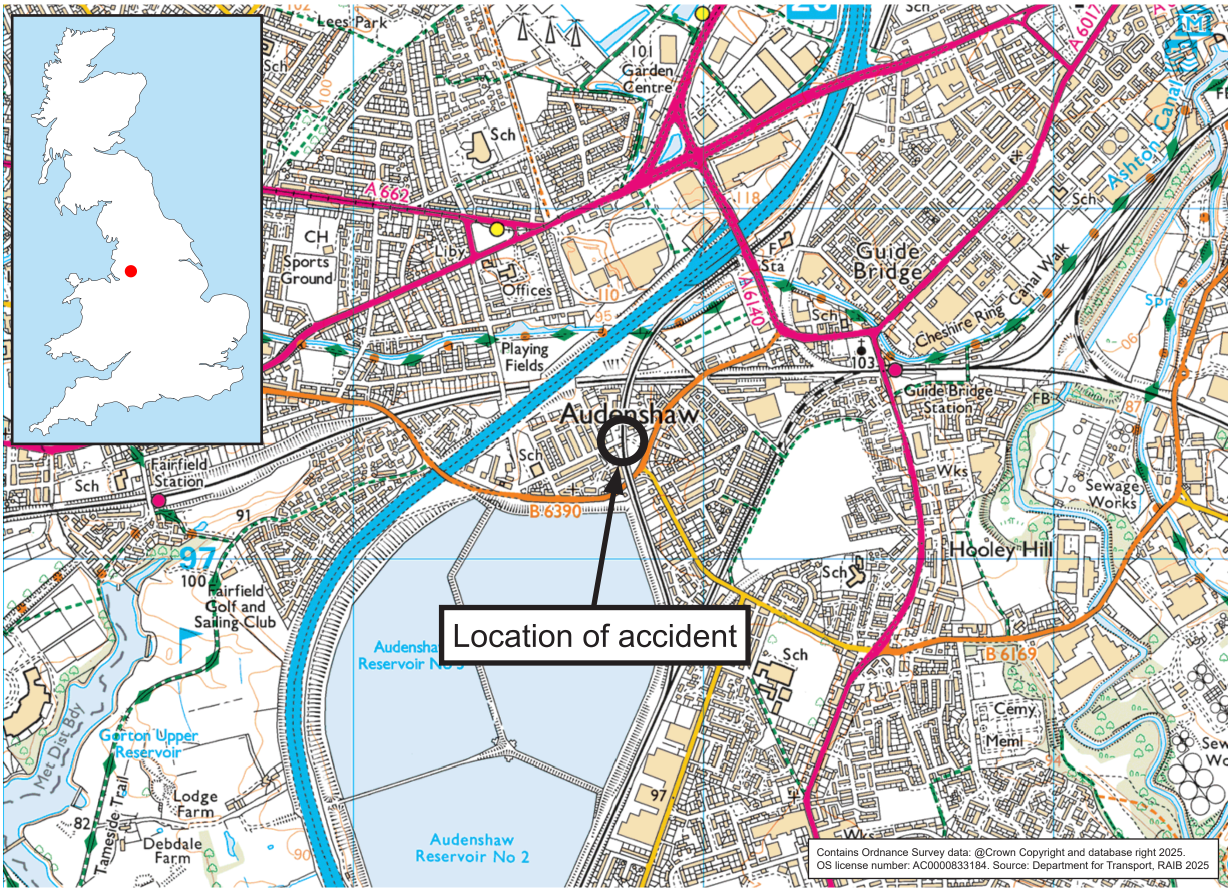


Figure 1: Extract from Ordnance Survey map showing the location of the accident at Audenshaw.

5 The bridge is approximately 14 metres long. The derailment happened between 2.4 and 4.8 metres from the start of the bridge and was caused by widening of the gauge (the distance between the rails), which allowed the right-hand wheels of the leading bogie of wagon 11 to drop between the rails. This caused the left-hand wheels of the wagon's leading bogie to flange climb over the left rail as the derailed wheels on the right-hand side became constrained. The right-hand wheels of the trailing bogie also dropped between the rails, with its left-hand wheels causing the rail to roll over. Wagons 12 to 14 all derailed to the left in a similar manner. As wagon 15 crossed the bridge, the right-hand rail broke underneath it at a welded joint. The rear wheels of wagons 15 and those of wagons 16 to 18 derailed to the right, initially running on the bridge deck before digging into the ballast, once they had passed over the bridge (figure 2).

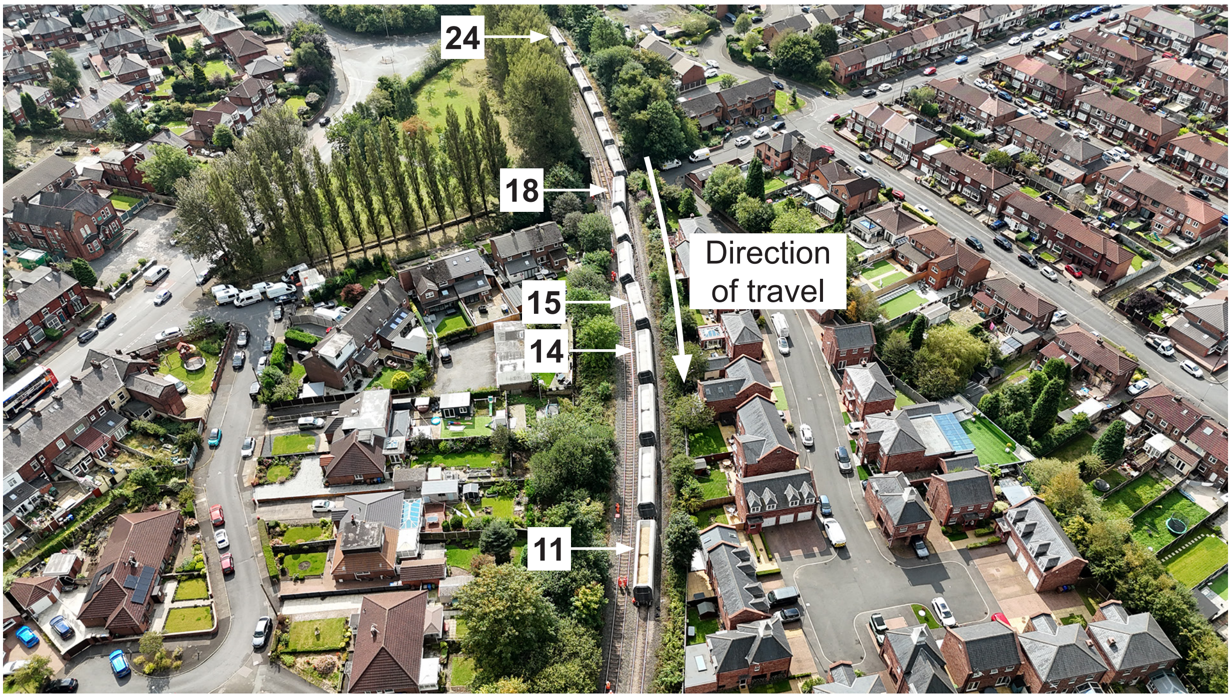


Figure 2: The derailed wagons.

6 The train continued until the coupling separated between wagon 10 and the derailed wagon 11, causing the train's brakes to automatically apply. The two sections of the train stopped about 70 metres apart.

7 No one was injured during the derailment, although there was a group of track workers underneath the bridge at the time. When they heard the noise from the derailed wagons, they quickly moved clear of the bridge. None were struck by falling debris from the bridge.

8 The accident caused significant damage to the bridge and track infrastructure. Five of the derailed wagons sustained significant amounts of damage. Both tracks of the railway line over the bridge were closed for more than 8 weeks to recover the wagons and repair the infrastructure.

Context

Location

9 The derailment happened on a bridge, known as bridge 3, which carries a double track non-electrified railway over Sidmouth Street in Audenshaw. Sidmouth Street is a footpath at this location, closed to road traffic just before it passes under the bridge (figure 3). The tracks on both lines over the bridge are carried by a longitudinal bearer system (LBS).

10 Bridge 3 is located on the railway line between Denton Junction and Ashton Moss North Junction (4 miles 1083 yards to 4 miles 1105 yards, with a zero reference at Heaton Norris Junction, north of Stockport). The Network Rail reference for this section of line is DJO1, so Network Rail refers to the bridge as bridge DJO1/3.

Figure 3: The bridge from Sidmouth Street level (courtesy of Network Rail with RAIB annotations).

11 The train was travelling on the Down Crowthorne line, which is the line heading north towards Ashton Moss North Junction. The line over the bridge has a maximum permitted speed of 30 mph (48 km/h). The signalling at this location is controlled by Denton Junction signal box, although the front of the train had moved into the area controlled by the Manchester North workstation at the Manchester Route Operating Centre by the time it stopped.

12 No passenger services are timetabled to travel over line DJO1. The traffic on this section of line mostly comprised freight trains passing around the eastern side of Manchester, carrying either aggregates, biomass or household waste. At the time of the accident, there were also three empty coaching stock passenger trains timetabled to pass over the line each weekday, and two on a Saturday, going between Newton Heath depot and Stockport.

Organisations involved

13 Network Rail is the owner and maintainer of the railway infrastructure. It is the employer of the staff who were responsible for maintaining the bridge and the track running over it.

14 The inspection and maintenance of the bridge was the responsibility of Network Rail's North West route structures team (a route in Network Rail is a geographical, devolved business unit that manages specific parts of the railway network). North West route is part of Network Rail's North West and Central region.

15 GB Railfreight Limited, known as GBRf, was the operator of the train. It is the employer of the driver. GBRf is also the owner of 12 of the wagons in the train. Touax Group is the owner of five of the wagons in the train and VTG Rail UK owned the remaining seven wagons.

16 All the above organisations involved freely co-operated with the investigation.

Train involved

17 The train that derailed, reporting number 6J46, was the 08:50 freight service from Peak Forest, near Buxton, to Hope Street sidings in Salford. It comprised two diesel-electric class 66 locomotives and 24 wagons. Only the leading locomotive was hauling the train.

18 The wagons were a mix of type IIA-A and type HYA-A bogie hopper wagons that were originally used for coal transport and had been shortened in length to carry aggregate (figure 4). Each was loaded with aggregate, with reported weights of between 99.2 and 101.2 tonnes per wagon. The total train weight, including the locomotives, was reported to be 2,413 tonnes and the train was 401 metres long.

Figure 4: The wagon types in the train.

Rail equipment/systems involved

Bridge 3

19 RAIB has been unable to find any detailed records to establish the age of the existing bridge 3. A Network Rail assessment report suggests that the original bridge was constructed in 1885. It is believed that the existing bridge is a replacement for the original and was constructed around the start of the 20th century.

20 Bridge 3 is constructed using a wrought iron riveted plate girder structure and a metal deck. The bridge carries two tracks on a single deck with two outer main girders, connected by 13 cross girders (figure 5). The bridge deck is approximately 19 metres long and it sits 3.9 metres above Sidmouth Street. The railway over the bridge curves to the right, in the derailed train's direction of travel, with a radius of about 450 metres.

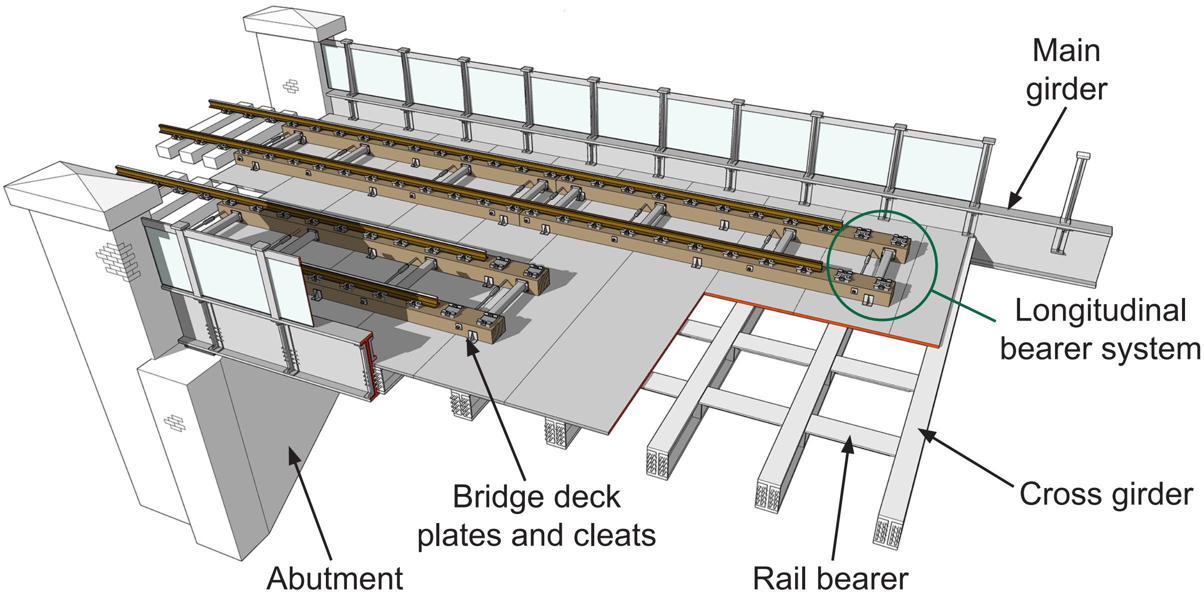


Figure 5: Structural components of bridge 3.

21 Bridge 3 is located a short distance to the north beyond the former Ashton Moss Junction, where a second line previously branched westwards towards Droylsden on a separate bridge. A now redundant abutment for this bridge still sits alongside the south abutment for bridge 3. The other abutment, which was located to the west of bridge 3's north abutment, was removed sometime between 1998 and 2008.

The longitudinal bearer system (LBS)

22 At the time of the accident, the track on either side of bridge 3 was ballasted, with continuously welded flat-bottomed rails secured to steel sleepers by track clips. The rails transitioned from the steel sleepers on the plain line sections to the LBS on the bridge via 15 wooden sleepers on ballast, situated at both ends. The complete LBS was last renewed in 2007.

23 The main components of the LBS before the derailment are shown in figure 6. The LBS on the down line of bridge 3 comprised three longitudinal bearers (sometimes known as waybeams or wheel-timbers) running along the bridge under each rail, made from a hardwood timber known as Greenheart. The bearers of the south end section of the down line (which was at the point of derailment) were 6.5 m long, 280 mm deep and 410 mm wide.

24 The rails were seated on PAN M6 baseplates and held down by Pandrol PR401A/P402A rail clips. The baseplates were attached to the bearers using two LSA chair screws (referred to in the remainder of this report as 'screws') per plate, each fitted within a polymeric ferrule in the bossed hole of the baseplate. LSA screws are approximately 205 mm long, measured from under the head. They have a plain shank about 57 mm long, before a transition into the threaded part of the fastener. The markings on the heads of the screws recovered from site indicated that they were manufactured in 2021 and were of the normal grade of steel. Between the baseplates and the bearers over the full length of the LBS were varying thicknesses of steel packing pieces. These were used to achieve the track's designed cross-level (cant) of between 30 and 40 mm.

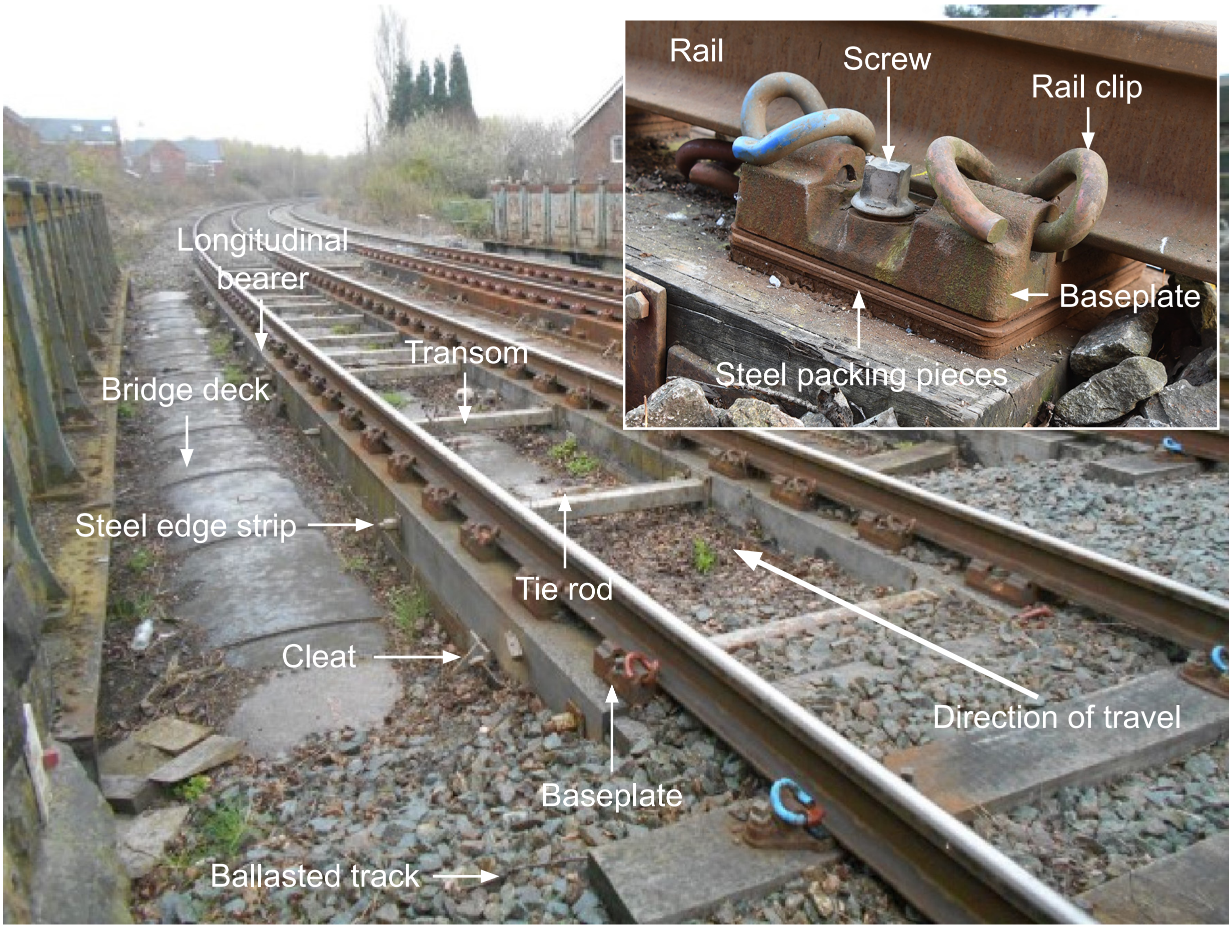


Figure 6: The main components of the LBS of the Down Crowthorne line on bridge 3 (courtesy of Network Rail with RAIB annotations).

25 Each pair of bearers was held laterally together at a set distance apart by steel hollow box section transoms and steel tie rods. There were layers of plywood packing pieces between the underside of the bearers and the bridge deck plates to achieve the correct vertical height of the rails. The bearers were restrained laterally relative to the bridge deck by a combination of metal brackets, known as cleats, which were fixed to the bridge deck, and timber wedges. The timber wedges, where present, were added between the cleats and the bearer sides.

26 Along both sides of each bearer, between the cleats and the bearer sides, were thin steel strips approximately 120 mm high. These vertically mounted strips were sitting on the bridge deck and formed a shallow trough in which the bearers sat. The strips were welded to the cleats but not to the bridge deck. In locations where there were gaps between these strips and the bearer sides, bitumen had been added to limit water ingress into the bearer undersides, the plywood packing pieces and the bridge deck. Additionally, horizontal rods passed through holes at each of the bearers' ends and the cleats at these locations. Their purpose was to provide vertical restraint of the bearers relative to the deck.

27 Across the UK, Network Rail owns 2,412 assets fitted with LBS. These are a mixture of hardwood, softwood and composite timber constructions. Within the North West and Central region, there are 226 individual track sections supported by LBSs.

28 Network Rail monitors the condition of its track using a fleet of track inspection and recording vehicles. These vehicles are formed into trains and travel over the national network to a predetermined schedule. They provide data, images and information to assist track maintenance staff to locate track faults.

Staff involved

29 The driver had 2 years' experience of working as a train driver. No issues were identified with how the train was being driven at the time of the derailment.

30 The inspection and maintenance of the track and the LBS on the bridge was the responsibility of the track team based at Network Rail's Guide Bridge depot. This team, including the section manager (track) and the section supervisor, was under the management of the East Manchester track maintenance engineer (TME), within the Manchester maintenance delivery unit.

31 The track maintenance engineer in post at the time of the accident (referred to as TME1) had 16 years' experience working in track related roles and had been acting in the post since April 2023. The person previously in this role (referred to as TME2) had been in post from 2016 to 2023 and had 21 years' experience on the railways.

32 The section manager (track) in post at the time of the accident (referred to as SM(T)1) had been in the post on a temporary basis since September 2023, having been a section manager since 2008. The person previously in this post, referred to as SM(T)2, left Network Rail in December 2024, having been in the section manager role for 30 years.

33 The section supervisor for inspection stopped being in the role in September 2023, but was reinstated to this role in December 2024, following the derailment. They had been in the role for 23 years.

34 The section supervisor for production stopped being in the role in August 2023.

External circumstances

35 The weather on the morning of 6 September 2024 was dry and bright. Local weather stations reported the air temperature was about 20°C at the time of the derailment. No external circumstances were identified that affected this accident.

The sequence of events

Events preceding the accident

36 Early in the morning of 6 September 2024, the wagons were loaded with aggregates and stabled in Dove Holes Quarry sidings, near Buxton, before being checked and the train prepared for travelling on Network Rail infrastructure. At 08:45, the train moved to Peak Forest long sidings ready to depart for Salford (paragraph 17).

37 While in the sidings, the driver identified that the locomotive was low on fuel, so a second locomotive was placed onto the front of the train to haul it to Salford. Train 6J46 then departed from Peak Forest at 10:16, running 56 minutes late.

38 The train's journey to Denton Junction was uneventful. The train passed Denton Junction at 11:21 and was signalled as planned onto the Down Crowthorne line. Train 6J46 was now running 65 minutes late.

39 From the junction, with the driver demanding the maximum amount of traction power from the locomotive, the train slowly accelerated up rising gradients of 1 in 115 and 1 in 122, reaching a speed of 17 mph (27 km/h), before passing onto a falling gradient of 1 in 109 that began about 120 metres on the approach to bridge 3. As more of the train moved onto the falling gradient, its speed began to increase. By the time wagon 11 reached the bridge, the train was travelling at 21 mph (34 km/h), well within the permitted speed (paragraph 11).

Events during the accident

40 Soon after the leading bogie of wagon 11 moved onto the bridge, its right-hand wheels dropped from the railhead and into the space between the two rails. This was due to the right-hand rail and its baseplates on the first longitudinal bearer section moving laterally to the right, widening the track gauge (figure 7). As this wagon continued forward, its derailed wheels were constrained between the rails until the flange on its first left-hand wheel on the leading bogie climbed up and over the left-hand rail towards the cess. The second left-hand wheel soon followed.

41 The wheels of the trailing bogie of wagon 11 followed the same path, but instead of climbing over the left-hand rail, these wheels caused the rail to overturn, rolling it free from its rail clips. The left-hand wheels then ran along the web of the overturned rail (figure 8). The following wagons 12 to 14 all derailed in the same way, with their left-hand wheels also running along the web of the overturned rail.

42 The wheels of the leading bogie of wagon 15 followed the same path until the right-hand rail broke under the wagon at a welded rail joint (green box in figure 7). Consequently, the unrestrained wheels of the rear bogie of wagon 15 derailed to the right. These wheels ran off the longitudinal bearers and onto the bridge deck, puncturing holes in it and causing debris to fall onto the footpath below. Continuing forward, these derailed wheels ran off the bridge and onto the ballast on its far side, continuing to run to the right of the original track's position.

