Rail Accident Investigation Branch

Rail Accident Report

Derailment of a passenger train near Kemble 15 January 2007

Department for Transport

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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; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

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Contents

Introduction

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

2 The RAIB does not establish blame, liability or carry out prosecutions.

3 The derailment near Kemble on 15 January 2007 is the fourth investigation undertaken by the RAIB into train derailments resulting from cutting failures; the other three were Merstham (13 January 2007), Moy (26 November 2005) and Oubeck (4 November 2005). The RAIB decided to undertake two parallel investigations. This report contains the findings of the RAIB's investigation into the specific circumstances of the derailment near Kemble. A further report will develop the earthworks issues from this incident and also investigate the broader issues of earthwork management across Network Rail. Where appropriate, this report will make reference to the work in the second investigation.

4 Access was freely given by Network Rail and First Great Western to their staff, data and records in connection with the investigation.

5 Appendices at the rear of this report contain the following glossaries:

- acronyms and abbreviations are explained in Appendix A; and
- technical terms (shown in *italics* the first time they appear in the report) are explained in Appendix B.

6 Throughout this report, vehicle and track components are described as 'left' and 'right'; this is relative to the direction of travel of the derailed train.

7 All mileages given are from a zero point at London Paddington.

Summary of the report

Key facts about the accident

8 On 15 January 2007, at approximately 22:14 hrs, the 21:52 hrs train from Swindon to Cheltenham Spa, consisting of a two-car diesel multiple unit (DMU), was travelling at 51 mph (82 km/h) when it struck debris from a collapsed wall following a landslip in the cutting just south of Kemble tunnel. The leading bogie of the train was derailed and the train was brought to a halt at the tunnel mouth.

9 There were no injuries to passengers or crew. Evacuation of passengers from the derailed train was completed by 23:40 hrs. The line was closed until early on 18 January 2007 to enable repairs to be undertaken to the track and the cutting.

Immediate cause, causal and contributory factors, underlying causes

10 There were two causal factors leading to the derailment, associated with the cutting slope and the wall. Both factors were necessary for the derailment to occur.

11 The immediate cause of the derailment was the leading vehicle of train 2G93 striking a large number of concrete blocks which had fallen onto the line from a collapsed wall adjacent to right hand cess.

12 The first causal factor was the failure of the cutting, which caused the overloading of the wall and its subsequent collapse, spilling a large number of concrete blocks onto the line. The contributory factors which led to this were:

- the heavier than average rainfall during December 2006 and January 2007;
- the poor drainage of the cutting slope resulting from the lack of a functioning crest drain; and
- the reclassification of the cutting as 'marginal' in 2004 from 'poor' which effectively increased its inspection interval from annually to 5 yearly.

13 The second causal factor was the collapse of the wall. Although this was a consequence of the cutting failure, the wall itself probably posed a greater risk to the railway than the cutting failure and its failure also generated a greater volume of debris than the cutting failure

14 Contributory factors which led to the collapse of the wall under the loading imposed by the cutting slip were:

- the blocked weep holes, which allowed water pressure to build up at the back of the wall in addition to pressure from the build up of slope material against the back of the wall; and
- the classification of the wall at Kemble as a 'retaining wall', which probably prevented a correct assessment of the wall's condition against the imposed loading .

Recommendations

15 Recommendations can be found in paragraph 118. They relate to the following areas:

- checks on similar wall structures on the network subject to similar loading, including checks on drainage condition;
- a review of the classification of walls in Network Rail company procedures so that the purpose of a wall is clear to examiners when they assess its condition.

The Accident

Summary of the accident

16 On 15 January 2007, train 2G93, the 21:52 hrs Swindon to Cheltenham Spa, operated by First Great Western (FGW), was approaching Kemble station along the single track south of Kemble tunnel, when it derailed at 22:14 hrs, after striking some concrete blocks.

17 The point of derailment (POD) was located approximately 240 m south of Kemble Tunnel, within a cutting on a right hand curve (Figure 1). The two car Class 158 DMU had already started reducing speed for Kemble station when it struck the blocks, which had fallen onto the line from a collapsed wall at the bottom of a failed cutting on the right hand side of the track. The block debris covered a 14 m length of track.

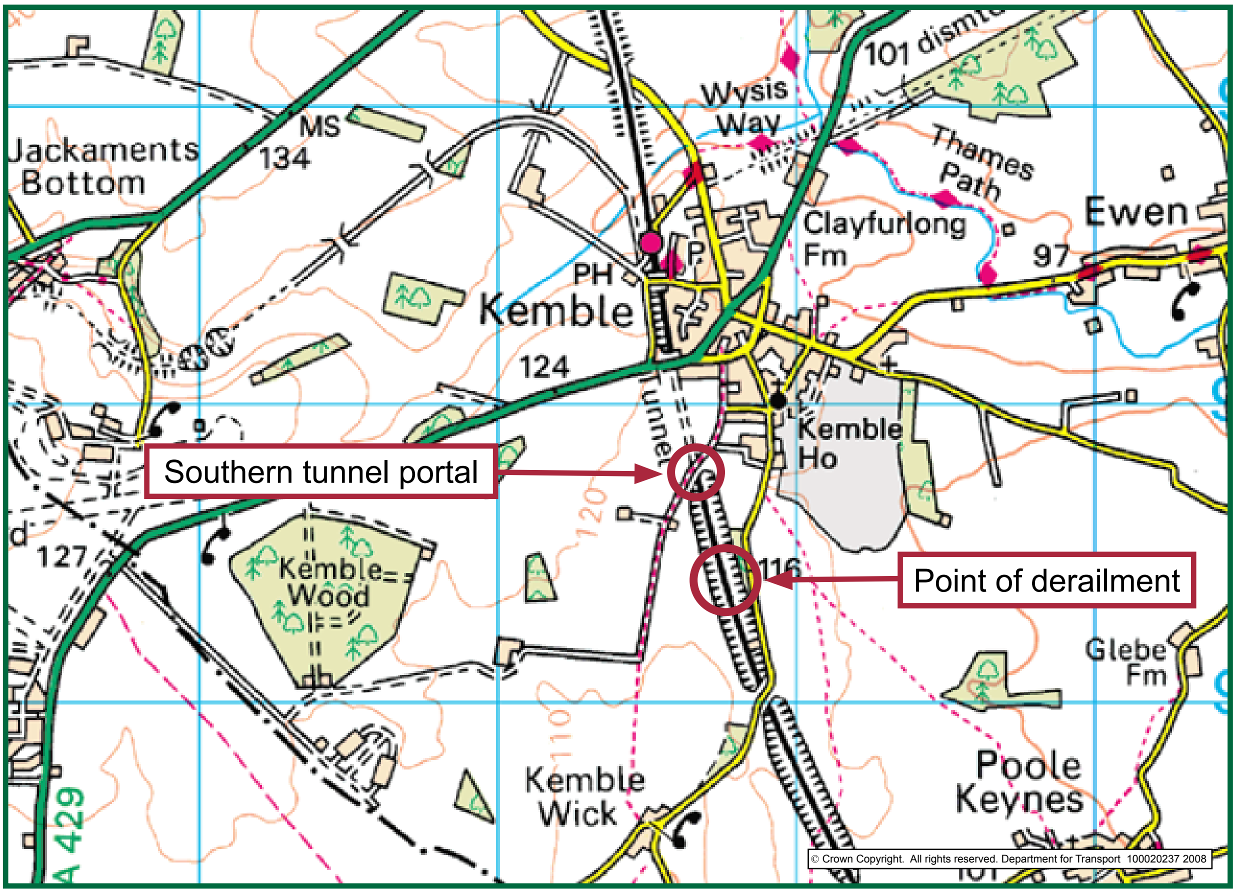

Figure 1: Site map showing location of derailment in relation to Kemble station and tunnel

18 The trailing wheelset of the leading bogie was derailed towards the outside of the curve and followed a path just to the left of the running rails, along the top of the sleepers and rail fastenings. The leading wheelset of the same bogie did not derail.

19 The driver applied the train's *emergency brake* when he realised something was wrong, bringing the train to a halt approximately 243 m further along the track with the leading end just inside the southern portal of Kemble tunnel. All the vehicles remained upright throughout the incident. There were 21 passengers and 5 staff (three of whom were travelling as passengers) on the train; none were injured. The emergency services were summoned and evacuation of passengers was complete by 23:40 hrs.