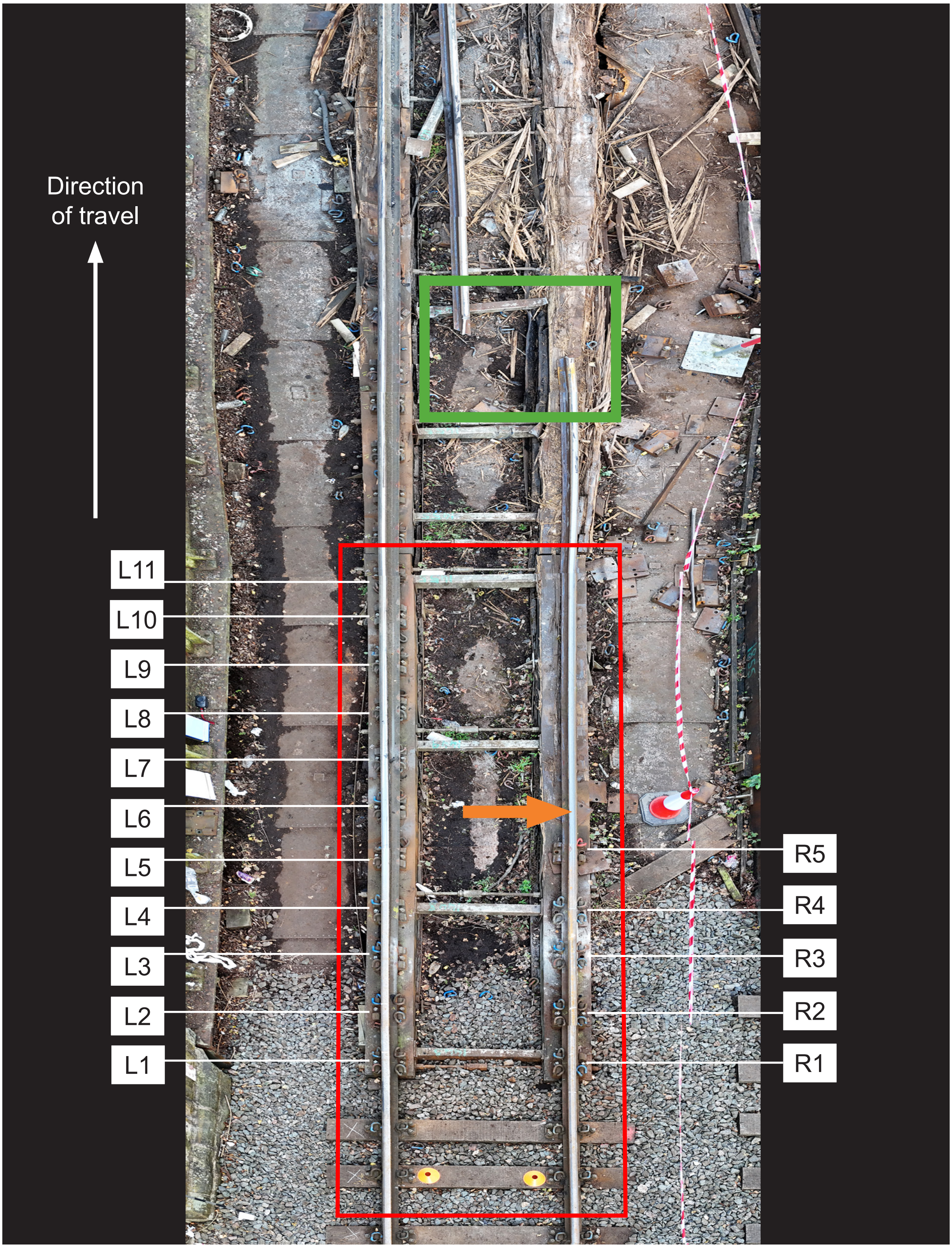


Figure 7: Area of the LBS showing the point of derailment (arrow) and the location of the broken rail welded joint (green box). The red box indicates the track section that was removed from site for the detailed examinations. (Note: all baseplates beyond R5 were displaced during the derailment).

Figure 8: The overturned left-hand rail.

43 All the wheels of the following wagons 16 to 18 also derailed to the right as they moved onto the bridge and reached the broken rail. They too ran over the bridge deck and onto the ballast beyond the bridge. Each of these derailed wagons dug further into the ballast. The increased load along the train due to the derailed wagon led to the coupling between wagons 10 and 11 breaking (figure 9). As these wagons moved apart, the train's brake pipe broke, which automatically began to apply the train's brakes.

Figure 9: The broken coupling between wagons 10 and 11.

44 As wagon 19 moved onto the bridge, wagons ahead of it had slowed down as they dug further into the ballast. The wheels of the leading bogie of wagon 19 derailed on the bridge, but the wheels of its trailing bogie stopped just before the point of derailment.

Events following the accident

45 The front portion of the train continued forward a short distance under braking, the rear of it stopping about 70 metres beyond the front of the uncoupled rear portion. The driver noticed the unsolicited brake application. At 11:31, once the train had stopped, they reported to the Manchester North workstation signaller that the train had come to a stand due to an unknown brake demand. The driver advised the signaller that they were going to investigate what the problem was.

46 At about the same time, the track workers who were underneath the bridge (paragraph 7) made an emergency call to the Denton Junction signaller, advising that a train had derailed on the bridge over Sidmouth Street and was foul of both lines. At 11:37, the Denton Junction signaller contacted the Manchester North workstation signaller to advise that the wagons behind the 10th wagon had derailed.

47 In response to these reports, Network Rail control staff called the emergency services and mobilised staff to the location. Due to the damage to the bridge, British Transport Police and Greater Manchester Police closed the footpath under the bridge to the public. RAIB was advised by Network Rail at 12:11 and immediately deployed a team to the site of the accident. RAIB released the site back to Network Rail at 18:00 on 7 September.

48 In the following weeks, each of the derailed wagons was removed by crane and the leading section of the LBS was finally removed from site as evidence for examination by RAIB. The recovery work included installing props under the bridge to strengthen the structure during the lifting and removal of the derailed wagons.

49 Once all the derailed wagons had been removed from the site, Network Rail completed repairs to the infrastructure on 3 November. The line reopened at 02:01 on 4 November after the completion of a series of route-proving runs with a locomotive had showed that the signalling system was functioning as expected. The props under the bridge were left in place while further work was planned by Network Rail to strengthen the bridge's structure.

Background information

Condition of the bridge

50 There is a division of responsibility within Network Rail regarding the management, including inspection and maintenance, of an LBS on a structure. The track discipline is generally responsible for all LBS elements above the upper surface of a structure, with the structure itself being under the management of the structures discipline.

51 Network Rail manages the condition of its structures, such as bridge 3, through regular examinations by suitably qualified staff. Network Rail provided RAIB with structures examination and assessment reports for bridge 3 dating back to 1998. The most recent detailed examination before the derailment was in April 2024. On a scale ranging from 'very poor' to 'very good', the overall condition of the bridge was considered by Network Rail to be 'fair', but with significant localised areas in poor condition. This examination had found that corrosion had caused widespread section loss to the main girders and cross girders.

52 The route availability (RA) system is used by the rail industry to assess the compatibility of rail vehicles with bridges. It checks the weight of rail vehicles against the load carrying capacity for bridges on a route. The weight of a vehicle is expressed as an RA number which is based on the vehicle's axle loads and the spacings between its axles.

53 The load-carrying capacity of an underline bridge at the permissible speed or speeds for trains passing over it is also expressed as an RA number. A model, which includes a dynamic increment of loading to account for vehicle speed, is used to calculate the bridge's RA number. Once all the RA values for the bridges on a section of route have been determined that section of the route is assigned an RA number. This is normally based on the lowest RA number of any bridge on that section.

54 At the time of the derailment, the RA documented in the sectional appendix for the line from Denton Junction to Ashton Moss North Junction was RA8. The freight trains running over this line were classed as RA10, and since they were higher than RA8, these trains were classified as heavy axle weight (HAW) traffic. Running RA10 trains over an RA8 route required a dispensation from Network Rail's access controllers. On the advice of the route's structures engineers, the dispensation required all HAW traffic to pass over the bridge at a maximum speed of 30 mph (48 km/h). However, as the maximum permitted speed for all trains passing over the bridge was already 30 mph (48 km/h) (paragraph 11), this meant no additional restrictions were needed for RA10 trains to run over the bridge.

55 An earlier structural assessment in 2010 had recorded that the bridge was unable to accommodate trains with heavy axle loads due to the conditions of the main girders. The report documented concerns about the shear capacity of these girders, due to visible defects in their webs. Consequently, the RA of bridge 3 was deemed by the assessment in 2010 to be RA0 or RA1.

56 In 2015, Network Rail carried out repairs to the girders, involving over plating the holes in the girder webs to strengthen them. An earlier structure examination had recorded that the north abutment also had defects. These were fractures, open joints and bulging wing walls. These north abutment fractures were also repaired in 2015. By 2019, Network Rail's managers who were responsible for the bridge had taken the view that the main issues affecting the bridge, such as the identified weaknesses in the main girders, had been mitigated through the work carried out in 2015. Plans to replace the bridge were then deferred to the 2027/2028 financial year.

57 Some of the structures examination reports identified evidence of vertical movement, referred to as 'pumping', over the north abutment affecting the down line. This had been ongoing for at least 8 years. In 2023, Network Rail carried out work to fit shims under the main girders at this end of the bridge, but this had not stopped the movement. It is possible that the removal of the redundant abutment next to the remaining north abutment (paragraph 21) and settlement of the remaining structure had weakened the bridge supports and allowed the adjacent main girder to move vertically under load.

58 At the time of the April 2024 structure examination, there were no significant bridge defects recorded at its south end where the derailment happened. However, movement of the main girder under load at the north end, and the associated deflection of the deck, is likely to have affected the stability of the LBS and track fixings over the preceding years (see paragraph 95).

Condition of the LBS

RAIB examinations of the recovered LBS section

59 RAIB undertook examinations of the LBS on site during the recovery operations of the derailed wagons. Relevant observations noted during the site phase included:

a. Many upper portions of broken screws, displaced baseplates and steel packing pieces were found on or near the bearers.

b. There were missing and rotten timber wedges.

c. The plywood packing on the underside of the bearers had slipped and the steel edge strip was bowed; this seemed to be related to a missing cleat on the left-hand side of the first left-hand bearer.

d. The vertical restraint rod at the far end of the first right-hand bearer was found broken (with an aged fracture face).

e. The baseplates remaining in place had four rail clips per plate.

f. The thickness of the steel packing pieces under some of the baseplates was in excess of the 30 mm prescribed by Network Rail's standards.

g. There was evidence of ballast migration from the down line leading to the bridge on to the bridge deck.

60 Once off-site (paragraph 48), RAIB disassembled and examined the recovered first section of the LBS where the derailment had started. The focus of this work was from the start of this LBS section as far as the 11th baseplates (figure 7). Beyond this point, the value of any detailed examinations was diminished by the amount of damage the derailed wheels had caused to the LBS. Each baseplate position was sequentially numbered from the leading end, together with an L (left) or R (right) prefix to indicate their positions. The designations left and right were based on viewing the LBS in the direction of the train's travel.

61 Both the transoms and the tie rods between the left and right bearers were examined (figure 6). Although there was evidence of the retraction of some coach screws holding the transoms to the bearer's sides, there were no signs of significant gauge widening of the track related to the bearers spreading apart. All the threaded fastening components on the tie rods had been secured by welds, and apart from at one location, the welds were all intact. This, and the retraction of some of the transom coach screws, some of which were impacted by the wagons' wheels, is thought likely to have occurred as a result of the derailment.

62 Each baseplate position was examined, with a record made of the components still in place and their condition. RAIB found that in some of the locations where the baseplate was still present, the screws had broken, but their upper portions remained in place within their ferrules and the associated baseplates' bossed holes. Some of these broken screws were so tightly wedged in the baseplate that they required a spanner to remove them. These upper portions of screws, together with those recovered from the debris scattered on the bridge deck close to the section on which the derailment initiated (a total of 22 components), were sent to an external organisation to be metallurgically examined to identify the mode of failure (figure 10).

Figure 10: Broken screws recovered from the debris on the bridge.

63 All the upper portions examined had failed within the first three threads close to where the plain shank ends and the threaded section begins (paragraph 24 and figure 11). The planes of all the fractures were below the upper surface of the bearer. There was also evidence of bending deformation on some of the screws.

SK CS 1A (top) & 1B (lower) | SK CS 2A (lower) & 2B (top)

SK CS 3A (lower) & 3B (top) | SK CS 4A (lower) & 4B (top)

Figure 11: Examples of broken upper portions of screws before metallurgical examination.

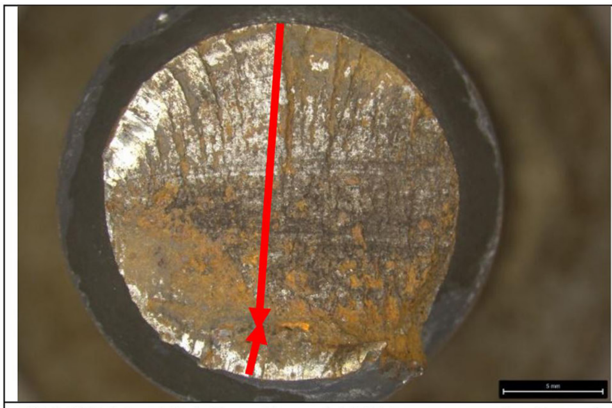
64 Detailed metallurgical examination of the fracture faces of these screws identified that all had suffered varying degrees of fatigue failure (figure 12). Fatigue refers to the weakening and eventual fracture of material through the initiation and propagation of cracks due to cyclic loading. Fatigue performance can be viewed as being of three distinct types:

a. low cycle fatigue (LCF), where the stresses in the component are high and above the yield strength of the material and it only takes a small number of cycles before structural failure

b. high cycle fatigue (HCF), where the stresses in the component are low and often below the yield strength of the material but where the component will still structurally fail after a large number of cycles has been applied

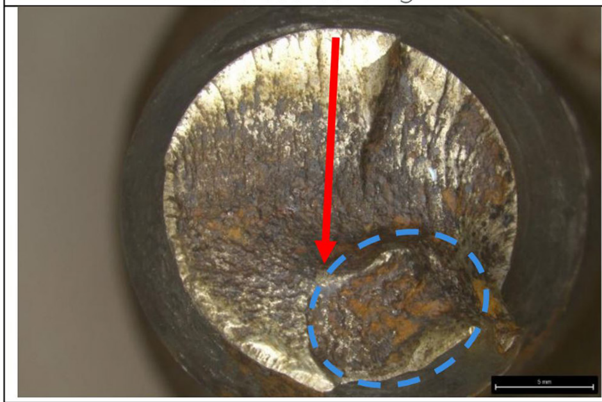
c. infinite fatigue life, where the stresses in the component are so low that a fatigue crack will never initiate, regardless of the number of cycles applied.

65 Although it was not possible from this examination to determine the ages or the sequence of the screw failures, the presence of HCF, LCF and overload failure shown on figure 12 indicates that there had been concurrent fatigue crack growth activity in all the samples examined. There was also evidence of reversed bending in most of the samples.

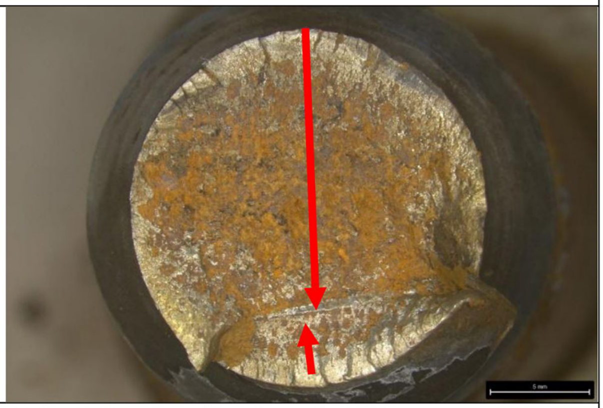


SK CS 1A. Unidirectional HCF over majority of section, and a small area of secondary reversed bending.

SK CS 1B. Unidirectional HCF across majority of section and secondary reversed bending



SK CS 2A. Unidirectional HCF across approx.. 50% of section, then LCF, and small area of overload (circled)



SK CS 2B. Unidirectional HCF across majority of section and secondary reversed bending

Figure 12: Fracture face examination showing reversed bending fatigue in three of the four samples shown, and one with signs of fatigue followed by final overload failure.

66 The presence of LCF followed by final overload failure in some of the screws (figure 12, lower left) indicates that the load and hence the stresses in these screws had increased once those exhibiting HCF were either partially or fully fractured. This then led to more rapid fatigue crack growth (that is, higher load and fewer loading cycles) in those showing LCF which subsequently broke by overload failure. This shows that some screws were in a deteriorated condition before the arrival of train 6J46.

67 The examinations found that at baseplate positions R5 to R9 on the right-hand rail and at baseplate position L6 on the left-hand rail there were indications of multiple holes in the bearers (figure 13). Both the use of a metal detector and X-ray images confirmed the presence of lower screw portions at the majority of these locations, with some holes where no screw was present (figure 14). This showed that there had been previous screw failures and replacements before the fitting of the screws which were in place at the time of the derailment.

Figure 13: The R7 baseplate position showing evidence of previous screw holes.

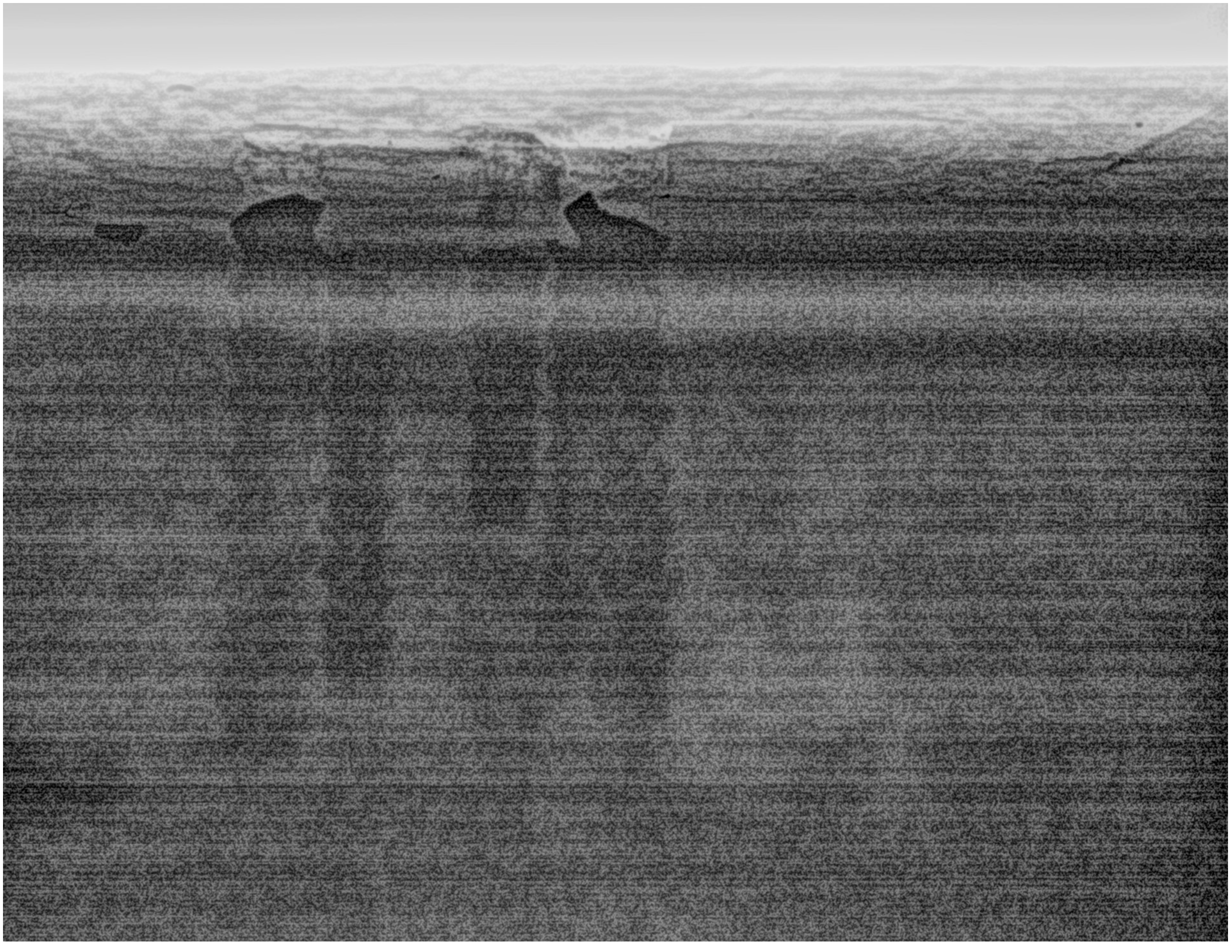


Figure 14: X-Ray image showing the presence of lower portions of broken screws within the bearer (courtesy of British Transport Police).

68 Cross sections were cut from the right-hand bearer and sawn open to remove the lower portions of the broken screws so they could be metallurgically examined. This examination found that all the older portions of screws had failed in fatigue, in the same manner as those in place at the time of the derailment.

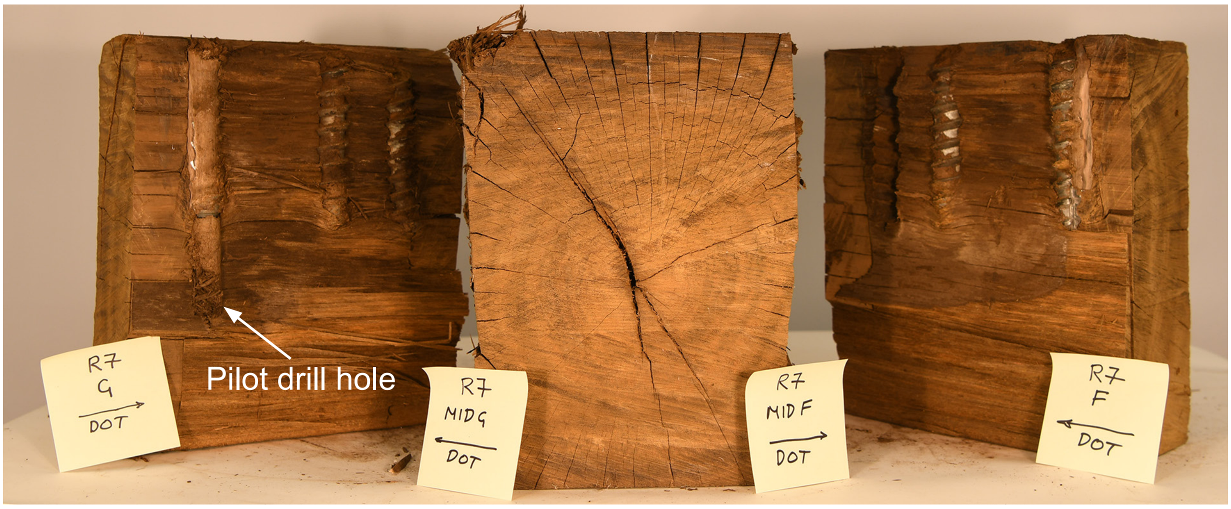


Figure 15: Cross sections of the bearer at the R7 baseplate location revealing the lower portions of broken screws.