The parties involved

20 The infrastructure is owned, operated and maintained by Network Rail.

21 The train was being operated, and the driver was employed, by FGW.

Location

22 The first part of the route from Swindon to Cheltenham Spa is single track from Swindon Loco Yard (78 miles 20 *chains*) to just beyond the northern tunnel portal of Kemble Tunnel (90 miles 61 chains). At this point the route becomes double track passes through Kemble station (90 miles 79 chains) and continues on to Cheltenham Spa.

23 The point of derailment was located at 90 miles 28.5 chains and lies on a rising gradient of 1 in 300 in the direction of travel, and in a steep sided cutting. The cutting extends from 90 miles 3 chains to the southern portal of Kemble tunnel (90 miles 41 chains). Figure 2 shows the view looking north in the direction of travel of train 2G93. The debris from the collapsed wall is on the right hand side of the track. The wide *cess* on the left side is where another track used to be before the route was reduced to a single line in 1968.

Figure 2: View of derailment site in the direction of travel

24 The permissible line speed from 82 miles 70 chains to the northern portal of the tunnel is 90 mph (145 km/h) for multiple unit trains and 100 mph (161 km/h) for High Speed Trains (HSTs).

External circumstances

25 The weather at the time of the accident was dry. It was also dark.

The train

26 Unit number 158750, which formed train 2G93, comprised vehicles 52750 (leading) and 57750. Each vehicle had one powered bogie. The maximum operating speed of the train was 90 mph (145 km/h). Figure 3 shows the leading end of the train and derailed leading non-powered bogie.

Figure 3: Leading end of Unit 158750 and derailed leading bogie

27 The leading bogie was fitted, as is normal, with *lifeguards* to protect the leading wheels from significantly sized objects entering the wheel/rail interface. In addition the leading end of vehicle 52750 was fitted with a snow plough. This is designed primarily for snow clearance but can also displace lightweight obstacles.

Events preceding the accident

28 The previous train over the single line from Swindon on the same evening passed through at approximately 21:20 hrs. There were no reports of problems or anything unusual.

29 Train 2G93 departed Swindon at 22:02:53 hrs bound for Cheltenham Spa via Kemble. It reached a maximum speed of 89 mph (143 km/h) at 22:08:29 hrs and remained below the line speed of 90 mph (145 km/h) until 22:13:16 hrs when the driver shut off power in preparation for a 40 mph (64 km/h) *permanent speed restriction* (PSR) at the north end of Kemble tunnel. The train began to reduce speed against the rising gradient down to 76 mph (122 km/h). The driver then made a normal brake application at 22:13:44 hrs to reduce train speed further in preparation for the PSR and Kemble station.

Events during the accident

30 The driver's brake application brought the train speed down to 51 mph (82 km/h). It was at this point that he noticed, in the train's headlight beam, that the track in front had become obscured; almost immediately the train struck the pile of concrete blocks on the track, which the driver initially thought was a pile of ballast. The speedometer signal to the on-train monitoring recorder (OTMR) was lost at 22:14:04 hrs when the speed sensor attached to the axle was destroyed.

31 The driver immediately applied the emergency brake, looked out of the right hand side cab window and decided to escape from the cab into the saloon. As he moved to the back of the leading vehicle he shouted a warning to the four passengers in that vehicle who also ran to the back of the vehicle. The train came to rest upright and in line, with the leading end approximately 3 m inside the southern portal of Kemble tunnel.

Consequences of the accident

32 There was significant damage to the equipment on, and the wheelsets of the leading bogie. The leading vehicle sustained minor impact damage to the snow plough.

33 There was extensive damage to the track from the POD to the southern portal of the tunnel. Approximately 130 concrete sleepers and numerous rail fastenings were damaged. The left hand rail was broken at four positions where the derailed wheel had struck welded joints. The pile of concrete blocks, which had fallen from the collapsed wall and which were partially flattened by the train, covered the track over a length of 14 m (Figure 3).

Events following the accident

34 Once the train had come to rest, the driver checked on the condition of the passengers and the conductor made an announcement to ask passengers to remain calm and seated while he investigated what had happened. The driver then contacted the signaller at Swindon Panel Signal Box. The signaller contacted the Network Rail Control at Swindon who called out the fire brigade and the British Transport Police at approximately 22:24 hrs.

35 The front vehicle was in darkness so everyone moved to the rear vehicle. The crew, assisted by three other FGW staff on board, kept the passengers informed about the arrival of the rescue services and plans for their evacuation.