69 The timber cross section at the R7 baseplate location is shown in figure 15. This is representative of the other cross sections examined. On each side of the bearer, where the baseplate had been located (the baseplate was not present due to derailment damage during the accident), there were three distinct drilled holes. A deeper pilot hole can be seen in one location. There is also wood grain deformation at the tip of one of the screws (central hole in figure 16), indicating that that hole had not been drilled to a sufficient depth. There was also evidence that both LSA and the shorter AS screws had been used at some time.

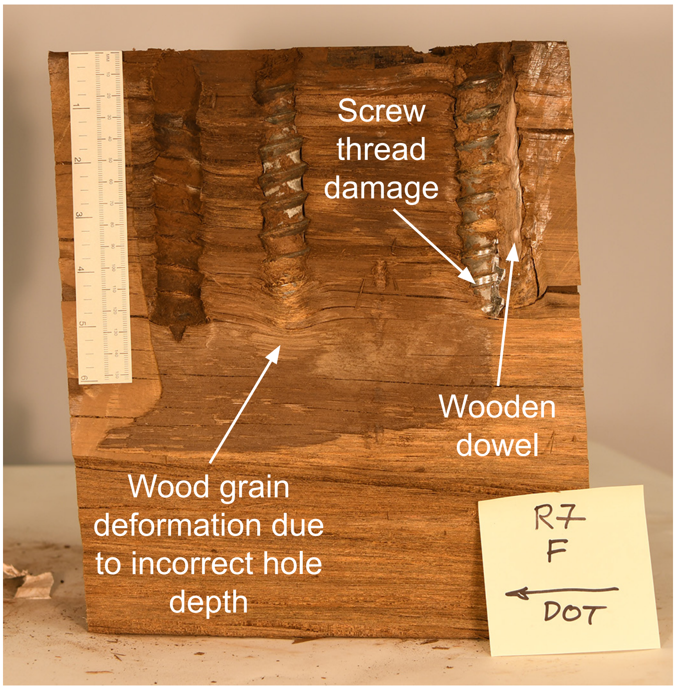


Figure 16: The screws and holes found within the sectioned R7 baseplate location.

70 The rightmost screw in figure 16 shows signs of thread tip flattening, possibly indicating that the hole had not been drilled to the correct diameter, depth or possibly both. This arrangement may have led to higher stresses being created in the screw as it was installed. To the right of this screw portion is a dowel showing that this hole had previously been plugged and redrilled. The use of wooden dowels and redrilling is an acceptable practice by Network Rail. This indicates that, had any screw been in this hole previously, it must have been removed intact, otherwise the broken lower portion would still be present.

71 This, and similar evidence from the other bearer cross sections examined, indicates that there had been at least two, or possibly three, previous occurrences of fatigued screws before those present at the time of the derailment. Baseplates R5 and R6 had at least three previous screw failures. Multiple previous failures were also found on the left-hand bearer at the L6 position. One of the screws from the L5 position broke while being unscrewed during disassembly and showed an advanced state of fatigue.

72 It was noted that the drilled holes were very close to one another, sometimes breaking into each other. There is a requirement within standards to have a minimum distance between adjacent holes (see paragraph 206).

Historical records of the previous conditions of the LBS

73 RAIB asked Network Rail for the design, installation, inspection and maintenance records of the LBS on bridge 3. However, Network Rail found that it held no records relating to the LBS design and installation, apart from the date within the LBS asset register stating that it had been renewed in 2007 (although it was incorrectly recorded as having softwood bearers). Very few records of track inspections and maintenance work undertaken by Guide Bridge depot on the LBS were available before 2023. Some limited records and witness evidence were available that indicated that a section of the left-hand rail had been renewed in August or September 2021.

74 Network Rail provided RAIB with records from the North West route structures team which included inspection records of the bridge structure. Although the LBS was the responsibility of the track team (paragraph 50), some observations were noted with regards to the track condition. These included photographs of the bridge deck and hence the LBS. RAIB examined these photographs as part of its investigation to identify the most likely sequence of degradation of the LBS.

75 Figure 17 shows an image of the bridge deck and LBS within a structure examination report dated April 2016. It shows that, on the down line, there was some ballast migration at the leading end of the LBS and that the baseplates were originally clipped with only two clips per plate (and a few of the rail clips had been highlighted as missing).

Figure 17: The LBS on bridge 3 during a structure examination in April 2016 (courtesy of Network Rail with RAIB annotations).

76 By January 2018, the baseplates at the north end of the LBS had been fitted with additional rail clips (figure 18). Network Rail's inspection and maintenance staff told RAIB that it is custom and practice to add additional clips in situations where rail clips are coming loose and/or have fully come out. Some staff thought that this practice was specified within standards, although it is not. A rail clip may come loose if it has been overloaded and lost its elasticity. Alternatively, it may come loose if it has lost its rail foot clamping load, for example, if the pad under the rail has become compressed, or if the housing in the baseplate in which the clip sits has become worn. The PAN M6 baseplate had been designed to be fitted with only two clips per plate, but it provides four possible positions for the clips (two on either side of the rail). This is to allow for a single clip of either left- or right-handed design to be used where access is restricted, for example, at a bolted rail joint.

77 In December 2020, a structures examination identified broken screws, missing clips and displaced steel packing pieces on the right-hand rail of the down line (figure 19). This was at the south end of the bridge where the derailment took place in September 2024. Figure 19 has been annotated by RAIB to indicate baseplate positions R5, R6 and R7. This is the same location at which the derailment of train 6J46 was initiated by gauge spread.

Figure 18: The LBS on bridge 3 during a structure examination in January 2018 showing additional rail clips on baseplates at the north end of the down line (courtesy of Network Rail with RAIB annotations).

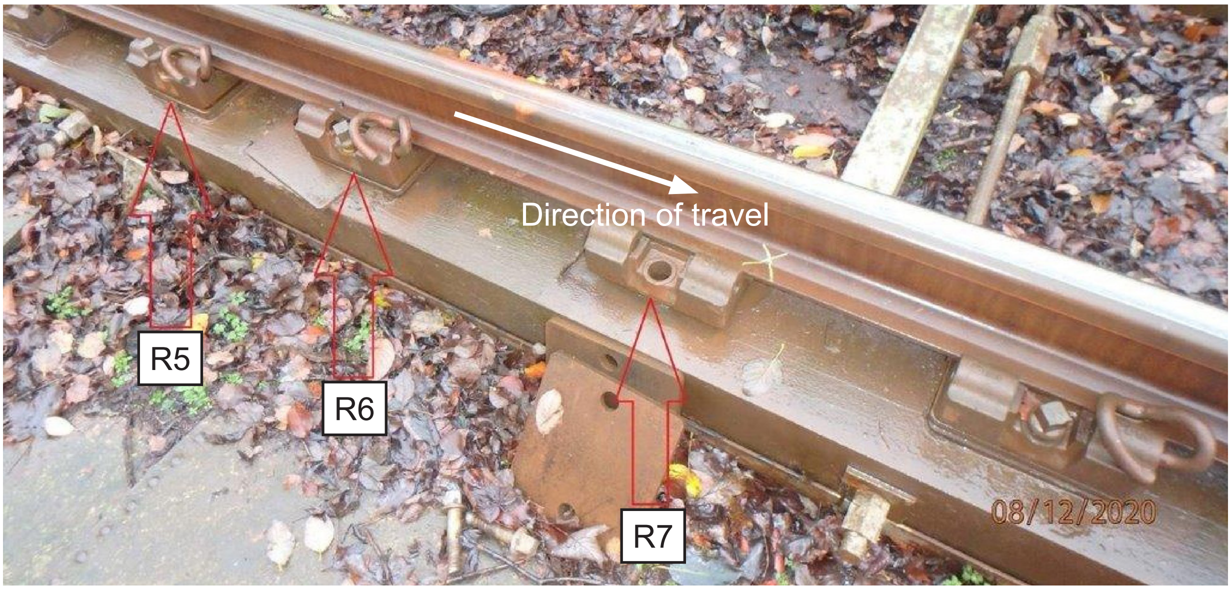


Figure 19: The leading section of the right-hand bearer on bridge 3 observed during a structures examination of the bridge in December 2020 showing baseplates with missing rail clips, evidence of broken screws and displaced steel packing pieces (courtesy of Network Rail with RAIB annotations).

78 The position of the displaced steel packing piece under the baseplate at position R7 in the image required the packing piece to have been unrestrained by the screws. This indicates that the screws on both sides of the baseplate had broken by this time. Taking this into consideration, and the examination of the holes and screws following the sectioning of the bearer (paragraphs 69 and 70), RAIB determined that these screw failures in December 2020 were not the first occurrences of screw fatigue failures at this location.

79 Two of the lower screw portions (in line with one another and one either side of the baseplate) removed from the sectioned bearer at this location suggests they were the shorter AS screws. Although their age cannot be determined, comparison of the screws' surface appearances (the shorter ones appearing to be the oldest) indicates that these screws were possibly present before those which had broken by December 2020. There are no records from Guide Bridge depot regarding any maintenance work undertaken at around that time.

80 Another observation made during the structures examination in December 2020 related to the deflection in the steel strip on the cess (left-hand) bearer (figure 20). Following the derailment, RAIB found that there was no cleat fixed to the bridge deck at the mid-span of the bowed strip (nor were there any signs that there had ever been one). When the leading section of the LBS was removed from the bridge, it was found that the plywood packing pieces under the bearer had shifted towards the left causing the bow in the steel strip (figure 21). The inserts in figure 21 also show the stack of 13 plywood packing pieces recovered from a single vertical section between the bridge deck and the bearer, together with a broken vertical restraint rod from the far end of the right-hand bearer of the first LBS section recovered from site.

Figure 20: The leading section of the down line on bridge 3 observed during a structure examination in December 2020 showing the bowed steel strip and the location of the missing cleat (courtesy of Network Rail with RAIB annotations).

Figure 21: The leading section of the down line cess-side bearer on bridge 3 following removal of the bearer and rail.

81 The movement of the plywood packing pieces together with the aged fracture of the vertical restraint rod at the end of the bearer suggest that there had been differential vertical deflection between the LBS and the bridge deck. This, and the lack of cleat on the cess side of the steel strip allowed the many plywood packing pieces (which were found to be damp and slippery following the accident) to slide to the left. There are no records from Guide Bridge depot regarding the bowed strip or the broken rod at around that time. The bowed strip and broken rod are not mentioned in the inspection records during the months before the derailment.

82 Many of the structures inspection reports over this time noted missing or rotten wooden wedges (figure 22). RAIB also observed this at some of the cleat locations during its time on site.

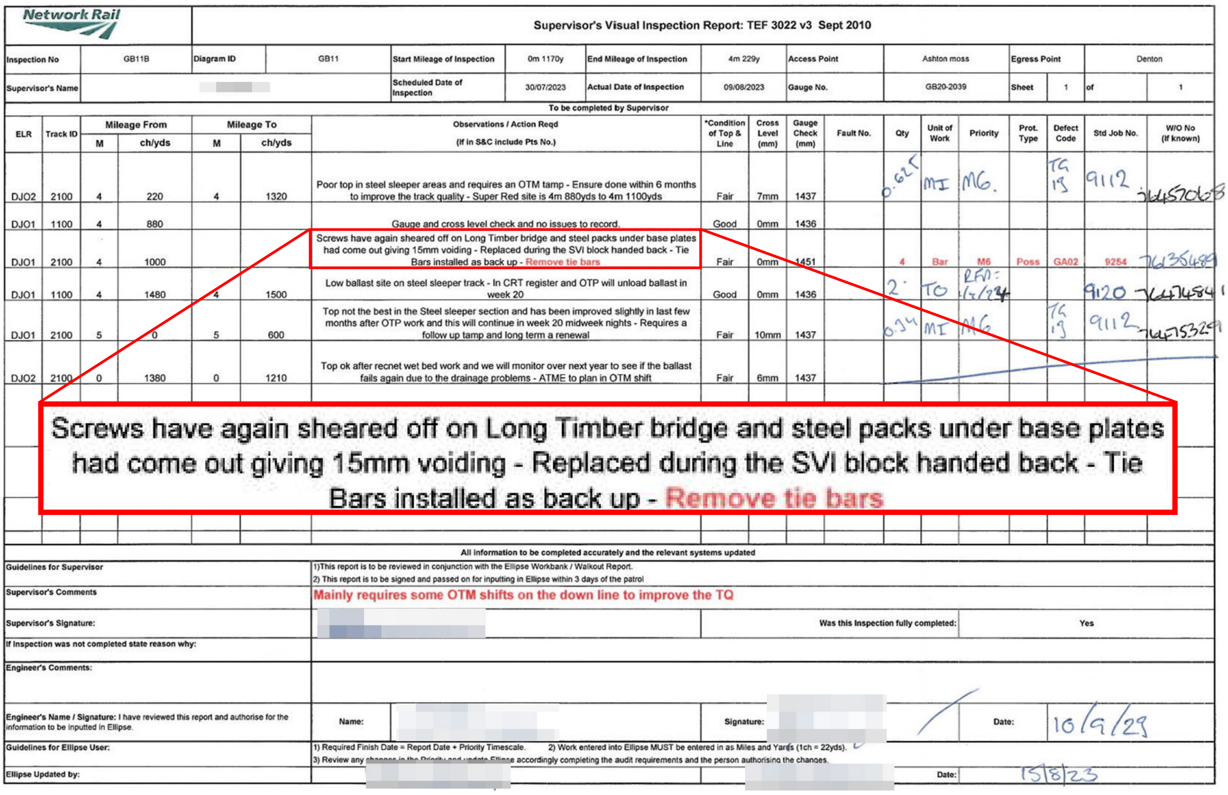
Figure 22: Photographs from structure examination reports on two dates showing the typical states of the wooden wedges between the cleats and the bearer sides (courtesy of Network Rail with RAIB annotations).

83 By September 2022, the doubling up of rail clips on the baseplates had been undertaken over the whole length of the LBS, suggesting that clip loosening and loss was becoming a wider issue (figure 23).

84 Network Rail provided RAIB with records from its asset management system, Ellipse, used for the planning and recording of track inspection and maintenance activities. The records that were available, together with witness interviews and detailed examinations by RAIB, were reviewed to understand the changing condition of the LBS and its management since 2022.

85 Paper documents that were provided to RAIB included a supervisor's visual inspection (SVI) report conducted on 9 August 2023. The SVI is a regular track inspection carried out on foot by the track section manager. This report had been signed by both SM(T)2 on 15 August 2023 and then by TME1 on 10 September 2023 (figure 24). It recorded that the '*screws have again sheared off on long timber bridge and steel packs had come out giving 15 mm of voiding'*. It further stated that this had been replaced during the inspection.

Figure 23: The presence of additional clips on the baseplates and missing clips from the baseplate at position R1 observed during a structure examination report in September 2022 (courtesy of Network Rail with RAIB annotations).



Network Rail

Supervisor's Visual Inspection Report: TEF 3022 v3 Sept 2010

Inspection No	GB11B	Diagram ID	GB11	Start Mileage of Inspection	0m 1170y	End Mileage of Inspection	4m 229y	Access Point	Ashton moss	Egress Point: Denton
Supervisor's Name				Scheduled Date of Inspection	30/07/2023	Actual Date of Inspection	09/08/2023	Gauge No.	GB20-2039	Sheet 1 of 1

To be completed by Supervisor

ELR	Track ID	Mileage From M	Mileage From ch/yds	Mileage To M	Mileage To ch/yds	Observations / Action Reqd (If in S&C include Pts No.)	*Condition of Top & Line	Cross Level (mm)	Gauge Check (mm)	Fault No.	Qty	Unit of Work	Priority	Prot. Type	Defect Code	Std Job No.	W/O No (If known)
DJO2	2100	4	220	4	1320	Poor top in steel sleeper areas and requires an OTM tamp - Ensure done within 6 months to improve the track quality - Super Red site is 4m 880yds to 4m 1100yds	Fair	7mm	1437		0.625	MI	M6.		TG 19	9112	[illegible]
DJO1	1100	4	880			Gauge and cross level check and no issues to record.	Good	0mm	1436								
DJO1	2100	4	1000			Screws have again sheared off on Long Timber bridge and steel packs under base plates had come out giving 15mm voiding - Replaced during the SVI block handed back - Tie Bars installed as back up - Remove tie bars	Fair	0mm	1451		4	Bar	M6	Poss	GA02	9254	[illegible]
DJO1	1100	4	1480	4	1500	Low ballast site on steel sleeper track - In CRT register and OTP will unload ballast in week 20	Good	0mm	1436		2.	TO	RFN: [illegible]			9120	[illegible]
DJO1	2100	5	0	5	600	Top not the best in the Steel sleeper section and has been improved slightly in last few months after OTP work and this will continue in week 20 midweek nights - Requires a follow up tamp and long term a renewal	Fair	10mm	1437		0.34	MI	M6		TG 19	9112	[illegible]
DJO2	2100	0	1380	0	1210	Top ok after recnet wet bed work and we will monitor over next year to see if the ballast fails again due to the drainage problems - ATME to plan in OTM shift	Fair	6mm	1437								

All information to be completed accurately and the relevant systems updated

Guidelines for Supervisor	1)This report is to be reviewed in conjunction with the Ellipse Workbank / Walkout Report. 2) This report is to be signed and passed on for inputting in Ellipse within 3 days of the patrol
Supervisor's Comments	Mainly requires some OTM shifts on the down line to improve the TQ
Supervisor's Signature:	Was this Inspection fully completed: Yes
If Inspection was not completed state reason why:	
Engineer's Comments:	
Engineer's Name / Signature: I have reviewed this report and authorise for the information to be inputted in Ellipse.	Name: Signature: Date: 10/9/23
Guidelines for Ellipse User:	1) Required Finish Date = Report Date + Priority Timescale. 2) Work entered into Ellipse MUST be entered in as Miles and Yards (1ch = 22yds). 3) Review any [illegible] accordingly completing the audit requirements and the person authorising the changes.
Ellipse Updated by:	Date: 15/8/23

Figure 24: The SVI report of 9 August 2023 reporting a repeat occurrence of broken screws (courtesy of Network Rail with RAIB annotations).

86 Additionally, the report stated that temporary gauge tie bars had been installed as a backup, although the record of gauge tie bars (known as the tie bar register), which is a requirement of standards, was found to be incomplete. A note had been added to the report which stated '*remove tie bars*'. This may have been a reminder that the gauge tie bars were only fitted as a temporary measure. The SVI report indicates that four gauge tie bars had been installed and had been given a priority of 6 months and assigned a work order number. As with almost all the few inspection and maintenance records made available to RAIB, the work order numbers were untraceable meaning that it was not possible to identify whether work that had been planned had been undertaken.

87 Attached to this SVI report were some photographs (figure 25). Witness evidence states that these were taken at the time of this inspection. The left image shows the south end of the down line, and three gauge tie bars can clearly be seen. The centre and right images show locations with evidence of broken screws. These are at adjacent baseplate locations to those that had failed in 2020 (paragraph 77) and were in the same area as the screw failures which led to this later derailment.

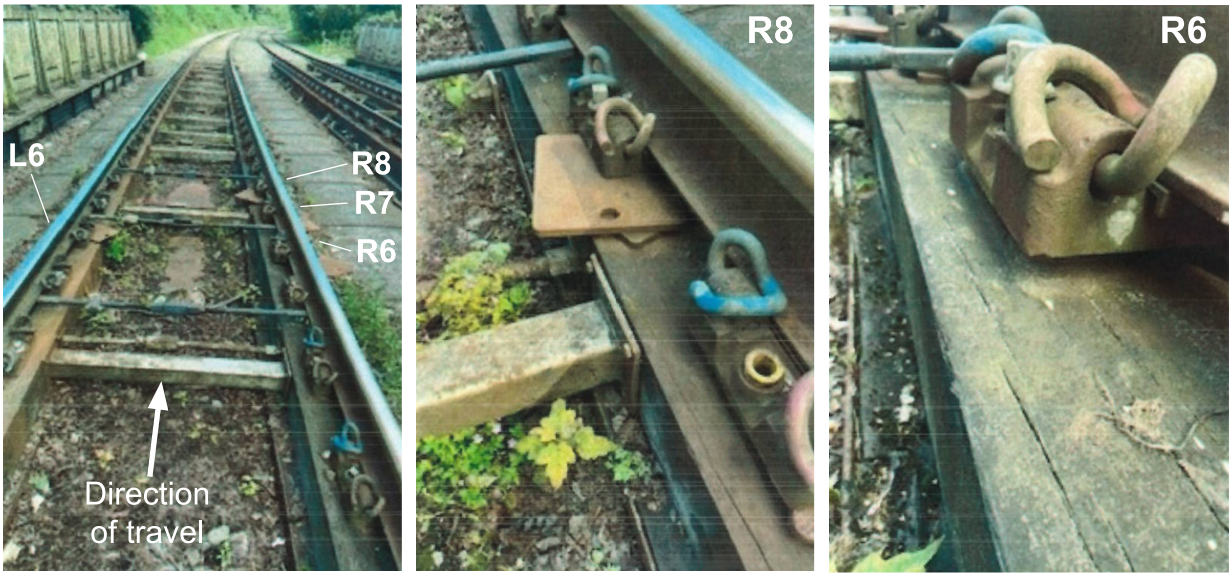


Figure 25: The down line as observed on the 9 August 2023 SVI report showing gauge tie bars fitted and displaced steel packing plates (courtesy of Network Rail with RAIB annotations).

88 The work to reinstate the condition of the track from the state recorded by the photographs would have required powered tools to drill additional holes and wrenches to tighten down the screws, as well as new screws. This is greater than the resources needed for simply undertaking the inspections. Other than the note on the SVI report, there was nothing in the records made available to RAIB showing that this task had been completed and fully reported within Ellipse.

89 Although supporting work records were not available and witness evidence from staff who were in post at this time is conflicting, post-accident metallurgical examinations show that the screws replaced at these baseplate locations during this period (that is, on or after August 2023) failed within a maximum period of 13 months.

90 Between August 2023 and the derailment in September 2024, there were repeated instances of rail clips coming loose, even though additional clips had been fitted throughout the LBS. A structures examination in April 2024 recorded that clips were again missing at the north end of the LBS (figure 26). The ringed annotations on the image were added by the structure's inspector.

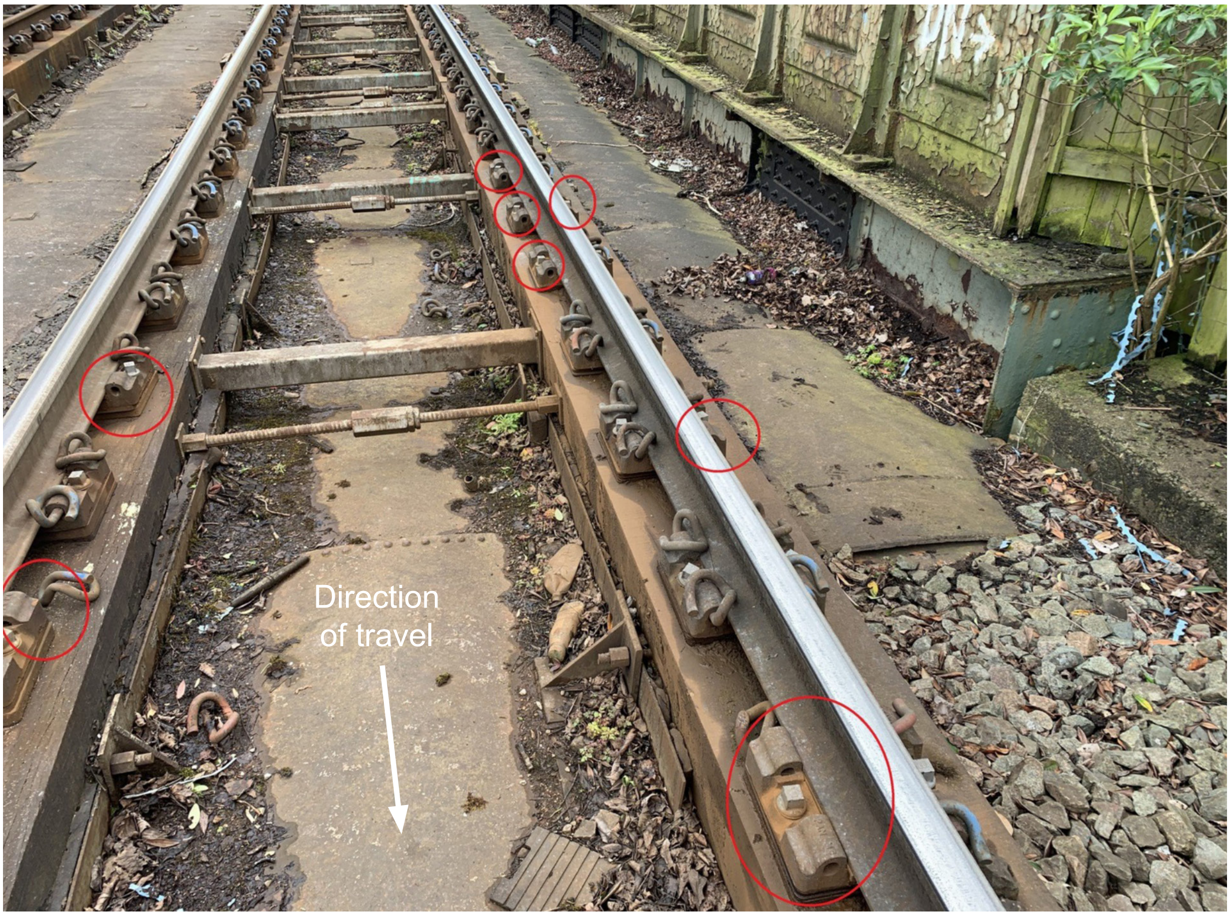


Figure 26: The LBS as observed during a bridge examination report in April 2024 showing the missing rail clips at the north end of the down line (courtesy of Network Rail with RAIB annotations).

91 Images captured by the plain line pattern recognition (PLPR) track inspection train during the last track geometry recording run on 28 August 2024 also recorded the presence of missing rail clips and the automatic pattern recognition system alerted the delivery unit to this (see paragraph 155).

92 RAIB's detailed examination of the PLPR images showed the packing pieces under baseplate R6 had possibly shifted and the screw appeared to be raised (figure 27). This image likely indicates that the screw on the field side may have been broken. However, the PLPR system is not capable of automatically detecting these failures (see paragraph 149).

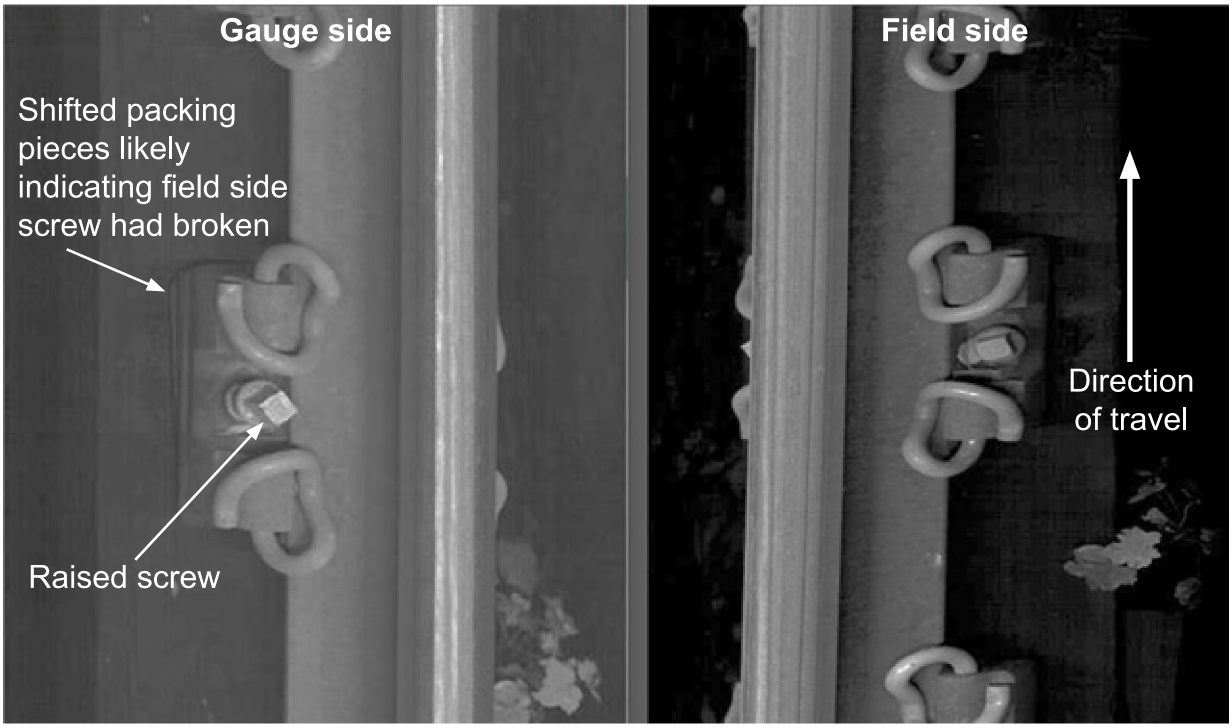


Figure 27: Baseplate R6 image from a PLPR train in August 2024 (courtesy of Network Rail with RAIB annotations).

Vehicle behaviour

93 Vehicle dynamics simulations were undertaken to understand the typical level of forces exerted on the track by freight wagons that pass over bridge 3. The computer software package VAMPIRE®, which allows a virtual model of any rail vehicle to be run over a model of the recorded track geometry, was used to estimate these forces. The model of the IIA-A/HYA-A wagon was provided by Wabtec, with track geometry files provided by Network Rail, and the wheel-rail profiles used were recorded by RAIB on site.

94 To model the track, data recorded by the track geometry recording train that had passed over the Down Crowthorne line in August 2024 was used. This provided a record of the track geometry in terms of its gauge, cant or cross-level (the difference in height between the two rails), lateral irregularity, curvature and vertical position (height). Derived signals such as dip angles and track twist were also provided.

95 To understand if this was a typical set of data and if there had been significant variation in track quality over time, 59 runs of track geometry data recorded from January 2018 to August 2024 were reviewed. The vertical position data showed that the track's vertical displacement over the bridge deck had increased over time, from less than 5 mm in 2018 to about 20 mm in 2024, indicating that the bridge had been losing vertical stiffness.

96 The gauge was found to have been historically wide across the bridge since 2018. Network Rail standard NR/L2/TRK/001 Module 11, ‘Track geometry - Inspections and minimum actions’, issue 11 dated 5 March 2022, requires that a recorded 35 mm variation in gauge width needs a correction within 36 hours, and that a 25 mm variation needs a correction within 28 days. It also defined a limit of 8 mm in gauge variation over a 3-metre length. In the year before the derailment, there had been more extensive variation in the gauge, but it was not sufficient to trigger the 36-hour correction limit (figure 28). The gauge variations within the 3-metre distance were also within limits. Periodic dip angle recordings were also evident on the entry to and exit from the bridge, suggesting that it was likely that the bridge had been moving relative to the embankments on either side.

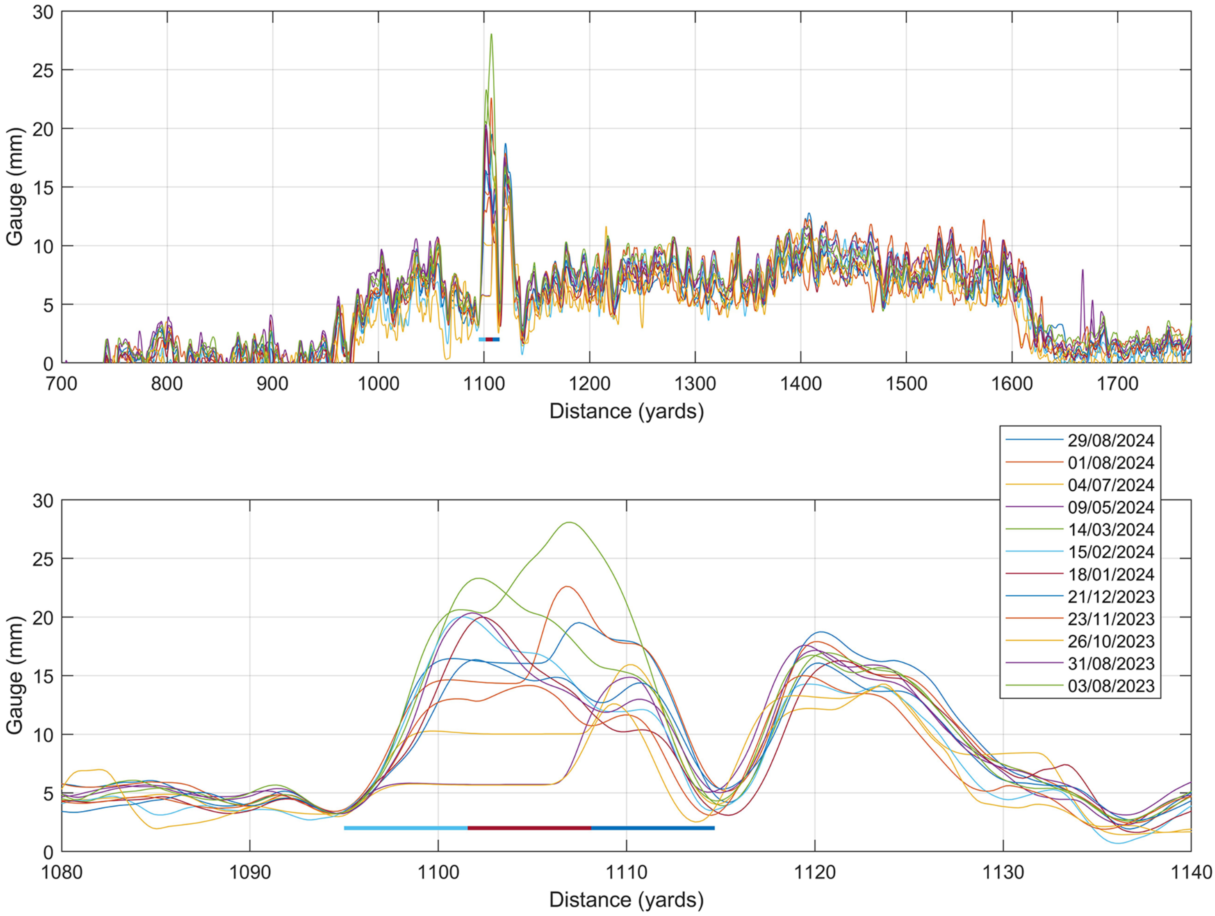


Figure 28: Gauge width variation 2023 to 2024.

97 For modelling the interaction between the wheels and the rails, the profile measurements of wheels and rails recorded at the site of the derailment were used. The wheel profiles of the leading 10 wagons and the first 6 derailed wagons were recorded where access was possible. None of the wheel profiles showed significant signs of wear and all met the requirements of Railway Group Standard GMRT2466, ‘Railway Wheelsets’, issue 5 dated 4 March 2023.

98 Various rail profiles were measured from where the plain line track transitioned onto the bridge to near the point of derailment on the LBS. Rail profiles close to the point of derailment and beyond were affected by damage during the derailment. Although some rail wear was present, all measurements were below the sidewear limit specified in Network Rail standard NR/L2/TRK/001 Module 9, ‘Loss of rail section’, issue 7 dated 2 March 2024.

99 A single wagon vehicle model was used for the simulations. It was configured to its laden condition, with a mass of 101.6 tonnes, equating to axle weights of 25.4 tonnes. The modelling used nominal friction values of 0.32 at the wheel tread and 0.16 at the wheel flange. A series of simulations were then carried out running the vehicle model over the track model.

100 Calculations undertaken by RAIB showed that the speed at which all lateral forces were neutral (otherwise known as the balancing speed) was approximately 25 mph (40 km/h). Results from the simulations showed that as the speed was reduced the leading wheelsets of each bogie were the most active in the steering of the train as it passed over the bridge.

101 The design requirements for the worst-case forces that can be exerted by a wheel on a rail are defined in Network Rail standard NR/L2/TRK/2102, ‘Design and construction of track’, issue 12 dated 3 June 2023. The maximum permitted vertical wheel force stated in the standard, due to the static and dynamic load, is 350 kN, although occasional peaks of 500 kN are permitted. The vertical forces measured during the modelling were well below these maximum values, with average values ranging from 110 to 140 kN and a maximum peak value of 157 kN due to the vehicle responding vertically to track irregularities.

102 NR/L2/TRK/2102 states that the maximum lateral force that a wheel is allowed to exert on a rail is 100 kN over a distance of 2 metres. The lateral forces measured by the modelling were on average much lower, with values ranging from 3 to 24 kN. However, the model predicted peak lateral forces in the 30 to 45 kN range that were sustained over the length of the first bearer. The largest lateral forces were exerted by the leading wheelsets and provided an outward force on each rail, attempting to spread them apart (also known as gauge spreading). The longitudinal forces from the modelling were also much less than the maximum force of 1200 kN stated in NR/L2/TRK/2102, with the average longitudinal force values at the wheels ranging from 1 to 9 kN.

103 The simulations were repeated to assess the sensitivity of the forces generated at the interface between the wheel and the rail to changes in track geometry, vehicle speed, levels of adhesion, changes to the wheel and rail profiles, and a different type of bogie. This analysis showed that none of these factors had a significant effect on the magnitude of the forces, with all the results being below the limits defined in NR/L2/TRK/2102. However, this analysis did consistently demonstrate that gauge spreading forces were cyclically loading the rail fixing systems on both outer and inner rails.

The volume of rail traffic over the bridge

104 From 2007, when the LBS was last renewed, to 2015, the railway working timetables show the planned rail traffic over the Down Crowthorne line. It consisted of up to three empty coaching stock passenger trains each day (paragraph 12), between five and ten freight trains each week carrying aggregates from the Peak District to various destinations, and occasional other freight trains which ran as required (such as for engineering works). Based on data of the trains that ran over the line during this time, Network Rail estimated that the frequency and weight of these trains led to an annual equivalent million gross tonnage (EMGT) of less than 1.

105 Network Rail used this EMGT value, along with the line's permissible speed, to classify the track on the Down Crowthorne line as category 5 track. This track category then defined, in accordance with standards, how often the local Network Rail maintenance delivery unit was required to plan and carry out its track inspections, as well as how often the track geometry needed to be measured by a track geometry recording train.

106 The working timetable from December 2014 showed a significant increase in the number of trains timetabled to run over the Down Crowthorne line. The number of empty coaching stock passenger trains each day remained at a similar level, but the line saw a large increase in the number of freight trains. While the aggregate freight traffic remained at a similar level, loaded freight trains carrying biomass fuel from Liverpool to Drax power station had begun running. The timetable showed between eight and ten of these biomass trains running each weekday, plus another five over weekends. By May 2015, further freight trains began running, carrying household waste from Liverpool and Manchester to Teesside.

107 This increase in freight traffic led to Network Rail changing the annual EMGT value for the Down Crowthorne line from the previous value of less than 1 to 11.6. This newer EMGT value changed the track category from 5 to 3, which in turn decreased the intervals between inspections that the local Network Rail maintenance delivery unit was required to plan and carry out. From 2015 to the time of the derailment, the working timetables show that the total number of freight trains scheduled to pass over the Down Crowthorne line remained around this level.

108 Overall, about 70 freight trains were timetabled over the Down Crowthorne line each week, although not all of these would have run; freight services often only operate when required. There have also been times when the number of timetabled freight trains has increased for short periods, such as when engineering trains needed to run over the line, or when freight trains were diverted from their normal routes due to line closures.

109 In March 2024, the railway line between Marple and New Mills was affected by a landslip, and it closed in June 2024. From this time until the derailment, loaded aggregate trains from Peak Forest were diverted from their planned path to run via Stockport, Denton Junction and Ashton Moss North Junction. Train running data showed these diversions meant up to six additional loaded aggregate freight trains were travelling over the Down Crowthorne line each week. This data also showed that an additional four waste trains and up to eight additional biomass trains were travelling over the line each week, instead of being routed to their timetabled path via Guide Bridge.

110 In all, this meant that up to 60 loaded freight trains were running over the bridge on the Down Crowthorne line each week in the period leading up to the derailment.

Analysis

Identification of the immediate cause

111 The track running over bridge 3 was unable to maintain the correct gauge as train 6J46 passed over it.

112 Wagon 11 in train 6J46 derailed due to the track gauge widening, because the LBS was unable to maintain the correct distance between the rails as this wagon passed over it (paragraph 40). Metallurgical examination of the broken screws (paragraph 64) showed that most had fully failed in fatigue before the passage of this train. The screws which had not fully broken, but had partially fatigued, were likely still offering some gauge retention. These would have then failed in overload under wagon 11.

113 There was no evidence of any track defects on the approach to the bridge or signs that any wagon had derailed before it reached the bridge. The first sign of damage indicating the point of derailment was between 2.4 metres and 4.8 metres beyond the transition from the ballasted track onto the LBS on the bridge.

Identification of causal factors

114 The accident occurred due to a combination of the following causal factors:

a. The LBS at bridge 3 was unable to withstand the repeated loading from trains passing over it (paragraph 115).

b. Those screws which had failed, or were failing before the passage of train 6J46, had not been detected by Network Rail's inspection regime (paragraph 142).

c. The significance of previous screw failures, which had been occurring since before 2020, was not fully appreciated by those responsible for inspecting and maintaining the LBS at bridge 3 (paragraph 183).

Each of these factors is now considered in turn.

The LBS configuration

115 The LBS at bridge 3 was unable to withstand the repeated loading from trains passing over it.

116 Evidence from the metallurgical examinations of the multiple broken screws recovered from the area close to the point of derailment indicated that they had failed due to fatigue (paragraph 64). The differences in the fracture faces show that most had failed before the train arrived at the bridge. Some screws showed existing partial fatigue followed by a final overload failure, indicating that it is probable that these finally failed under the incident train.

117 This causal factor arose due to a combination of the following:

a. The design, installation and maintenance of this LBS led to its screws being prone to fatigue failure (paragraph 118).

b. An increase in the volume of traffic on the down line over bridge 3, together with a possible contribution from changes in the bridge's vertical stiffness, had accelerated the rate of fatigue failure of the screws (paragraph 136).

Each of these factors is now considered in turn.

The LBS design, installation and maintenance

118 The design, installation and maintenance of this LBS led to its screws being prone to fatigue failure.

119 Network Rail was unable to provide RAIB with any documentation for the design of the LBS from when it was renewed in 2007. Neither was it able to provide any design assurance documentation on the fatigue performance of the baseplate assembly, including the screws. RAIB was unable to establish if this documentation was lost or if it had ever existed.

120 RAIB considered the forces exerted on the screws by the passage of train wheels using those forces found in the vehicle dynamics analysis (paragraph 102). This analysis suggested that the screws when used in this baseplate assembly do not have an infinite fatigue life (paragraph 64).

121 The baseplates fitted to the LBS on the down line were of the PAN M6 type, which have only two screws per baseplate (figure 6). More common types of baseplates used on timber sleepers and bearers across the network (for example, the NRS2 baseplate) use three or four screws. At a basic engineering level, each screw in the baseplate assembly fitted to the down line will be subjected to a higher level of stress than one fitted in a three or four screw baseplate assembly under the same track loading conditions.

122 The rail/baseplate/bearer configuration included the use of varying thicknesses of steel packing pieces between the baseplate and the bearer, with several packing pieces under most of them. The amount of packing installed under some of the baseplates exceeded the limit of 30 mm stated in Network Rail standard NR/L2/TRK/3038/03, 'Survey, design and replacement of a longitudinal bearer system', issue 2 dated 2 December 2023 (see paragraph 196).

123 Post-accident evidence and historical records show that from around 2018 onwards there had been a practice of introducing an additional two rail clips per baseplate throughout the whole length of the LBS (paragraph 83). The baseplate is made from cast iron and over time, and with repeated removals and insertion of clips, the bore of the clip's baseplate housing will wear, leading to a loss of rail foot clamping force.

124 Existing literature from the designer of the rail clip states that only one rail clip should be used on each side of the baseplate. Following the accident, it has clarified that two clips per side may be used should an additional rail foot clamping force be required.

125 The screws fitted to the LBS at the time of the accident were of the LSA type. The more common type used across the network is known as an AS screw (figure 29). The LSA screws are longer than the AS type by around 45 mm, although the shanks (the plain, unthreaded portion under the head) are of an equal length. LSA screws are manufactured from both normal and high tensile grades of steel. Examinations of the markings on the head, and metallurgical testing, showed that those fitted to the LBS were of the normal grade.

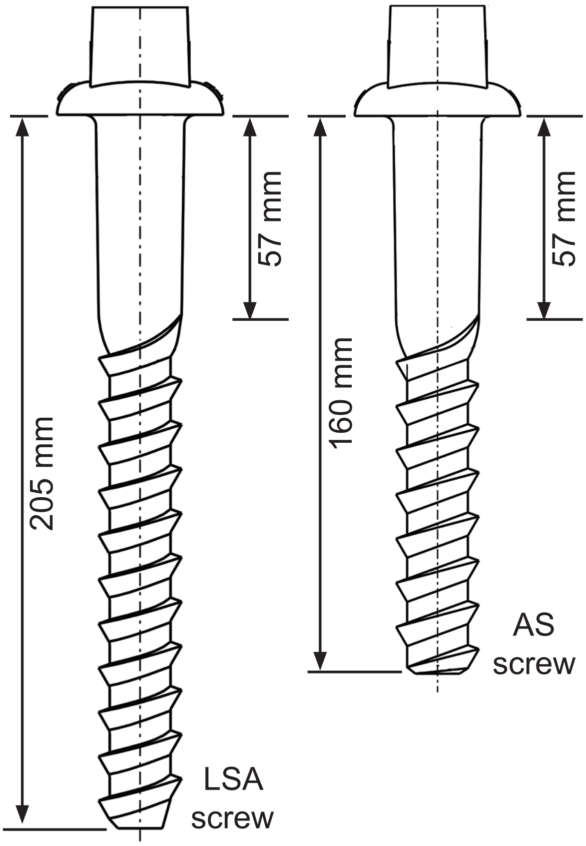


Figure 29: LSA and AS screw comparison (courtesy of Network Rail with RAIB annotations).

126 During operational service, bridge 3 and the LBS were subjected to, and were required to be capable of withstanding, the dynamic forces generated by the repeated passage of wagons weighing up to 101.6 tonnes. Modelling work found that the dynamic forces exerted on the down line by passing wagons weighing 101.6 tonnes were within the acceptable limits defined within the Network Rail standards (paragraph 101). However, despite this, the repeated dynamic forces from these passing wagons were leading to the screws failing by fatigue. While Network Rail's standards consider performance of the LBS against defined maximum dynamic forces, the standards do not directly consider the fatigue performance under repeated applications of lower forces.

127 Standard NR/L2/TRK/2102 references BS EN 13481, 'Railway applications – Track – Performance requirements for fastening systems' and BS EN 13146, 'Railway applications – Track – Test methods for fastening systems'. These collectively suggest that, for the axle loads present on bridge 3, fastening systems should be designed and tested to withstand a lateral load of 45 kN for 3 million cycles.

128 RAIB's assessment of the effect on the fatigue performance of the screws from the repeated dynamic forces applied by passing wheels on the top of the rail considered the forces in three directions (figure 30). These were:

- longitudinal – the force along the length of the rail
- vertical – the force acting directly from above through the rail
- lateral – the force acting on the rail from side to side.