36 The fire brigade arrived at Kemble station at 22:41 hrs and a Network Rail *mobile operations manager* took over control of the site at 22:52 hrs. FGW control became aware of the derailment at approximately 22:20 hrs and mobilised staff, who arrived at Kemble station at 23:20 hrs.

37 Evacuation of the train commenced at approximately 23:00 hrs. Passengers were detrained onto the track by the FGW staff and the fire brigade and walked through the tunnel to Kemble station. Lighting in the tunnel was provided by the fire brigade. From Kemble station they were carried forward by waiting taxis. Evacuation of the train was complete by 23:40 hrs.

38 The RAIB examined the derailed train on site during the early hours of 16 January 2007 and released the train for re-railing. It was fitted with *wheel skates* and moved at slow speed to Gloucester, pending removal to Doncaster for repair.

39 Following examination of the track, wall and cutting by the RAIB and Network Rail, initial repair work was undertaken to remove the slipped material and *regrade* the cutting slope. The line was open to traffic on 18 January 2007. Two *watchmen* were posted to observe the cutting in case of further slips and an emergency speed restriction of 20 mph (32 km/h) was put in place. Further extensive remedial work was undertaken by Network Rail in the following months as detailed at paragraph 114.

The Investigation

Sources of Evidence

40 The RAIB attended site on the night of the derailment to carry out an inspections of the train and to examine the cutting failure, the collapsed wall and track damage.

41 Evidence was obtained from Network Rail and FGW as follows:

- the train's data recorder (OTMR);
- statements of the train crew and interviews with relevant personnel responsible for the management of the cutting and wall;
- a report on the cutting failure prepared by Network Rail's *special examinations* contractor;
- Network Rail's examination records for the cutting;
- details of remedial work undertaken following this and previous cutting failures;
- structural inspection records for the wall which collapsed;
- Network Rail company standards and procedures for the management of *structures* and *earthworks*;
- relevant Network Rail standards for examination of structures and earthworks;
- other factual information supplied by Network Rail.

Factual Information

The train

42 The first parts of the leading vehicle to strike the concrete blocks were the snow plough and lifeguards. The impact with the snow plough did not cause any significant damage to its bottom edges, indicating that it had merely clipped the top of the blocks. Both the left and right hand lifeguards at the front of the leading bogie had struck the blocks and had sustained sufficient impact force to cause yielding of the mounting brackets.

43 The axle mounted brake discs, various parts of the underside of the bogie frame and its suspended equipment were damaged by the impact with the concrete blocks. The right hand side of the bogie sustained greater damage than the left side. The derailed trailing wheelset had started to impact on and damage the concrete sleepers and rail fastenings immediately after the concrete block debris.

The cutting

44 The cutting rises to a maximum height of approximately 9 m above track level and the *crest* is located 13 m from the cess rail. The geology of the cutting comprises soft limestone rock strata overlaid with a stiff clay. In places the clay has been weathered to a very soft, almost fluid, consistency. Towards the top of the slope, there was a primary slip (Figure 4) which had left a *scar* face approximately 10-14 m long and 1-1.5 m deep. Approximately half way down the slope, there was a secondary *slip*, approximately one third the size of the primary slip from which a soft clayey discharge, loose rocks and firmer clay layers had descended down the slope and run onto the back of the wall.

Figure 4: Derailment site showing cutting slips, state of backfill and typical weep hole (inset)

45 At the crest, which marks the Network Rail boundary, the remnants of a drain, which runs part way along the crest, was found. The history of this crest drain is not known by Network Rail and there are no records of it. It would appear to have been broken a long time ago and had ceased to perform any drainage function.

46 The adjoining land from the crest to a road running almost parallel to and approximately 70 m east of the railway, was waterlogged, with standing water or wet mud over most of the width. The adjoining land does not belong to Network Rail.

47 The cutting failure was inspected by Network Rail's special examinations contractor in the Western Territory, who prepared a report based on a visual inspection and analysis of the stability of the wall. The findings are summarised at paragraph 95.

48 Southwards, along the cutting towards the *overbridge* at 90 mile 03 chains, several much smaller slips were observed. It is not known when these occurred, but they appeared to have been recent. None of these slips had deposited material onto the track.