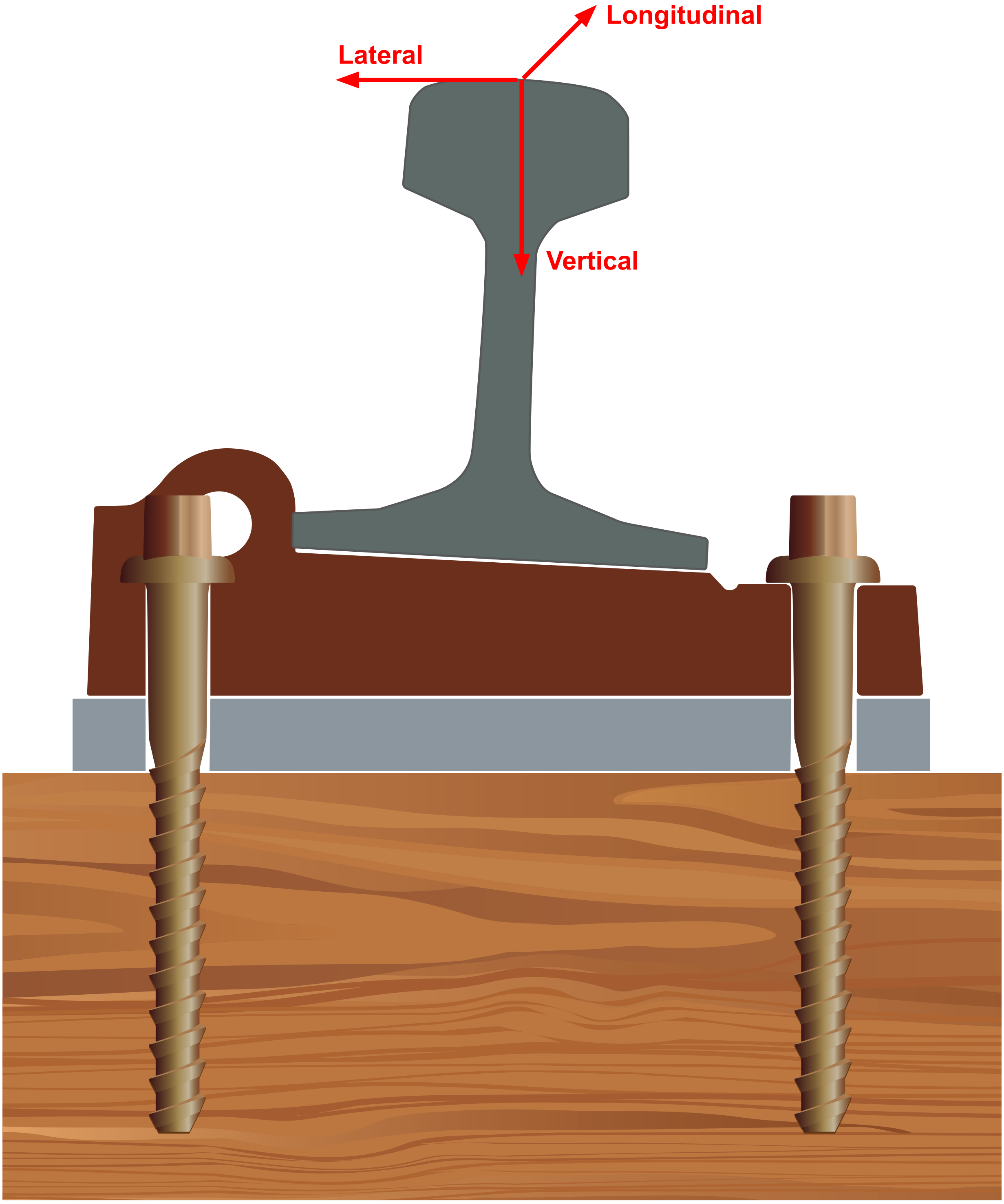


Figure 30: The effect of the forces applied by passing wheels on the top of the rail in three directions.

129 The longitudinal forces predicted by the modelling were significantly less than the maximum values permitted by the Network Rail standards and were considered as adding minimal, if any, contribution to the fatigue loading on the screws. The vertical forces were transferred directly from the rail through the baseplate, its rail pad, the steel packing pieces and into the bearer. These vertical forces also had minimal, if any, contribution to the fatigue loading on the screws, but they may help in reacting some of the lateral load applied to the baseplate assembly through friction. This was not accounted for in RAIB's assessment and probably means that the assessment underpredicts the expected life of the screws.

130 When the lateral forces on the rail were considered, it was found that these significantly loaded the screws, in both axial and shear directions (figure 30). The axial force is unlikely to create bending stresses in the screws, as witnessed in the failed screws (paragraph 64), whereas the shear force will. In the assessment, the shear force was applied to the screw at a plane level with the underside of the baseplate. This shear force leads to increasing bending stresses in the screw along its length up to the point where the threaded part of the screw is firmly embedded in the bearer.

131 RAIB carried out a simple fatigue assessment of the screws by calculating the bending stresses created by the shear force and determining the damage (that is, the weakening of the component) created by one application of load. The results were then used to estimate the expected life of a screw before it fully failed in fatigue. This initial assessment considered the LSA screw to be of normal grade rather than the high tensile type, as this grade of screw was fitted on the LBS at the time of the accident (paragraph 24). The loading condition was taken as a 40 kN lateral force at the top of the rail, applied by two axles from each wagon in a twenty-wagon long train, with five of these trains passing over the bridge daily.

132 The assessment considered the baseplate to be secured to the bearer by two LSA screws (one each side), and with 20 mm of steel packing pieces under the baseplate. The assessment found that the predicted number of cycles before the screw failed in fatigue was between 0.3 and 0.6 million, depending on the ultimate tensile strength of the screw material within the range for its grade. This gave a predicted life of between 4 and 8 years based on the number of trains, wagons and axles at the level of lateral force considered. While the fatigue assessment carried out by RAIB has limitations due to the assumptions used, it nevertheless shows that the screws should not be expected to have an infinite fatigue life. This finding is confirmed by the history of repeated screw failures through fatigue that this investigation has identified.

133 The assessment was then repeated to understand the sensitivity of the results to changes in:

- the screw's material between normal or high tensile grades
- the value of the lateral load at the top of rail, which was varied from 25 to 55 kN
- the thickness of the steel packing pieces under the baseplate, ranging from 12 to 34 mm thick (as measured on site).

134 The main finding was that the expected life is strongly dependent on the thickness of packing pieces under the baseplate. The effect of the total thickness of the baseplate packing pieces and how this affects the fatigue failure of the screw is illustrated in figure 31. This shows that, as the thickness of the steel packing pieces increases, the point at which the lateral force acts on the screw moves from the larger diameter shank to the smaller diameter threaded section. All the broken screws examined afterwards were found to have broken through their threaded section, just below the upper surface of the bearer (paragraph 63).

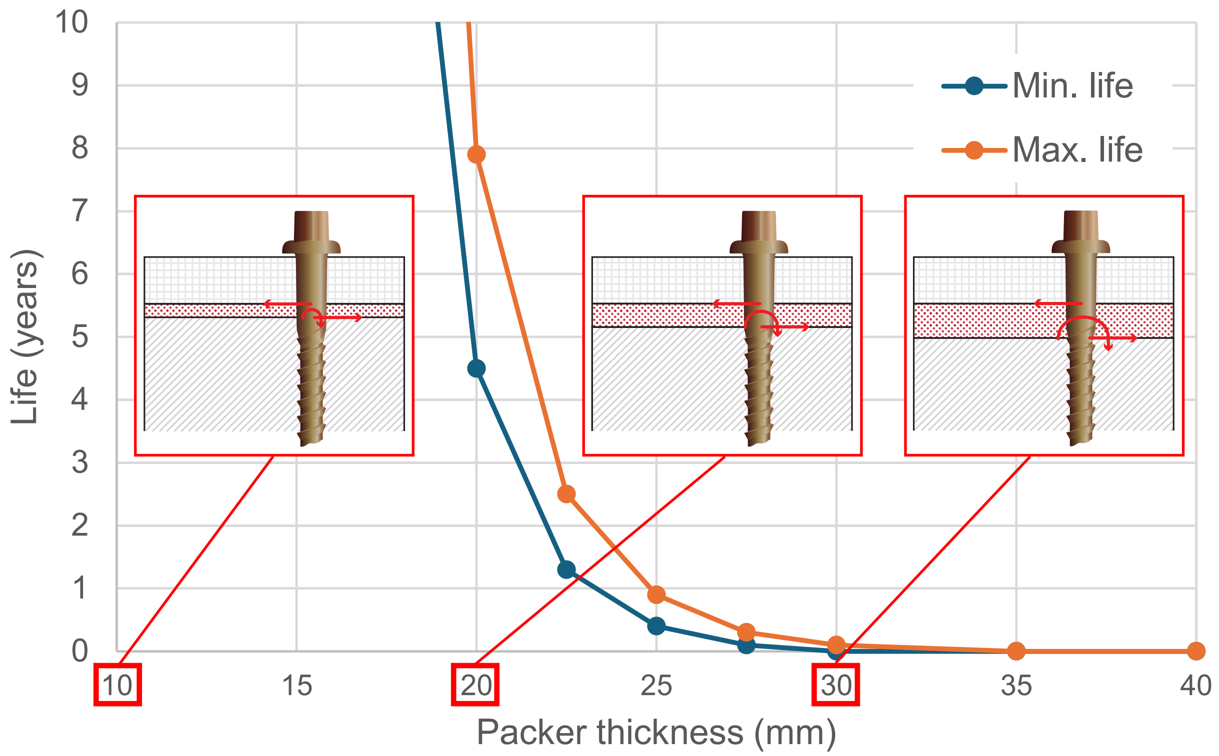


Figure 31: The effect of the steel packing thickness on the fatigue failure of the screws.

135 There may be other factors involved with how, and at what rate, the screws failed in fatigue, such as the way they were installed. For example, the depth of the holes drilled in the bearer may have contributed to the stress levels seen by the screws. There is a requirement in Network Rail standard NR/L2/TRK/029, 'Wood sleepers, bearers and longitudinal timbers', issue 6 dated 5 March 2023, to drill the hole 30 mm deeper than the installed screw depth (see paragraph 205). However, RAIB's examination of the bearers after the accident found some holes had not been drilled sufficiently deep to receive the length of screw subsequently installed (paragraph 69).

Rate of degradation

136 An increase in the volume of traffic on the down line over bridge 3, together with a possible contribution from changes in the bridge's vertical stiffness, had accelerated the rate of fatigue failure of the screws.

137 The volume of freight traffic running on the Down Crowthorne line over bridge 3 from when it was first installed in 2007 up until 2015 was low (paragraph 104). However, freight traffic increased significantly from 2015 onwards, with more than a tenfold increase in the EMGT (paragraphs 106 and 107).

138 The screw fatigue sensitivity analysis also considered the increase in freight traffic passing over the LBS (figure 32). As the fatigue failure of a screw is related to the number of cycles it is subjected to, increasing or decreasing the number of trains changes the rate of crack propagation, and therefore the duration over which a screw would suffer fatigue crack growth before eventual failure.

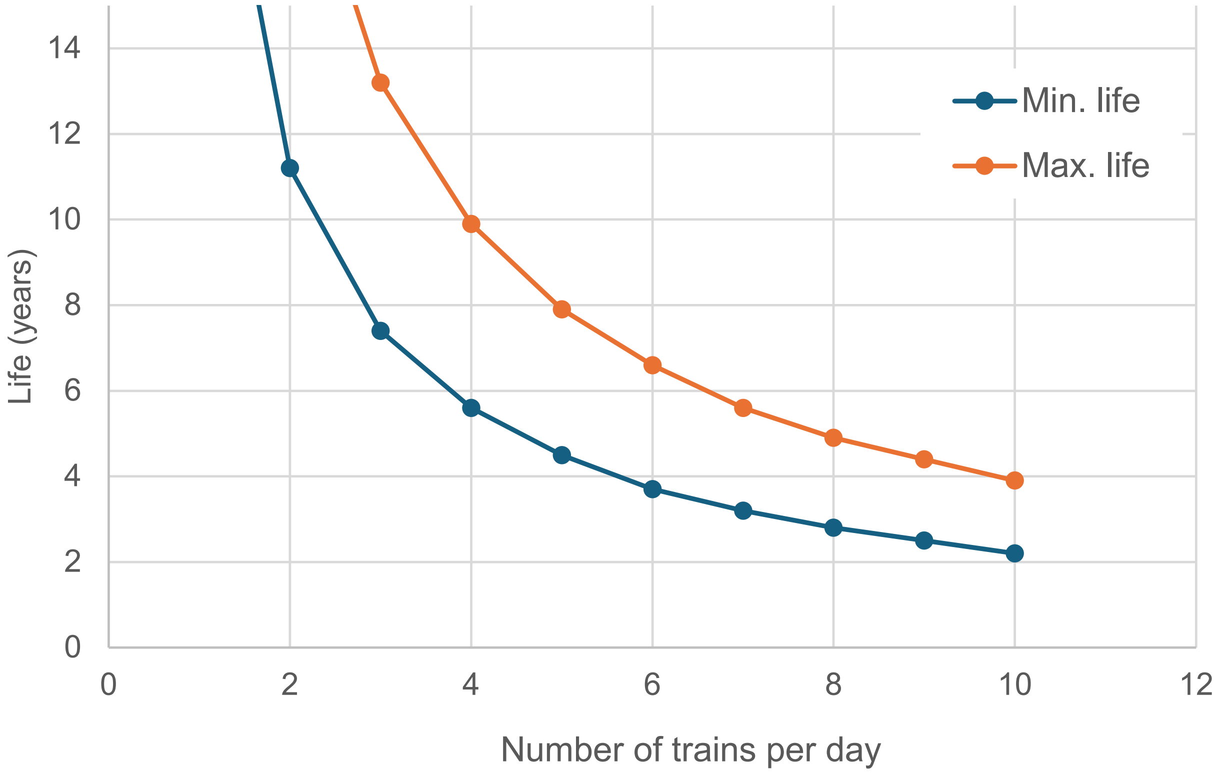


Figure 32: Graph showing how the number of trains affects the time before a screw would fail due to fatigue.

139 With a single daily train, the assessment showed that a screw of normal grade material was predicted to fail in fatigue after around 20 to 40 years. This decreased to about 7 to 14 years for three trains daily and to about 2 to 4 years for 10 trains daily. Screws of the high tensile grade performed better but followed a similar pattern.

140 Based on the number of freight trains running over the LBS in the weeks before the derailment (paragraph 109), this analysis showed that the screws were likely to be failing in about 2 to 4 years when fitted with 20 mm of packing under the baseplates.

141 It is noticeable that the bridge's vertical stiffness changed (paragraph 95) over the period that the traffic increased. For ease of simulation, the change in the bridge's vertical stiffness was not included in the dynamics simulations (paragraph 93) but it is possible that this also increased the rate of screw fatigue.

LBS inspection and maintenance regime

142 Those screws which had failed, or were failing before the passage of train 6J46, had not been detected by Network Rail's inspection regime.

143 Metallurgical examinations of the broken screws showed that all had experienced fatigue failures to some degree, with some fully failing before the passage of the train (paragraph 64). The variation in the aged appearance of the fracture faces of the upper portions of screws and the fatigue fracture marks indicate that they had failed at different times and at different rates, indicating that they had seen different levels of loading.

144 Screws that were partially fractured and which were adjacent to those that had fully broken would have experienced a subsequent increase in load, with a comparative increase in the rate of fatigue crack growth. Some of the screws that failed are known to have been in place for as little as 13 months (paragraph 89). It is very likely that some of the screws close to those that had been found to have failed following the derailment, but which had not been replaced in August 2023, were experiencing fatigue crack growth at that time.

145 The integrity of the track when broken screws were found during both the December 2020 structures examination (paragraph 77) and the August 2023 track inspection visit was at a stage approaching a derailment condition. These occurrences, and the September 2024 derailment, show that the regime of detecting screw failures before they reached this condition was not effective.

146 Fatigue cracks within materials can only practically be detected by very close examination and specialist equipment or techniques. In this type of installation, a very close examination would be impractical as it would require screws to be removed, as the location of any partial fatigue failures is below the upper surface of the bearers and under the baseplate. General good engineering practice is that components subjected to cyclic loading, that are not going to be inspected or periodically replaced, are designed to have an infinite fatigue life.

147 Once a screw has broken, it may not be visually detectable unless its upper portion has been either fully, or partially displaced from its hole in the baseplate. During the disassembly of the LBS section removed from site, RAIB found that some screws had broken, but their upper portions remained in position due to being held in place within the ferrule. At a few locations, the upper portions of broken screws were held tightly in place, and a spanner was required to remove them from the baseplates (paragraph 62).

148 This causal factor arose due to a combination of the following:

a. Regular measurement train track geometry recording runs, including the use of the PLPR process, were not capable of reliably detecting this type of failure (paragraph 149).

b. Manual inspections of the LBS had not identified the need to replace the screws (paragraph 159).

Each of these factors is now considered in turn.

Track geometry measurements and the PLPR system

149 Regular measurement train track geometry recording runs, including the use of the PLPR process, were not capable of reliably detecting this type of failure.

150 For track within category 3 (paragraph 107), Network Rail standard NR/L2/TRK/001, ‘Inspection and maintenance of permanent way’, issue 24 dated 2 March 2024, requires an automated track geometry recording together with an automated visual inspection by a track geometry measurement / PLPR train every 4 weeks.

151 The PLPR system is used by Network Rail to detect and report certain types of rail-related faults by automatically pattern matching the images recorded by its cameras. The PLPR system is able to identify where rail clips are missing or partially retracted, as well as rail and welded joint defects present in the track.

152 Records show that automated track geometry recording runs were taking place at the required frequencies. The last track geometry recording from the measurement train fitted with the PLPR system ran over this line on 28 August 2024. The recorded track geometry data did not exceed any of the thresholds, as defined in standard NR/L2/TRK/001, needed to trigger immediate action by the Manchester delivery unit.

153 The measurements of track gauge during that run over the LBS were in some places between 16 and 19 mm greater than the design gauge value of 1435 mm. While exceeding 1450 mm in places is an alert limit in NR/L2/TRK/001, none of the gauge measurements were above 1460 mm which, for the category 3 track, requires maintenance action to be taken within 14 days.

154 Records show that automated inspections by PLPR trains were taking place at the required frequencies. In a similar manner to the reporting of exceedances within track geometry, any defects identified are automatically generated and reported to the maintenance delivery unit responsible for the track section to be actioned. However, PLPR is not configured to identify missing or displaced screws, nor displaced steel packing pieces.

155 The report from the PLPR run in August 2024 was sent to the Manchester delivery unit. The report stated that there were multiple ineffective rail clips. This fault was given a timescale of 1 month to be rectified. These clips, along with notifications of potential gauge and rail level defects, were around the centre and north end of the LBS. Those at the north end of the LBS were around the location where ineffective clips had been previously found and reported over many years (paragraphs 76 and 90).

156 All the monthly PLPR inspection reports since February 2024 showed similar repeat findings at the north end of the LBS. The PLPR reports from February and March 2024 also showed that consecutive rail clips were missing at the south end of the bridge. However, these findings were not reported in the PLPR run of the following month. This indicates that it was likely that there was activity to replace the displaced rail clips between the March and April runs, although this was not recorded in Ellipse.

157 RAIB examination of the detailed images captured by the cameras of the PLPR system 9 days before the accident revealed missing and raised screws (figure 27), along with the missing rail clips which had been reported by the system (figure 33). From this, and considering the aged condition of the screw fracture faces, it is very likely that some of the screws were already broken 9 days before the derailment.

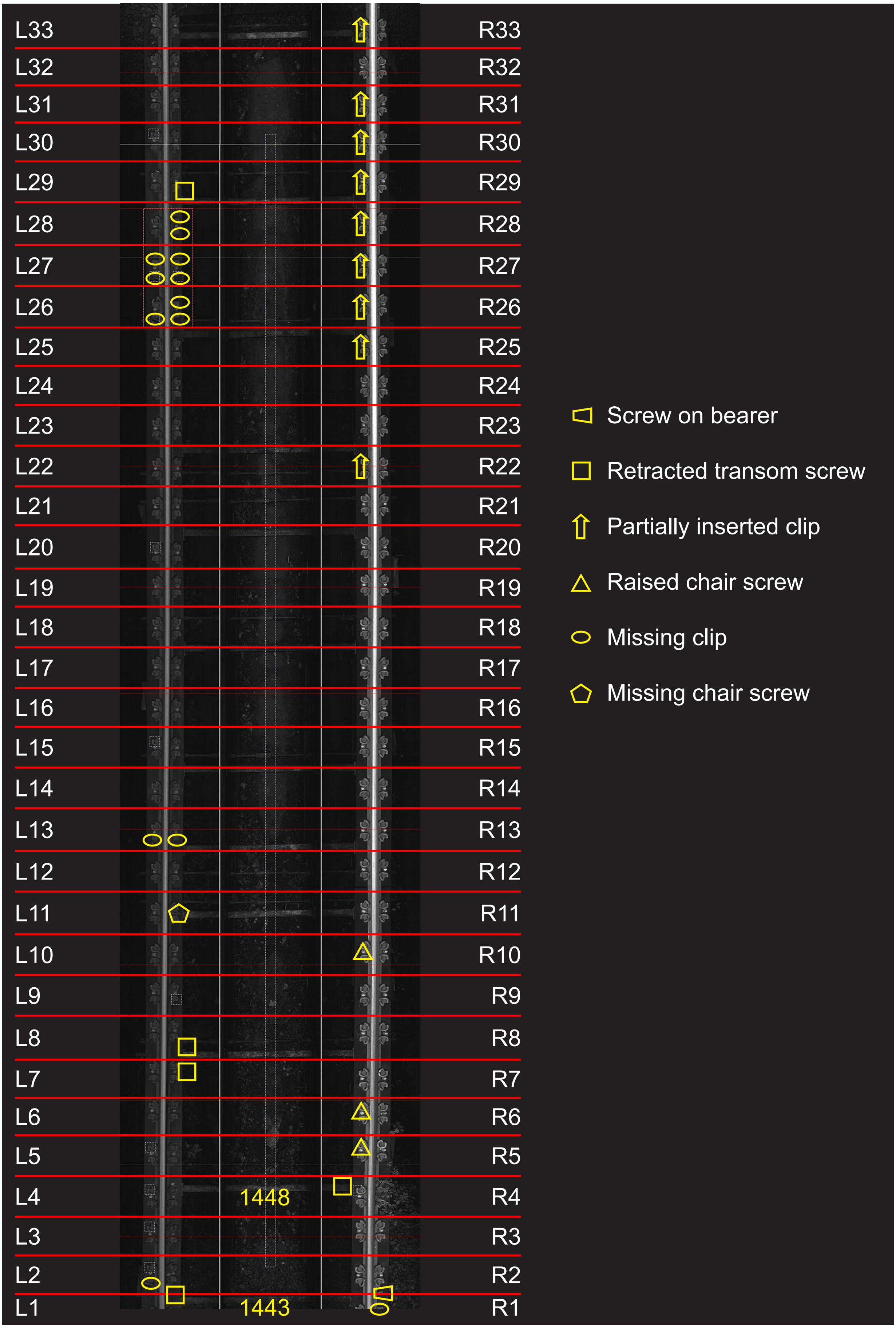


Figure 33: Composite of the full LBS using images from PLPR (courtesy of Network Rail with RAIB annotations).

158 It may be possible to configure the track geometry measurements over a structure to report at a lower alert limit value of track gauge. It may also be possible to configure the PLPR system to identify signs that screws have broken. However, this would be at a stage at which screw failures would have already occurred. This is not a safe or reliable means of identifying these failures as a precursor of an oncoming derailment condition, as the rate at which fatigue failures will occur over the number of baseplates sufficient to lead to a derailment condition would be very difficult to predict.

Manual LBS inspections

159 Manual inspections of the LBS had not identified the need to replace the screws.

160 Basic visual inspections by track patrollers have been replaced by PLPR. Visual inspections were non-intrusive inspections covering the whole length of the section being walked. In common with the identification of broken screws by detailed examination of the PLPR images, failures would only be detectable in practical terms if screws or steel packing pieces were seen to be displaced from their correct locations. This means that the LBS could be in a condition at which derailment could shortly occur, as was the case in December 2020 and August 2023.

161 For track within category 3 (paragraph 107), Network Rail standard NR/L2/TRK/001 also requires an SVI by an SM(T) once every 16 weeks, with the LBS requiring a detailed longitudinal bearer supervisor visual inspection by an SM(T) annually. The LBS was also subject to an engineer visual inspection by a TME every 2 years.

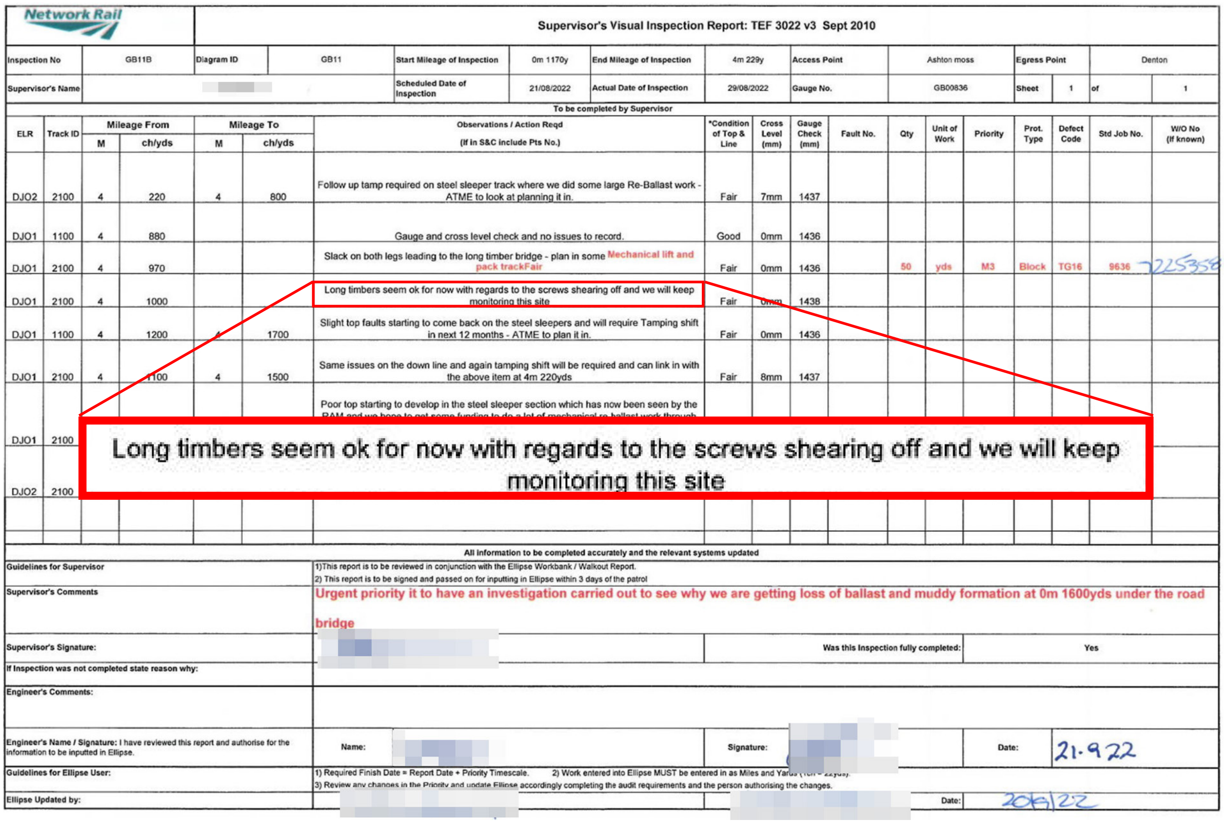
162 These inspections are visual only and no tools are carried that would enable the checking of the integrity of screws. Preparation ahead of these inspections requires that a walkout report is reviewed together with a review of the most recent track geometry recording trace. The walkout report is generated from Network Rail's Ellipse system and enables the SM(T) or TME to consider previous inspection findings and planned work order items in the asset to be inspected.

163 Much of the evidence relating to the inspection and maintenance activities on the LBS before mid-2022 was not available to RAIB because of the way the track team at the depot was using and maintaining its asset tracking and management systems (see paragraph 247).

164 The earliest relevant record available was from August 2016. The section manager at that time reported that there was voiding under the ballasted sleepers at each end of the bridge. The TME at that time noted on the printout of the track geometry trace that the bearers and the bridge were moving under rail traffic. The report states that additional ballast was added to those track sections and that the migration of ballast would be monitored. This supports the view that bridge movements were likely affecting the track (paragraph 141).

165 Ellipse work records suggest that gauge tie bars may have been fitted to the LBS on the down line in July 2021 and July 2023 in response to track geometry measurements reporting the gauge to be in excess of 1460 mm. However, the tie bar register, which is a document required by standards for recording where and when they have been fitted, did not confirm this. It is a requirement of Network Rail's standards that temporary gauge tie bars are not fitted to track for a period greater than 6 months. This is to ensure that the faults leading to the wide track gauge geometry are corrected within this timescale.

166 In August 2022 an inspection was undertaken by SM(T)2. An observation in the associated SVI report stated that '*Long timbers seem OK for now with regards to the screws shearing off and we will keep monitoring this site*' (figure 34). This is the first record available identifying screw failures by the track team. It may be a reference to the previous screw failures when gauge tie bars were possibly fitted in July 2021. However, evidence from other earlier structure examination reports (paragraph 77), together with the broken screw parts found in the sectioned bearers (paragraph 79), suggest that this is not likely to be reporting the first occurrence of screws breaking.



Network Rail

Supervisor's Visual Inspection Report: TEF 3022 v3 Sept 2010

Inspection No	GB11B	Diagram ID	GB11	Start Mileage of Inspection	0m 1170y	End Mileage of Inspection	4m 229y
Access Point	Ashton moss	Egress Point	Denton				
Supervisor's Name		Scheduled Date of Inspection	21/08/2022	Actual Date of Inspection	29/08/2022	Gauge No.	GB00836
Sheet	1	of	1				

To be completed by Supervisor

ELR	Track ID	Mileage From M	Mileage From ch/yds	Mileage To M	Mileage To ch/yds	Observations / Action Reqd (If in S&C include Pts No.)	*Condition of Top & Line	Cross Level (mm)	Gauge Check (mm)	Fault No.	Qty	Unit of Work	Priority	Prot. Type	Defect Code	Std Job No.	W/O No (If known)
DJO2	2100	4	220	4	800	Follow up tamp required on steel sleeper track where we did some large Re-Ballast work - ATME to look at planning it in.	Fair	7mm	1437								
DJO1	1100	4	880			Gauge and cross level check and no issues to record.	Good	0mm	1436								
DJO1	2100	4	970			Slack on both legs leading to the long timber bridge - plan in some Mechanical lift and pack trackFair	Fair	0mm	1436		50	yds	M3	Block	TG16	9636	7225358
DJO1	2100	4	1000			Long timbers seem ok for now with regards to the screws shearing off and we will keep monitoring this site	Fair	0mm	1438								
DJO1	1100	4	1200	4	1700	Slight top faults starting to come back on the steel sleepers and will require Tamping shift in next 12 months - ATME to plan it in.	Fair	0mm	1436								
DJO1	2100	4	1100	4	1500	Same issues on the down line and again tamping shift will be required and can link in with the above item at 4m 220yds	Fair	8mm	1437								
DJO1	2100					Poor top starting to develop in the steel sleeper section which has now been seen by the											
DJO2	2100																

All information to be completed accurately and the relevant systems updated

Guidelines for Supervisor	1)This report is to be reviewed in conjunction with the Ellipse Workbank / Walkout Report. 2) This report is to be signed and passed on for inputting in Ellipse within 3 days of the patrol
Supervisor's Comments	Urgent priority it to have an investigation carried out to see why we are getting loss of ballast and muddy formation at 0m 1600yds under the road bridge
Supervisor's Signature:	Was this Inspection fully completed: Yes
If Inspection was not completed state reason why:	
Engineer's Comments:	
Engineer's Name / Signature: I have reviewed this report and authorise for the information to be inputted in Ellipse.	Name: Signature: Date: 21.9.22
Guidelines for Ellipse User:	1) Required Finish Date = Report Date + Priority Timescale. 2) Work entered into Ellipse MUST be entered in as Miles and Yards 3) Review any changes in the Priority and update Ellipse accordingly completing the audit requirements and the person authorising the changes.
Ellipse Updated by:	Date: 20/9/22

Figure 34: The SVI report of August 2022 reporting an occurrence of broken screws (courtesy of Network Rail with RAIB annotations).

167 This SVI report was signed off by TME2 in September 2022 and shows that there was an awareness at a management level that screws on the LBS had been breaking. There is no evidence that this issue was examined further or elevated within the route's organisation so that an understanding of the reasons for the screw failures could be sought.

168 In May 2023, TME1 conducted an engineer visual examination over this track section which included both LBSs on the up and down lines on bridge 3. Evidence that this examination had taken place was recorded in Ellipse, but RAIB was advised that the detailed report made as a result of the examination had been lost. Subsequent Ellipse work entries related only to replacing the AS screws with LSA screws, although only on the up line.

169 RAIB was provided with a partially completed work order document for planned activity on 26 July 2023. The work order records the findings from a track recording run on 6 July 2023 which showed that the gauge was over 27 mm wide at the south end of the down line on the LBS. The action stated was to fit four gauge tie bars. As before, there were no further details of this within the tie bar register, but there was an associated entry in the Ellipse system dated 13 July 2023. Although it could not be ascertained whether this related to screw failures at that time, there is an entry stating that the track gauge be reset and that the distance over which gauge ties bars were added be increased to 20 yards (which is the approximate length of the full down line on bridge 3). It was signed as being entered into the Ellipse system and also signed by SM(T)2 and TME1. Despite this, no subsequent associated records in Ellipse were available to indicate whether this work had been completed.

170 Network Rail measures track quality over an 1/8th mile section of track using a standard deviation (SD) value. The SD is rated from good to very poor using colour-coded quality bands. The worst quality band is called ‘maximum’ and is commonly known as a ‘super-red’. The July 2023 track recording run showed the track quality level for the 1/8th mile section which included bridge 3 to be in the super-red category. There is a requirement in standard NR/L2/TRK/001 to conduct an inspection on a super-red section within 14 days. This track section had been in the very poor or worse bands for its track level (known as ‘top’) for at least the previous 12 months. This led to SM(T)2 creating a planned new super-red inspection report. The date on which this planned work was entered into Ellipse was 8 March 2023, with a completion date of 8 August 2023.

171 The related inspection is recorded as having taken place, although SM(T)2 did not record a completion date on the form. It noted that the track ‘*had lacked being tamped in the past few years*’ and that the ‘*trigger point*’ for the super-red was in the area of the bridge and on the LBS, having a high point at the start. The report recommended manual repairs and to follow up with tamping within 6 months. It was given a works order number, signed off as being entered into the planning system in August 2023 and signed by TME1 in September 2023. No records were available to show if this work had been carried out before the derailment, and tamping alone would not have fully corrected the geometry of the track leading up to and over the bridge.

172 Documents indicate that an SVI on the track section and an SVI for the LBS took place on 9 August 2023 (paragraph 85). The SVI report was signed by SM(T)2 and the LBS SVI by one of the section supervisors. The SVI report stated that ‘*screws have again sheared off long timber bridge and steel packs under base plates had come out giving 15 mm of voiding – Replaced during the SVI block handed back – Tie bars installed as back up*’. There was an additional comment in red text ‘*Remove tie bars*’ and that four gauge tie bars had been fitted with a priority of 6 months.

173 The section supervisor who completed the LBS SVI forms was present during the inspection. Witness and photographic evidence indicate that at that time the gauge tie bars were in place. The static gauge measurements they recorded were up to 1455 mm. The SVI document made available to RAIB shows a comment made by the section supervisor stating that '*Fortnightly inspections be imposed due to screws snapping over long timber bridge*'. Witness evidence indicates that this may have been a later addition to the document, after it had been signed off. Relationships between the track staff at Guide Bridge depot were described by witnesses as strained, and RAIB cannot ascertain whose account of the findings of this inspection is the correct one.

174 Attached to this report were several photographs (figure 25). These showed that some screws had broken, and the steel packing pieces had become displaced under some of the baseplates. RAIB was unable to determine whether the gauge tie bars had been added before, or following, the inspection's finding that screws had broken. There is a requirement in standard NR/L2/TRK/3038 to conduct special inspections every 7 days on LBSs where gauge tie bars are fitted. The SVI report was signed by the TME in September 2023. No work records exist to show what inspections were planned, nor any work done to reinstate the track's condition.

175 By February 2024, SM(T)2 had been replaced in their post by a temporary track section manager, SM(T)1. SM(T)1 undertook an inspection of the LBS on 13 February 2024, around 7 months before the derailment. The static gauge measurements were all within allowable limits. The sole observation was that the track's cross level was less than the design value of 40 mm and that the baseplate packings required some work to correct the level of the track. SM(T)1 expected from the records within the walkout report to have found temporary gauge tie bars present, but none were there. There were no records available, including in the tie bar register, to show when the gauge tie bars fitted in August 2023, or possibly in July 2023, had been removed. Comparison of the gauge and cross level values recorded during this February 2024 inspection and those from August 2023 show differences which cannot be explained unless either one set of measurements was incorrectly taken or recorded, or there was unreported significant work done to correct the cross level.

176 The SVI report of the track section inspected by SM(T)1, conducted on the same day, recommended that work be planned to correct both the track gauge and alignment of the down line over the LBS. The timescale planned for this work was within 6 months. This, and the LBS inspection report, were signed by TME1 and work order numbers were created.

177 On 15 June 2024, just under 3 months before the derailment, SM(T)1 completed a supervisor inspection of the track section as well as both the basic and the annual detailed inspection of the LBS on the down line at bridge 3. Following both LBS inspections, no new work was proposed nor observations made, other than recording that displaced rail clips had been reinserted during the inspection. Static gauge and cross level limits were recorded, and these were similar to those that had been measured in the February 2024 inspection.

178 The detailed LBS inspection did not identify any signs of broken screws or baseplate movements and the conditions of other components, including the bearers, were rated to be in good condition. The baseplate steel packing thicknesses were all reported to be less than 30 mm. No observations were made of the deflected steel strip on the left-hand side of the first section of the LBS, present since 2020, or the broken vertical restraint rod, likely broken by that time (paragraph 59).

179 As in the February 2024 report, SM(T)1 recommended that work be planned to correct both the track gauge and alignment on the down line over the LBS. The associated walkout report showed the previous work order for this task had been cancelled and a new one created. These reports were reviewed and signed by TME1 in July 2024. The original proposed completion date was August 2024, but there is no evidence that this work had been completed by the time of the derailment.

180 SM(T)1 told RAIB that they were unaware of the history of the down line over the LBS, including the repeated screw failures. A typical sign of gauge widening, which is associated with screw failures and commonly observed during track inspections where softwood timber is used as a sleeper or bearer, is the presence of ‘shuffle’. This is the indentation and movement of a baseplate across the timber’s surface creating visible marks. During RAIB examinations of the LBS, it was noted that there were few signs of shuffle at the baseplate locations known to have experienced screw failures. This is likely due to both the hardness of the hardwood bearer’s surface compared to softwood, and that any gauge widening movement results in slippage of the baseplate over the steel packing pieces, or slippage of the packing pieces over themselves.

181 A requirement within standard NR/L2/TRK/3038 is that the LBS be observed under load during SVI visits unless alternative arrangements have been recorded in the longitudinal bearer management plan (LBMP). The LBMP is a document required by this standard (see paragraph 226). The requirement is marked as amber in the standard to indicate that it is not mandatory, and that variations from it are ‘*permitted subject to approved risk analysis and mitigation*’.

182 Some LBMP documents were provided to RAIB and one, dated 2014, states that the annual detailed inspection carried out will include observation from the cess of the long timbers under traffic, although there is no evidence that this was regular practice. Witnesses have told RAIB that, as well as the difficulties of gaining access to the track while trains are running, such observations add little value as only one rail of each line can be viewed at a time, and more information can be found from looking at the track geometry traces. However, some senior track engineers at Network Rail stated to RAIB that they thought that observing the LBS under traffic was an important part of the inspection process.

Response to the history of broken screws

183 The significance of previous screw failures, which had been occurring since before 2020, was not fully appreciated by those responsible for inspecting and maintaining the LBS at bridge 3.

184 RAIB found evidence from its examinations and within the limited records available that there was a history of screw failures over many years at the same baseplate locations on the LBS and that repeated interventions to replace broken screws had taken place. RAIB also found that staff responsible for the management of the safety and quality of the track were aware of these.

185 Network Rail standard NR/L3/TRK/1015, 'Management of basic visual inspection', issue 8 dated 4 March 2023, states that a track section manager shall evaluate the root cause of repeat defects and initiate remedial action and, if necessary, mitigation measures to protect the safety of trains. However, although there is witness evidence and some limited documentary evidence showing that repeated failures were known about and reported to the track management team, no further action was taken to address the underlying issue. This is discussed in more detail in paragraph 218.

186 The lack of attention to the repeated screw failures was probably due to both the poor local record keeping practice (see paragraph 251), and a loss of continuity of knowledge about the problem. There were numerous staffing changes, including the role of TME. Staff in key roles, such as the TME and SM(T) , changed in 2023 (paragraphs 31 and 32) and the handover between the TMEs was limited.

187 The configuration and construction of LBS track is different from the more common plain line track. LBS track includes different components, such as longitudinal timbers and packing pieces. The way in which they are supported and restrained (such as being fixed relative to a structure) means that there is less flexibility in repositioning the track than is available with track on ballast.

188 Forces from passing trains transmitted through the components and assemblies on LBSs are also reacted differently to those on ballasted plain line track because of the difference in track support conditions. The behaviour and changes in the supporting structure's condition (in this case bridge 3) will additionally affect the way in which the LBS components behave. The transition areas at each end of an LBS track section leading from, and to, the ballasted track can also give rise to levelling and alignment issues.

189 RAIB found that there was a general lack of understanding at the Manchester delivery unit about LBS assets. All the witnesses within the unit who were, or had been, responsible for LBS inspection and maintenance, showed an incomplete knowledge of the requirements of the standards covering the management of LBS assets, some of which are bespoke to this system. This incomplete knowledge, and the way in which the failures and deficiencies in the LBS had been inspected, recorded and actioned, reflects on the competency of the staff involved (see paragraph 223).

Identification of underlying factors

Background to underlying factors

190 The governing standard for LBS assets is NR/L2/TRK/3038 (paragraph 122). This standard refers to many other standards to provide guidance on managing these assets (figure 35).

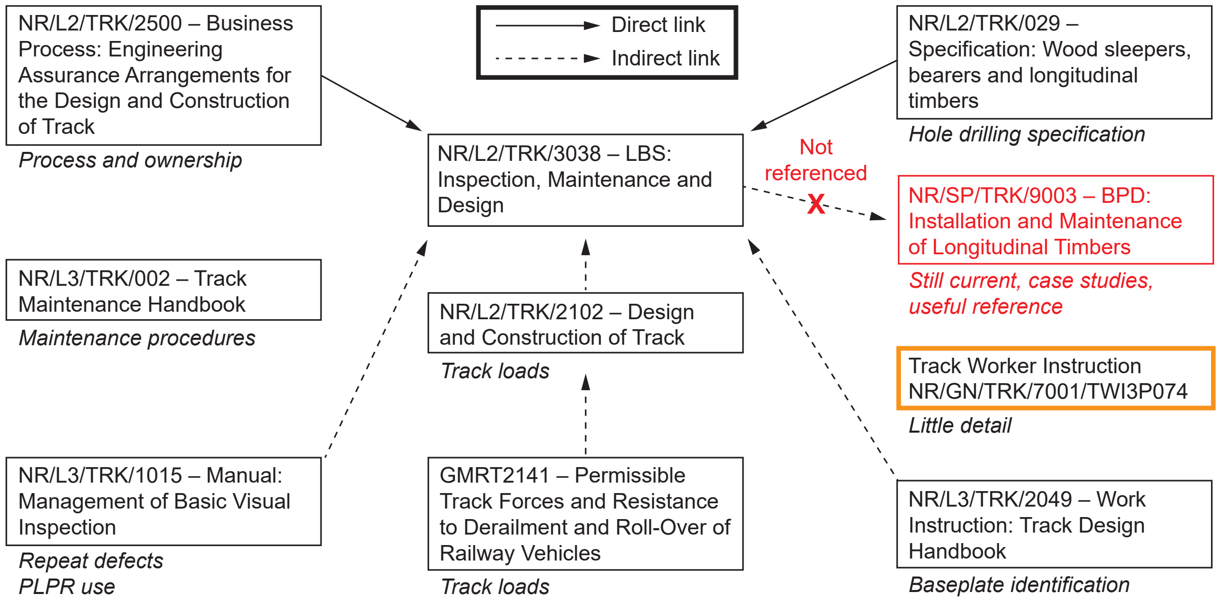


Figure 35: Network Rail standards relationship for LBS assets.

Management of LBS assets

191 Network Rail did not have effective processes for managing LBS assets.

192 RAIB's investigation has found a range of issues with how Network Rail was managing LBS assets, including the one over bridge 3. These are considered under the following four main topic areas:

- Network Rail's design assurance for LBS assets to withstand both proof and fatigue loading (paragraph 193)
- Network Rail's management of LBS assets from specification and installation to inspection and maintenance (paragraph 199)
- the competence of the Network Rail staff responsible for the inspection and maintenance of LBS assets (paragraph 222)
- the Network Rail interdisciplinary interfaces needed to jointly manage LBS assets and their supporting structures (paragraph 225).

Each of these areas is now considered in turn.

Engineering design assurance

193 The investigation has found that there had been repeated failures of screws on this LBS over several years. Some of the screws that had failed in fatigue had only been installed for around 13 months. RAIB calculated that the screws in the LBS at bridge 3 do not have an infinite life under repetitive loading from lateral forces of a lesser magnitude than the maximum dynamic lateral force defined in NR/L2/TRK/2102 (paragraph 132).

194 The investigation examined the engineering design processes Network Rail had in place to assure that its LBS assets were able to withstand the maximum loads consistent with their operational requirements and achieve the required service life under normal operating conditions. The maximum dynamic loads an LBS must be able to withstand are defined in NR/L2/TRK/2102 (paragraph 101), referred to in NR/L2/TRK/3038. However, when Network Rail was asked about how the baseplate configuration fitted to the LBS on bridge 3 had been assessed to achieve the required service life under normal operating conditions, it was unable to provide any evidence that such an assessment had been undertaken.

195 RAIB's analysis also found that the total thickness of the steel packing pieces under the baseplate assembly has a great influence on the behaviour of fatigue failures in the screws (paragraph 134). It indicated that a normal grade screw would fail in fatigue under the loading considered with a thickness of 20 mm or greater. The current version of NR/L2/TRK/3038 states the maximum thickness of packing to be 30 mm.

196 Network Rail told RAIB that the maximum thickness of 30 mm defined in NR/L2/TRK/3038 was introduced in March 2011 in issue 5 of the standard. No technical evidence was provided to RAIB to assure this maximum value, and Network Rail told RAIB that this was determined using engineering judgement at the time.

197 The current version of NR/L2/TRK/3038 (issue 8) does not mention any fatigue assessment. Issue 1, dated February 2000, through to issue 6, dated September 2014, did reference fatigue, but it was in the context of evaluating the expected service life of the bearers. The standard stated that bearers were usually certified to have a minimum service life of 40 years unless an alternative period was agreed when the LBS design was approved. There is no mention of fatigue assessment of other LBS components. Network Rail standard NR/L2/TRK/2102 refers to BS EN 13481 and BS EN 13146 (paragraph 127) which describe the fatigue tests that track components must withstand. Network Rail was unable to provide RAIB with evidence to show that the track components fitted to the LBS on bridge 3, complete with the 30 mm of packing allowed in standards, had been tested to demonstrate compliance with those standards.

198 The above demonstrates that Network Rail did not have a process, either by testing or calculation, for assessing the fatigue performance of the various components within different LBS configurations. Therefore, it did not know what the screw's performance would be under fatigue conditions on the LBS configuration at bridge 3. Neither were there any engineering assessments to support, and assure, the prescribing of screw lengths, their grades, the number of screws required for each baseplate, nor an assured technical assessment of the maximum limit of the thickness of baseplate packing.

LBS asset management

199 RAIB examined the processes that Network Rail had in place for the management of its LBS assets from their design configuration, specification and installation through to their inspection and maintenance.

Design configuration, specification and installation

200 Network Rail was unable to provide evidence to show that it had assured both the component parts, the configuration of the assembly and the overall management of the specification and installation of the LBS on the Down Crowthorne line over bridge 3.

201 NR/L2/TRK/3038 does not mention or prescribe any baseplate types suitable for LBSs. PAN M6 baseplates are within a table in NR/L3/TRK/2049, but only regarding which rail clips and rail pads are to be used with them. Some staff in the track team believed that they could substitute baseplates with any other approved type that were contained within standards.

202 NR/L2/TRK/3038 states that screws shall be of suitable length, and longer screws should be considered when the baseplate packing is greater than 10 mm, but it does not specifically mention either the AS or LSA screw, nor any specific screw dimensions.

203 NR/L2/TRK/3038 references standard NR/L2/TRK/029, 'Wood sleepers, bearers and longitudinal timbers', issue 6 dated 5 March 2022. NR/L2/TRK/029 mentions only the shorter AS screw and not the LSA type. Neither does it mention the different grades of screw. NR/L2/TRK/3038 has an amber requirement that a high tensile grade be used for hardwood bearers. All the broken screws recovered following the accident were found to be of the normal grade and almost all the witnesses interviewed by RAIB were unaware of this requirement. Staff who had enquired about the high tensile grade of screw following the accident found that there were supply issues with obtaining it.

204 Following the derailment, Network Rail has acknowledged this omission and noted that clearer guidance on component selection for an LBS, including screw lengths and their compatibility with baseplates, could be provided. Network Rail also acknowledged that this information would support the consistent application of component types within LBS assets on its infrastructure.

205 Hole drilling depths for screws are specified within NR/L2/TRK/029. Although only AS screws are mentioned, Network Rail told RAIB that the specification also applies for LSA screws. It states that the hole should be drilled to a depth of 30 mm greater than the screw's penetration depth and be 19 mm in diameter for hardwood. It also states that for hardwood the hole should be counterbored to 25 mm diameter for a maximum depth of 25 mm. Although RAIB was unable to discern whether the holes had been counterbored, the examination of the bearer sections showed locations where an insufficient depth of hole had been drilled (paragraph 69).

206 These examinations also revealed the proximity of adjacent holes to one another under the baseplate positions. Many of them were close to interfering with an existing adjacent hole. Issue 6 of NR/L2/TRK/3038 (dated 2014 and superseded in March 2020) stated a requirement for a minimum distance of 75 mm to be maintained between adjacent screw holes. It is not known why this was removed from the standard, but this requirement is within Network Rail's track work instruction 2G064, 'How to regauge plain line', version 1 dated March 2005, which is still current.

207 There is a requirement in standard NR/L2/TRK/3038 (both in current and historical issues) to have the centres of adjacent baseplates no further than 600 mm apart. RAIB examinations found that the baseplates were at approximately this spacing. However, the spacing requirement would be unable to be met if new holes for replacement screws were separated by the 75 mm stated in the track work instruction, likely requiring baseplate repositioning and regauging over the whole length of the LBS.

208 RAIB found that the common practice was to replace an LBS on a like-for-like basis, with broadly similar components and construction decided by those charged with providing the new LBS. Occasionally, this task was undertaken by staff within a local delivery unit, but it was mostly done by a Network Rail projects team. Standard NR/L2/TRK/3038 refers to standard NR/L2/TRK/2500, 'Engineering assurance arrangements for the design and construction of track', which was first issued in 2005. This business process document defines the way in which track is assured and controlled. This entails design approval (approval in principle), detailed design (specification of components), acceptance (checking) and manufacturing/construction stages of new, or replacement track, outside the scope of day-to-day maintenance activities. RAIB was unable to determine whether this process had been followed for the LBS replacement on bridge 3 in 2007, as Network Rail told RAIB that no documents were available to demonstrate this.

209 NR/SP/TRK/9003, 'Installation and maintenance of longitudinal timbers', issue 1 dated 3 December 2005, is a Network Rail business process document. Within it are examples of different design configurations, including some details of where LBS components and assemblies have failed in the past. One case study is an installation in 1997 of an LBS on King George V bridge over the River Trent at Althorpe. The way in which the longitudinal bearers were placed on top of a base comprising timber packing and bitumen has similarities to the down line at bridge 3.

210 It was found that within 6 months of being installed there was a degradation in the track quality. The bedding layer under the bearers was not stable due to the bitumen remaining partially fluid (figure 36). It was removed around a year later and the replacement installation used a resin as an alternative to bitumen. Comparing this figure with figure 21, it can be seen that the lessons of the poor bedding layer of a bitumen base and timber packing leading to slippage following the first installation at Althorpe were not apparently taken account of by those installing the LBS at bridge 3, if they had been aware of them.

211 NR/SP/TRK/9003 contains useful information and guidance on LBSs which is not within NR/L2/TRK/3038. Network Rail stated that NR/SP/TRK/9003 should be read in conjunction with NR/L2/TRK/3038 although it is not referred to in the latter document. NR/SP/TRK/9003 was available to Network Rail staff when the LBS over bridge 3 was designed and installed in 2007. Network Rail aimed to withdraw NR/SP/TRK/9003 and to incorporate its relevant guidance into track work instructions when it reissued NR/L2/TRK/3038 in 2020. However, this had not been done by the time of the accident and NR/SP/TRK/9003 has still not formally been withdrawn.

Figure 36: Failed 1997 LBS installation at Althorpe (from business process document NR/SP/TRK/9003 courtesy of Network Rail).

212 Network Rail advised RAIB that its processes dictate that it would be a competent designer who decides which components are used in an LBS design, following relevant design and construction standards. It was unclear whether any of these standards provided guidance on what component to use in what situation, for example, when considering the expected loading from passing trains and its potential impact on the service life of the LBS. Network Rail acknowledged it did not have any published data or formal engineering calculations available for the different types of components used in an LBS. Therefore, there was no documentation to assist a designer with assuring that the components they chose were suitable for a particular LBS design.

Inspection

213 Inspections conducted by the track geometry and PLPR trains are unable to detect and output alerts for fractured or missing screws on an LBS. The PLPR system is also not configured to identify where steel packing pieces have become displaced (paragraph 92).

214 Inspections by track geometry recording trains have the same alert thresholds for measured gauge defects on LBS assets as for plain line track. The output from track geometry recording runs, as viewed by track maintenance staff, is usually in the form of a trace, with the data for each track geometry channel shown against distance. These traces should be reviewed by the TME as part of their role to monitor the status of the track geometry in their area. Witness evidence indicates that these trace reviews were not being routinely undertaken in the past. When TME1 took on the role in May 2023, it was found that the LBS supervisor inspections were not being done at the required frequencies.

215 However, if only the traces are used to monitor change of the gauge over the LBS above the alert threshold, then the level of detail provided by them is probably insufficient to identify a significant change. By the time a widening of gauge has been detected, it is likely that the screws on several consecutive baseplates would have broken and an unsafe condition already been reached.

216 The regular planned inspections by the track team had not detected that screws had failed or were failing due to fatigue before the accident (paragraph 159). As the screws were breaking below the baseplate, these failures were not detectable by visual means unless either the screw or the steel packing pieces under the baseplate became displaced. There were no signs of baseplate shuffle during the more recent visual inspections to indicate that the baseplates had been moving back and forth under load in the past (paragraph 180). The only reliable method of detecting a broken screw is checking it manually with a hand tool. This was not a mandated requirement. This could only realistically be done annually during the LBS detailed inspection, but it is unlikely that the staff carrying out these inspections would check every screw.

217 Several defects or deficiencies with the LBS were found after the derailment. These included a broken vertical restraint rod, missing or decayed wedges that fit between the bearers and cleats, a missing cleat, baseplates that were fitted with additional rail clips, and signs that the wooden packing under the bearers was slipping. There was no evidence that the visual inspection regime had identified and recorded any of these defects.

218 The repetitive defects occurring at the LBS were also not being identified and recorded by the inspection regime. NR/L3/TRK/1015, which covers basic visual inspections (paragraph 185), defines a repeat defect as one which has previously been reported and repaired, but has reappeared. It states that the SM(T) shall evaluate the root cause of a repeat defect. The SM(T) should then initiate appropriate remedial action and, if necessary, mitigating measures to protect the safety of trains.

219 Network Rail acknowledged that there is no mandated process for doing this, with repeat defects managed locally. It relies on an SM(T) using their judgement to determine when further technical input is required. This could involve getting support to review information, or by arranging for more detailed examinations to take place to identify why a defect keeps happening. Additionally, Network Rail expected an SM(T) to escalate repeat defects to their TME to ensure there was appropriate engineering oversight and appropriate risk-based decision-making taking place. There is evidence that indicates the issue of repeat screw failures had been escalated, but no further action was taken. This is discussed further in paragraph 247.

Maintenance

220 Multiple holes in the LBS bearers showed that the track team was repairing repeat screw failures (paragraph 67). There were many mentions of missing wedges and loose or missing rail clips in structures examination reports (paragraphs 75 and 82). There was also evidence that maintenance staff had reacted to the repeated missing rail clips by doubling up the number of track clips at each baseplate (paragraph 83). However, RAIB found no evidence that anyone was examining why these defects kept occurring.

221 Calculations by RAIB found that doubling the number of rail clips increased the likelihood of a screw failing in fatigue. The addition of rail clips increased the load on the screws, which in turn reduced the time before the screws were likely to fail in fatigue. This highlighted how the reasons for the screw failures were not understood by the track team, showing how the processes being followed to manage this LBS asset were ineffective.

Staff competence

222 The evidence examined by RAIB as part of this investigation found a number of instances where the requirements of standards and good practice had not been followed by the staff within the track team at Guide Bridge depot who were responsible for inspection and maintenance of the LBS on bridge 3. These include:

- the use of the wrong grade of screw with hardwood bearers and evidence that screws different to those prescribed by standards had previously been used
- incorrect practices followed when drilling holes in the bearers, with holes not drilled to a sufficient depth and too close to existing holes
- doubling the number of rail clips at each baseplate, which had become custom and practice, although this action was not documented in Network Rail standards
- not correctly recording the presence of temporary gauge tie bars and conducting follow up inspections and remedial works
- the LBS bearers being wrongly recorded in documentation as being softwood timber
- SVIs taking place every 24 weeks before 2023, rather than at the required 16-week interval, and so not reflecting the change in track category due to the increase in rail traffic
- no evidence of the review and updating of the LBMPs since 2018
- repeat defects not being escalated beyond the local management for further investigation.

223 Network Rail has a training and competency module for the inspection of LBSs as part of its supervisor inspection training. Some of the staff within the track team held this competency having undergone the training many years previously. However, Network Rail does not have any training, or a staff specific competence, for the installation or maintenance of its LBS assets. Witness evidence from track staff working at all levels within the maintenance delivery unit indicated that there was a general lack of competency in the skills needed to inspect and maintain LBSs within the track team at Guide Bridge depot.

224 RAIB found omissions in Network Rail standards related to the maintenance of LBS assets. NR/L2/TRK/3038 does not contain all the necessary information to define the configurations of components for LBS assets to allow staff to be able to manage an LBS correctly. Similarly, its supporting track work instruction also lacks this and other specific details. It was noted that NR/L2/TRK/001 has dedicated modules for many types of track related assets such as switches and crossings, rail joints, adjustment switches and buffer stops, but there is no dedicated module for the correct management of LBS assets for staff to refer to.

Interfaces between asset management disciplines

225 Network Rail maintains a register for all its LBS assets. Information in the register includes the location, the year of installation, and the type of timber used, but it contains no details of baseplate type, screws nor ancillary components. It was noted that the LBS on the down line of bridge 3 had been recorded in the register as being constructed using softwood rather than hardwood bearers. This was still the case in December 2024 despite Network Rail completing a special nationwide inspection of all LBS assets in 2020 and updating the register (see paragraph 241).

Longitudinal Bearer Management Plans

226 The nature of an LBS fitted on a structure, such as a bridge, means that different disciplines within Network Rail need to jointly manage the LBS and its supporting structure (paragraph 50). NR/L2/TRK/3038 requires that a plan (known as an LBMP, paragraph 181) be produced for each structure supporting one or more LBS. Its purpose is to record decisions taken and be a source of information and requirements relating to the configuration, inspection, maintenance and replacement of the LBS. Another purpose is to record any co-operative working arrangements between the two asset disciplines which deal with a structure (that is, track and structures). A single LBMP may be produced for a structure which supports more than one LBS (for example, a bridge may carry an up and down line), if the LBS constructions are similar and the inspection requirements for each are the same. RAIB found that this was the sole formal way in which the track and structures disciplines co-operated on LBS asset management.

227 The TME is responsible for the production of an LBMP for each of those assets in their area. It is to be reviewed by the responsible engineers for track, known as principal route engineers (PREs) at route level. It is required to be reviewed, and revised if necessary, following every detailed LBS examination by the TME and the SM(T). The review should take account of the findings from inspections and examinations, recent maintenance or replacement activities, any comments made by the PREs, and the effect of recent or future changes in operational use.

228 RAIB requested all the LBMPs for bridge 3. Some LBMPs were made available to RAIB, but these did not cover the whole period of this LBS installation. The earliest was dated 2007 and had been updated with information from the SM(T) in post at that time. The photographic image within it suggests that it was produced following the LBS renewal on the down line which took place that year. The plan records inspection dates in 2005 and 2006, which would have been conducted on the previous installation. There is one recorded inspection in 2007. It records the bearers as being made from softwood timber.

229 The record of the 2007 inspection was partially complete and had not been signed off, but it defined the maintenance tasks for the LBS components. This included tightening rail fastenings and wedges by the track patroller at a weekly frequency. The interface between the LBS and the bridge is stated to be the cleats, and their owner and the responsibility for their inspection and maintenance is stated as the territory civils engineer (a territory was an earlier form of geographic division, and civils was the previous title of the current structures discipline).

230 An LBMP from 2014/2015 was signed by SM(T)2, the then TME, and the PREs (at that time known as route asset managers) for both the track and structures disciplines. The plan contained a track geometry trace dated 2013. Subsequent annual reviews were signed by the TME in 2016, 2017 and 2018. The plan stated that annual visual inspections by both disciplines would be jointly undertaken where possible and the LBS be inspected under traffic from the safe cess. There is no further evidence to show that these actions were done.

231 The 2014/2015 LBMP again incorrectly recorded the timber type of the bearers as softwood, which was also an uncorrected error in the LBS asset register. It marked changes to the track/structures interface, altering the responsibility for the cleats from the structures discipline to the track discipline. Structures had recorded that in 2012 the bridge required steelwork repairs and that there were fractures to the substructure. There were no updates to the plan, nor records of maintenance activities by the track staff. It incorrectly recorded that there was no holding down system fitted to the LBS. It further recorded that the way in which the security of components be tested during inspections and following remedial work be by visual assessment and by use of a wrench respectively.

232 There was no evidence that the LBMP for bridge 3 was updated and reviewed between 2018 and 2024. There was also no evidence that the LBMP was reviewed following the increase in traffic levels around 2015 and the associated change of track category over the LBS (paragraphs 106 to 107). RAIB found that Network Rail did not have any assurance processes in place to check that LBMPs were being updated and signed off in accordance with its standards. Some witnesses indicated that staff saw little value in the LBMPs as a way of jointly managing these assets.

233 RAIB examined a maintenance plan created by SM(T)1 and dated 15 February 2024. Although this document is dated 2 days after the supervisor LBS inspection (paragraph 175), it contained a track geometry trace dated August 2024, which was 6 months after the date on the document and was the date of the most recent geometry run before the derailment. It had not been signed off by SM(T)1, TME1, nor by the track or structures PREs by the time of the accident.

234 The template for the plan (TEF3279) had been updated and required more detailed information to be recorded than the version in use before 2020. It recorded the bearers to be hardwood and the baseplate type as PAN M6, but it did not contain any information relating to temporary gauge tie bars being added since the last review, nor broken screws. Neither did it state the work planned to address the geometry issues identified by SM(T)1 in February 2024, and again in June 2024 (paragraphs 176 and 179).

235 RAIB found little evidence that, in the years leading up to the accident, there was technical or assurance oversight by the track PRE and the infrastructure maintenance engineer. This included an apparent lack of involvement to ensure that an up-to-date LBMP was in place for the LBS over bridge 3. The track PRE should provide the delivery unit with expert technical advice, leadership, and support for track related matters. The infrastructure maintenance engineer is the senior manager responsible for leading and directing the maintenance delivery unit in carrying out the inspection and maintenance on all infrastructure assets to meet relevant standards.

236 The track and structures disciplines within Network Rail routes operate in different organisational ways. The track staff are based within the maintenance delivery unit in depots local to the track asset areas that they are responsible for. The structures staff are centrally based and are responsible for all the structures within a Network Rail route.

237 Staff from the structures discipline who carried out examinations of bridge 3 had recorded instances of track component failures in their structures asset management system, which is a different system to Ellipse used for the management of track. The recorded component failures included missing wedges in September 2019, numerous track related defects in July 2022, rotten wedges in October 2023 and missing track clips in May 2024. Their visit in December 2020 found the track to be in a state close to that which would lead to a derailment (paragraph 77).

238 Some of the track related defects identified were recorded within the structures asset management system and assigned an action to inform the TME of them. While there is evidence from the structures system that this was done on some occasions, there is no equivalent record available from the track asset management system to show that this was received. Some witnesses told RAIB that some instances were reported by phone calls and that it was sometimes difficult to identify who to report the inspection findings to because of staff changes.

239 Staff within the track discipline were not made aware of how the condition of bridge 3 was degrading and how this might be affecting the track geometry or performance of the LBS. The structures discipline knew that there was movement at the northern abutment of bridge 3 under load, with the bridge deck deflecting as trains passed over it (paragraph 141). However, the track discipline staff, being unaware of this, could not take it into account when considering any increased inspection or proactive maintenance activity to ensure the quality and safety of the track. This further indicates that the combined assets of bridge 3 and LBS were not being managed collectively by the two disciplines.

240 RAIB also found no evidence of any joint visits by the two disciplines. Witnesses from both disciplines acknowledged that communications between the track and structures disciplines for LBS assets were ad hoc, not documented, and needed to be better.

Special inspection notices

241 In addition to the routine inspection regime in place at the time, Network Rail had issued a special inspection notice (SIN), number 196, in 2020. This was in response to derailments and incidents involving its LBS assets, where the subsequent investigations had highlighted inadequacies in how it was managing them. The purpose of SIN 196 was for Network Rail to understand the existing risk level of its LBS assets, prioritise tactile inspections of those with the highest risk, plan to manage the risk and to provide assurance that the risk of these assets was being '*reduced to as low a level as possible*'.

242 The inspection for SIN 196 for the LBS over bridge 3 was closed out by TME2 on 16 June 2021. TME2 reported that the LBS had the potential to get '*worse than anticipated*', although the inspection document incorrectly referred to the Up Crowthorne line being on the loaded route for freight traffic to Drax power station, whereas the loaded route was the down line. The closure of SIN 196 also required an update to the LBMP to be undertaken, but RAIB found no evidence that this had been done (paragraph 232).

243 There are 226 track sections supported by LBSs across the North West and Central region. In May 2025, Network Rail told RAIB that all LBS assets had an LBMP, but that only 70 of these had been signed off by the PREs of both disciplines. The required sign off of the remaining LBMPs was completed by the end of June 2025.

244 In December 2024, following the derailment, Network Rail issued another special inspection notice, SIN 220. The scope of this was to undertake detailed, tactile inspections nationally on LBS assets with hardwood bearers on curves where the track radius was less than 800 metres. It required the checking and recording of the quantity of baseplate packing, the type of screw fitted and presence of broken screws. On the North West route, there was a total of 34 LBSs in the scope of this SIN. Its inspections found:

- 30 were not fitted with high tensile grade screws
- 21 had a baseplate packing thickness of between 10 and 30 mm
- 3 had a baseplate packing thickness greater than 30 mm
- 21 were fitted with two screw baseplates (which was not an inspection and reporting requirement of SIN 220).

245 From the 198 LBSs inspected nationally by the end of February 2025, the findings were:

- 182 did not have LSA screws throughout, with 160 having a mixture of LSA and AS screws
- 160 did not have high tensile grade screws throughout
- 95 had a baseplate packing thickness of 10 mm or greater, with 21 of these having a thickness greater than 30 mm.

246 The tactile tests found that 12 LBSs had defective screws which were either loose or broken. On one LBS, with 360 screws in total, 40 defective screws were found. This indicates that the asset management of LBSs is an issue with the potential to affect the whole network.

Network Rail assurance of the work of the local track team

247 The Guide Bridge track team responsible for the LBS at bridge 3 neither correctly recorded nor reported previous screw failures, and this was not identified nor corrected by Network Rail's assurance regime over a period of years.

248 Despite at least three maintenance interventions over several years to replace broken screws at the same baseplates (paragraph 67), no one within the maintenance delivery unit had planned or carried out work to investigate the cause of the failures to find a solution. The only records found which provided information about broken screws were the SVI reports from inspections in August 2022 and August 2023 (paragraphs 166 and 172).

249 Witness evidence indicated that the previous SM(T), SM(T)2, had made both TME2 and then TME1 aware of the repeated screw failures after carrying out their SVIs at the LBS. TME2 had signed off the record for the supervisor inspection record for August 2022 which contained a reference to ongoing work to monitor for broken screws. TME1 had signed off the supervisor inspection record for August 2023 and has stated that this was the only occasion that they were made aware of instances of broken screws on the LBS. This record included a reference to broken screws being found again on the LBS. It also mentioned that baseplate packing pieces had become dislodged. This entry referred to these defects being addressed during the inspection. However, there is no record on Ellipse of the findings from these inspections, nor of any corrective actions that were taken.

250 Apart from the planned maintenance activity, proposed in February 2024 and then again in June 2024, there is also no evidence of any further actions to address the track geometry quality, nor elevate or investigate the repeat failures. Also, none of this information, nor any from the earlier instances of broken screws, was recorded in any of the LBMPs for this LBS. The photographs and track related issues within the reports from the examinations by the structures staff were not readily available to track staff, but neither were they requested.

251 At the time of the derailment, TME1 had been in post for about 17 months (paragraph 31). There had only been a two-week overlap with TME2 for a handover. TME1 soon discovered that Ellipse did not contain the expected records of track inspection and maintenance activities. The LBS inspection frequency was still that for the lower, pre-2015, track category (paragraph 107). This led to a mistrust of the quality and accuracy of the information within Ellipse by TME1 and SM(T)1 and the decision was made to make a '*fresh start*' with the Ellipse system being '*cleansed*' of some of the past records. Witness evidence indicates that this involved removing open works orders following reviews by competent persons over a cycle of inspections with consideration of the assets' conditions.

252 Before the appointment of TME1, there had been limited intervention by previous TMEs and other senior managers within the delivery unit to check what practices were taking place and recorded within this track maintenance section, including checks on the competencies and capabilities of the staff carrying out the work. Network Rail carried out its own investigation into this derailment, and its investigation found issues with the competencies held by track staff at the depot. Although some staff held certain competencies, the Network Rail investigation found that these staff were not capable of doing those tasks.

253 The change of TME caused friction within the track team, and there were some staff with supervisory grades in the Guide Bridge track team disciplined in August and September 2023.

254 Taken together, these might help explain why Network Rail was unable to provide a complete set of track inspection and maintenance records for work carried out by the Guide Bridge depot track team to RAIB following the accident. It was only after the derailment that Network Rail identified that inspection and maintenance work by the depot was not being recorded correctly in Ellipse. During the investigation, some of the records of inspections were found in paper form in filing cabinets in a shipping container because of an office move. Although these records give an indication of the state of this LBS at various times, neither RAIB nor Network Rail were able to identify whether planned or completed work was actually done, or the accuracy of such records, during their respective investigations.

255 As part of its duties to undertake assurance checks, Network Rail had carried out audits on the depot approximately every 2 years. An audit in July 2017 found no deficiencies related to the track section responsible for bridge 3. The same track section was not included in an audit that took place in July 2019. The subsequent audit was in March 2022. This found some issues, including switch inspection activities not being managed through Ellipse, but overall, the delivery unit was rated as ‘good’.

256 A report covering an audit between November 2023 and May 2024 found that some track geometry reviews were not taking place within the required timescales and noted issues with how work was being captured in Ellipse. This audit was supplemented by another undertaken by an assistant TME in December 2023 using a remit provided by TME1. Its scope included LBS assets and a check on compliance with the requirements of module 02 of standard NR/L2/TRK/3038. This found some non-compliances which included longitudinal bearers not being uniquely identified, and the LBMPs for the section’s LBS assets not containing information about roles and responsibilities. This audit also noted that the LBMPs needed to be signed by the PREs from both the track and structure disciplines, to show co-operative working was taking place.

257 In May 2024, during the time TME1 was in post, a partial audit found non-conformances related to how Ellipse was being used by staff at Guide Bridge depot. It also found that individual bearers were not being logged as assets as required by NR/L2/TRK/3038, that the bearers were not being viewed under traffic from passing trains, and that detailed LBS examination findings were not being documented correctly. The audit noted that there were many omissions on Ellipse for activities before 2023.

258 Monthly management self-assurance audits were also taking place at the depot, but these were conducted internally by the delivery unit. Network Rail’s own investigation raised concerns about the quality of these self-assurance activities. There was no detailed checking by senior management within the delivery unit down to the TME, SM(T) and operative roles. There was also no evidence that the quality of the work taking place on the track was being checked.

259 Following the accident, the Office of Rail and Road (ORR, the safety and economic regulator for railways in Great Britain) conducted its own investigation, principally focused on the management of the Manchester delivery unit. This resulted in ORR issuing Network Rail with an improvement notice on 16 April 2025 (see paragraph 275). This identified that there were failures with the track inspection regime, in terms of defects not being reported and no action being taken in response. ORR found that the track's geometry under the responsibility of the delivery unit was not being managed in compliance with NR/L2/TRK/001.

260 ORR also found that LBMPs were incomplete, that staff were unaware of their status and that there were issues with how LBSs were being managed. These issues related to staff training and asset record keeping, which in turn affected how the conditions of these assets were being monitored and assured. More generally, ORR also found issues related to missing documentation for managing the safety of staff while working on the railway, which extended to a lack of leadership and oversight, plus a failure to escalate problems.

Previous occurrences of a similar character

261 RAIB has previously investigated accidents involving both broken screws and LBSs. However, none of the recommendations made in these previous investigations are directly relevant.

262 RAIB investigated a derailment at Liverpool Street station which occurred on 23 January 2013 (RAIB report 27/2014). This accident was caused by track gauge widening on a switch and crossing because a number of baseplate screws had broken. Each of the baseplates was fitted with three screws and the screws exhibited signs of fatigue failure. It was found that this was principally due to the tight geometry at the location and the forces in the screws were high enough to cause them to break.

263 RAIB made three recommendations relating to improving systems for managing any enhanced risk of derailment, assessment of staff competency in safety-critical track maintenance roles, and the possible extension of this to other disciplines. ORR reported to RAIB that one of these recommendations had been implemented by June 2020, with the remaining two recommendations being implemented by October 2021.

264 RAIB investigated a derailment which occurred near Wanstead Park, London on 23 January 2020 (RAIB report 12/2020). A freight train derailed on an LBS track section on a bridge due to track gauge widening. The cause of this was found to be rotten softwood bearers and the inspection method and tools used by Network Rail staff not being sufficient to detect the poor internal condition of the timber. There was also a finding relating to the condition of the wheels on some of the wagons involved in the accident.

265 RAIB made two recommendations. One was for the wagon maintainer to improve the monitoring of its maintenance activities. ORR reported to RAIB that this recommendation had been implemented by November 2022. The other recommendation, to Network Rail, asked it to improve the clarity of information from its track recording vehicles to better identify track defect locations. ORR reported to RAIB that this recommendation was implemented by October 2022.

266 Network Rail informed RAIB that since the accident at Wanstead Park it has created an e-learning training module to provide a comprehensive understanding of LBSs to its staff. It has also created two in-person courses giving theoretical and practical training on aspects principally related to the examination of the integrity of LBS timber bearers.

267 RAIB investigated a derailment at Sheffield station which occurred on 11 November 2020 (RAIB report 07/2021). This accident was caused by track gauge widening on a switch and crossing because of a number of baseplate screws breaking. The investigation found that the track's tight curvature played a part in the level of forces applied to the screws. These screws had failed by fatigue over an extended period before the derailment, and these failures had not been detected by routine visual inspections.

268 It was found that, although there may have been signs of baseplate shuffle as the baseplates were on softwood timbers (paragraph 180), the track gauge did not exceed a level requiring corrective action. It also found that some of the upper portions of the broken screws were being held tightly in their baseplates, making the identification of any broken screws by any tactile inspections difficult. The screws on this section of track were of the normal grade AS type. Each of the baseplates was fitted with three screws, dated 2005 and 2006, although it is not known when they were installed.

269 RAIB made four recommendations to Network Rail. The first two recommendations related to reviewing the process for the application of site-specific risk assessments and improving the implementation of safety-critical track maintenance activities. The third was to update its standards for the fitting of check rails to limit the lateral track forces applied to the screws. The fourth related to reviewing the format of its track recording data to better identify trend analysis of changes in track geometry. ORR reported to RAIB that the first and third recommendations were closed in July 2025, and that implementation of the second and fourth recommendations remains ongoing.

270 At the time of publication of the Sheffield report in October 2021, RAIB was informed by Network Rail that it had started work to develop a new technical specification for the design of screws and the associated rail fixing components. This recognised that there was no data on the performance characteristics for existing baseplate and screw configurations. The work proposed to include an engineering analysis of existing designs to inform the new technical specification.

271 In September 2025, Network Rail informed RAIB that the engineering analysis concluded that there was no significant benefit in using the high tensile grade screws to improve fatigue life. However, it concluded that in higher-risk locations replacing screws during maintenance activities would prevent early fatigue failure. As a result of this conclusion, some standards were updated to mandate screw replacement where the nature of the maintenance work permits it. This new requirement applies where the track radius is less than 300 metres and is not specific to track fitted to LBSs.

Summary of conclusions

Immediate cause

272 The track running over bridge 3 was unable to maintain the correct gauge as train 6J46 passed over it (paragraph 111).

Causal factors

273 The causal factors were:

a. The LBS at bridge 3 was unable to withstand the repeated loading from trains passing over it (paragraph 115). This causal factor arose due to a combination of the following:
   i. The design, installation and maintenance of this LBS led to its screws being prone to fatigue failure (paragraph 118), **Recommendation 1**.
   ii. An increase in the volume of traffic on the down line over bridge 3, together with a possible contribution from changes in the bridge's vertical stiffness, had accelerated the rate of fatigue failure of the screws (paragraph 136), **Recommendations 5 and 6**.

b. Those screws which had failed, or were failing before the passage of train 6J46, had not been detected by Network Rail's inspection regime (paragraph 142). This causal factor arose due to a combination of the following:
   i. Regular measurement train track geometry recording runs, including the use of the PLPR process, were not capable of reliably detecting this type of failure (paragraph 149), **Recommendation 2**.
   ii. Manual inspections of the LBS had not identified the need to replace the screws (paragraph 159), **Recommendation 2**.

c. The significance of previous screw failures, which had been occurring since before 2020, was not fully appreciated by those responsible for inspecting and maintaining the LBS at bridge 3 (paragraph 183), **Recommendation 2**.

Underlying factors

274 The underlying factors were:

a. Network Rail did not have effective processes for managing LBS assets (paragraph 191), **Recommendations 2, 3, 4, 5 and 7**.

b. The Guide Bridge track team responsible for the LBS at bridge 3 neither correctly recorded nor reported previous screw failures, and this was not identified nor corrected by Network Rail's assurance regime over a period of years (paragraph 247), **Recommendation 8**.

Actions reported as already taken or in progress relevant to this report

Actions reported that address factors which otherwise would have resulted in an RAIB recommendation

275 On 16 April 2025, ORR served an improvement notice on Network Rail following its own investigation, which had found safety management issues within the maintenance delivery unit (paragraph 259).

276 This notice required Network Rail to undertake the following activities, or any equally effective measures, within its Manchester delivery unit:

- define the scope of track maintenance activities to be managed and delivered
- quantify the resources needed for each activity
- conduct a gap analysis comparing demand with current capability, including training and competence
- develop a timebound plan to address identified shortfalls and to ensure that risks are reduced so far as is reasonably practicable
- establish monitoring and review mechanisms to detect persistent non-compliance with safety and maintenance standards
- ensure non-compliances are recorded and escalated to appropriate management for root cause resolution.

Other reported actions

277 In response to the derailment, on 19 September 2024 Network Rail issued a safety alert to its staff regarding the derailment on the LBS.

278 On 25 October 2024, RAIB issued urgent safety advice to UK infrastructure managers who may have LBSs on their networks (see appendix C). This was in response to identifying that the screws that led to the derailment had failed in fatigue, and that screw failures may not be easily identified by current inspection regimes.

279 In December 2024, Network Rail issued SIN 220. The outcome of the work on this SIN is summarised in paragraphs 244 to 246. While the work on this SIN is ongoing, initial findings show that the issues identified by this investigation apply beyond this delivery unit.

280 Network Rail has told RAIB that it has made changes within the maintenance delivery unit to improve how inspection and maintenance work is recorded on Ellipse by staff at Guide Bridge depot (paragraph 254).

281 It has also told RAIB that it is conducting modelling work to determine the optimal design for the baseplate, ferrule and screw assembly. This includes its use in both existing installations and new builds.

282 Network Rail confirmed that it currently does not provide guidance on the use of double rail clips on one or both sides of a single baseplate (paragraph 76). It is reviewing the applicability of this and is planning to issue updated requirements and guidance.

283 Network Rail is also investigating automated techniques to identify loose and broken screws. It is exploring the use of automated pattern recognition (in a similar way PLPR is currently able to identify missing rail clips) to identify screw position changes fitted with tell-tale markers. If successful, it plans to use this technique to complement its current inspection regime.

284 Network Rail is considering introducing a new competence for the detailed examination of its LBSs. This will include improving the understanding of the installation and maintenance requirements of these assets.

Recommendations

285 The following recommendations are made:[1]

1 *The intent of this recommendation is for Network Rail to gain greater assurance of the reliability of its designs for longitudinal bearer systems.*

Network Rail should review its standards and processes that relate to the design of components used in its longitudinal bearer systems so that such components are assured to withstand the proof and fatigue loading they will be subjected to throughout their expected service life.

Network Rail should develop a timebound plan for the implementation of any appropriate changes to standards and processes identified by this review (paragraph 273a.i).

2 *The intent of this recommendation is for Network Rail to improve its management of longitudinal bearer systems.*

Network Rail should review its standards, procedures and guidance documents covering the management of longitudinal bearer systems so that:

- There is clear guidance to designers and installers as to which components and assemblies are appropriate for use in various configurations and expected operational conditions.
- Clear procedures and guidance exist for the inspection and maintenance of the assets, and that any inspection methods specified are capable of identifying component failures.
- Effective processes exist for the reporting of any failures and degradation of individual components which will ensure that any technical issues arising can be clearly understood and rectified.
- Its track risk register work instruction (NR/L3/TRK/9025) reflects any findings of the assessments of the risk of derailment on its assets.

Network Rail should develop a timebound plan for the implementation of any appropriate changes to standards and procedures identified by this review (paragraphs 273b.i, 273b.ii, 273c and 274a).

[1] Those identified in the recommendations have a general and ongoing obligation to comply with health and safety legislation, and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Offifce of Rail and Road to enable it to carry out its duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 200 to 203) can be found on RAIB's website www.gov.uk/raib.

3 *The intent of this recommendation is for Network Rail to improve the competency of those working with its longitudinal bearer systems.*

Network Rail should review its competency management systems for those working on longitudinal bearer systems so that:

- The installation, inspection and maintenance of its assets are effectively covered by its competency management systems.
- There are sufficient competent people available at route, delivery unit, and depot level to effectively manage its LBS assets.

Network Rail should develop a timebound plan for the implementation of any appropriate changes to its competency management systems identified by this review (paragraph 274a).

4 *The intent of this recommendation is for Network Rail to improve the interface between disciplines that are jointly responsible for the management of longitudinal bearer systems and their supporting structures.*

Network Rail should:

- review whether its current process of using longitudinal bearer management plans is the most effective way of sharing information between disciplines to better manage longitudinal bearer system assets
- review the processes which assure that any cross-disciplinary management activities are fully completed, updated and acted upon
- review whether longitudinal bearer systems would be better managed as a discipline/subject area more distinct from plain line track, so that the specific skills and activities required by those assets can be better managed.

Network Rail should develop a timebound plan for the implementation of any appropriate changes to standards and processes identified by this review (paragraph 274a).

5 *The intent of this recommendation is for Network Rail to improve its understanding of its assets.*

Network Rail should research the effects of the condition of supporting structures on the behaviour of longitudinal bearer systems and track to better understand and pre-empt future degradation.

Network Rail should develop a timebound plan for the implementation of any appropriate findings from this research (paragraphs 273a.ii and 274a).

6 *The intent of this recommendation is for Network Rail to manage its longitudinal bearer systems when changes in loading conditions occur.*

Network Rail should review current procedures for the management of longitudinal bearer systems and their supporting structures when changes in traffic volumes occur. This should include:

- the process by which changes in traffic volumes are used to assess the likely performance and degradation of the assets
- the process by which these changes are used to consider the necessity of design modifications or adjusted inspection and maintenance frequencies or activities.

Network Rail should develop a timebound plan for the implementation of any appropriate changes to standards and processes identified by this review (paragraph 273a.ii).

7 *The intent of this recommendation is for Network Rail to improve its understanding of its longitudinal bearer system assets.*

Network Rail should review the accuracy and completeness of its asset records relating to its existing longitudinal bearer systems, including the recording of component configurations and any failures.

Network Rail should develop a timebound plan for making any identified changes to its asset records identified by this review (paragraph 274a).

8 *The intent of this recommendation is for Network Rail to improve its assurance processes for the maintenance of its longitudinal bearer system assets.*

Network Rail should review the implementation and effectiveness of its assurance processes on its longitudinal bearer systems. This should include consideration of the quality and depth of the assurance activities. This is to assure that maintenance delivery units are keeping accurate records of inspection and maintenance activities on longitudinal bearer systems.

Network Rail should develop a timebound plan for the implementation of any appropriate changes to standards and processes identified by this review (paragraph 274b).

Appendices

Appendix A - Glossary of abbreviations and acronyms

Abbreviation / acronym	Term in full
EMGT	Equivalent million gross tonnes
GBRf	GB Railfreight Limited
HCF	High cycle fatigue
LBMP	Longitudinal bearer management plan
LBS	Longitudinal bearer system
LCF	Low cycle fatigue
ORR	Office of Rail and Road
PLPR	Plain line pattern recognition
PRE	Principal route engineer
RA	Route availability
RAIB	Rail Accident Investigation Branch
SD	Standard deviation
SIN	Special inspection notice
SM(T)	Section manager (track)
SVI	Supervisor’s visual inspection
TME	Track maintenance engineer

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- information taken from the train's OTDR
- signalling data records
- CCTV recordings taken from an adjacent property
- ground and aerial photographs and videos recorded on site by RAIB, the British Transport Police and Network Rail
- site measurements
- weather reports and observations at the site
- examinations during the disassembly of the LBS section recovered from site
- a report of the metallurgical examinations commissioned by RAIB
- industry electronic and paper records
- a review of previous RAIB investigations that had relevance to this accident.

Appendix C – Urgent Safety Advice

Rail Accident Investigation Branch

Urgent Safety Advice 01/2024: Derailment on bridges with longitudinal timber systems

Published 24 October 2024

1. Safety issue

Existing inspection and maintenance regimes may not be sufficient to detect the failure of baseplate chair screws, which can lead to a loss of lateral track support in longitudinal timber systems.

2. Safety advice

Duty holders should take urgent steps to consider and mitigate this risk.

3. Issued to:

Network Rail and other infrastructure managers, and those companies responsible for maintaining or inspecting longitudinal timber systems.

4. Background

At around 11:25 on 6 September 2024, a freight train travelling between Peak Forest and Salford derailed as it passed over a bridge in Audenshaw, Manchester.

The train involved was made up of 2 class 66 locomotives and 24 wagons, which were loaded with aggregate. The 2 locomotives and the leading 10 wagons passed safely over the bridge, but the next 9 wagons derailed, with the last of these coming to a stand on the bridge itself.

No injuries were caused by the accident. However, the derailment caused substantial damage to railway infrastructure and damaged some of the wagons.

RAIB is investigating this accident. The evidence available at this stage to RAIB's investigation indicates that the derailment was caused by gauge spread within the first half of the bridge, with the track having transferred from ballasted track to a longitudinal timber system as the train entered the bridge.

The track at this location is curved to the right with a radius of approximately 480 metres and an installed cant of around 40 mm. The rails on the bridge were supported on PAN M6 baseplates held to the timber by only two LSA chair screws.

On site, RAIB recovered 13 failed LSA chair screws from the baseplates of the low-side rail. None of these screws were marked with ‘HT’ on their heads, which indicates that these chair screws were probably not made of high-tensile strength material.

Early results from metallurgical analysis of these failed chair screws show that they all exhibited signs of low-cycle and high-cycle fatigue failure in bending (figure 1). A number of them also exhibited a small area of unfatigued material which eventually fractured by overload (figure 2). The plane of failure in most cases was just below the top level of the timber, typically one or two threads below the screws’ shanks.

This mode of failure of the chair screws is not easily detectable by visual inspection means. As was found from RAIB’s investigation into the derailment of a freight train at Sheffield station on 11 November 2020 (RAIB report 07/2021), the upper portion of a broken screw may still offer some resistance to rotation or removal by hand which makes detection of an impending failure by gauge widening difficult. At the site of the Audenshaw derailment, it was noted by RAIB that there were no clear indications of significant baseplate, or baseplate packing, shuffle nor timber indentation.

Factors for consideration

RAIB has determined some characteristics which may indicate a higher potential risk of a loss of lateral support due to the failure of chair screws in this manner. These are:

1. longitudinal timber systems using hardwood timbers
2. the use of PAN M6 baseplates, or similar, with only 2 chair screws per plate
3. the presence of non-HT chair screws, which may be more susceptible to failure by fatigue (although breakages of the screws marked ‘HT’ have been found on the high-side rail baseplates these are yet to be fully examined)
4. the quantity of packing present between baseplate and timber. This may exacerbate screw bending behaviour and subsequent fatigue failure
5. a history of local gauge widening under traffic over a short period of time. This may be below the values measured by either manual (static) and automated (dynamic) means which would trigger an intervention
6. the presence of high gauge spreading forces applied to the rails due to track curvature, vehicle characteristics or a transition from ballasted to longitudinal timber supported track
7. the degree of support available from, and fixity of the longitudinal timber system to, the structure.

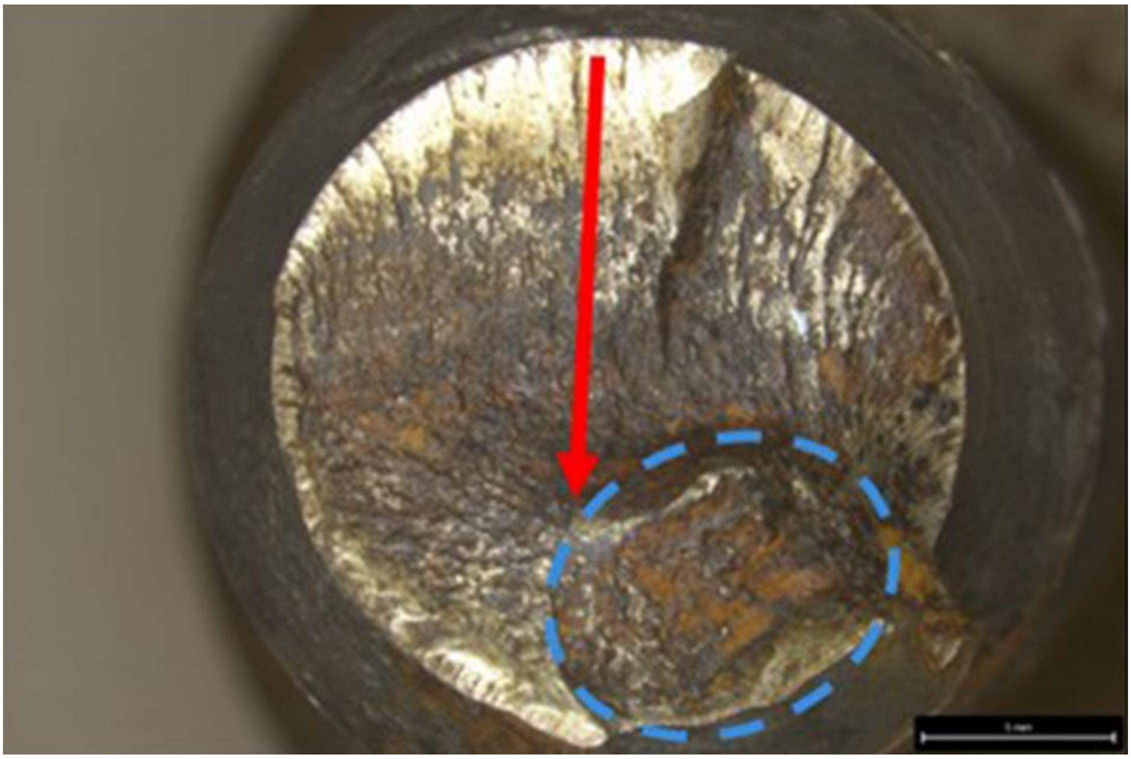


Figure 1: Fracture face of the upper portion of a recovered screw with indications of unidirectional high-cycle and low-cycle bending fatigue and a small area of overload (circled).

Figure 2: One of the recovered top portions of a screw with signs of historical fracture and subsequent failure by overload (bright area).

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