49 At the time of the cutting failure and subsequent derailment, two watchmen were on duty at the overbridge. They had been posted there following a previous slip at that location (paragraph 59). They had arrived at the overbridge at approximately 18:00 hrs on 15 January and carried out patrols in the immediate vicinity of 90 miles 03 chains every 30 minutes. They did not see or hear the landslip at 90 miles 28.5 chains, nor the subsequent derailment and only became aware of it when they were informed about it at approximately 05:00 hrs.

The inspection regime for the cutting

50 Prior to May 2005 on the Western Territory of Network Rail, earthworks and drainage inspections were carried out in accordance with Network Rail Company Standard RT/CE/P/030 Issue 1, 'Management of embankments and cuttings', dated August 1997. This standard applied to all earthworks greater than 3 m in height and those below this height which were known sites of instability. The standard required earthworks and associated drainage to be examined and then evaluated for condition in accordance with a prescribed marking scheme in order to prioritise further *evaluations* of earthworks.

51 In December 2002 issue 2 of RT/CE/P/030 came into force which uses classifications for earthworks as *'poor'*, *'marginal'*, or *'serviceable'*, terms which were defined in another Network Rail standard RT/CE/S/065, which was then in development until its issue in April 2005. The prescribed examination frequencies were 1, 5 and 10 years respectively, with maximum permitted increases to planned inspection intervals of 4, 6 and 12 months respectively.

52 RT/CE/S/065 Issue 1 specified the current scoring system based on *slope stability hazard index* (SSHI). In the interim period between December 2002 and April 2005, draft versions of RT/CE/S/065 were used to varying degrees by the different regions of Railtrack. On the Western Region, they continued to use the previous scoring system but adopted the new classifications (poor/marginal/serviceable). Local criteria were devised in order to translate scores made under RT/CE/P/030 Issue into the new classifications of Issue 2.

53 Network Rail's Western Territory identified a total of 1175 miles of relevant earthworks using mapping information. These earthworks comprised 52 % embankments and the remaining 48 % as cuttings. Following examination of these using the process specified in RT/CE/P/030, approximately 4 % of the total earthworks miles were classified as 'poor', 52% as 'marginal' and the remaining 44 % were classified as 'serviceable'.

54 Examination records for the section of cutting from 90 miles 20 chains to 90 miles 30 chains on the north side show that it was examined on three occasions; 6 June 2001, 20 November 2002, and 6 January 2004. After each inspection the cutting was marked to give a total score and this score was used to classify the condition of each earthwork into one of the classification, 'poor', 'marginal' or 'serviceable'.

55 In the first two inspections the cutting between 90 miles 20-30 chains was classified as 'poor'. In the final inspection it was upgraded to 'marginal' following extensive clearance of trees on the cutting slopes. This vegetation clearance had been requested by the Western Territory Earthworks and Drainage Engineer because the trees had started to overhang the track, causing leaf fall problems and were obstructing the visibility of the cutting for examination purposes. Hence the cutting moved from annual examination to 5 yearly examinations and its next planned examination would have been due on 6 January 2009.

Previous earthworks failures in the Kemble area

56 Available records show that the problems of slips or rock falls in the Kemble area are relatively recent (paragraphs 57 - 59). However, there is anecdotal evidence, which has emerged in discussions with retired British Rail civil engineering staff, that there was a history of slips in the Kemble cutting in the 1970s and possibly earlier. No formal records of these earlier slips are available but the introduction of the wall in the 1970s would tend to indicate that there was concern at that time.

57 In November 2003, during a planned programme of vegetation removal and *rock combing* on the *Up* side cutting near the southern end of Kemble tunnel, it was identified that urgent works were needed to safeguard the line. Emergency earthworks were undertaken between 90 miles 32.5 chains and 90 miles 40.5 chains to remove unstable areas of the cutting, install rock netting on the rock face and regrade the top 2-3 m of the cutting. This work was completed in during 2004. This stretch of cutting had been classified as 'marginal' following its last inspection on 20 November 2002.

58 On 5 April 2006 a landslip of the north side cutting occurred at 90 miles and half a chain. The mid slope of the cutting had failed and deposited soil onto the lower slope and in the cess to within 1 m of the cess rail. The failure was caused by excessive groundwater washing out the slope face. It was noted that there was standing water in the field adjacent to the failed area and the drainage ditch at the crest of the cutting slope was blocked with vegetation debris. Remedial work was undertaken to remove spoil, regrade the slope, and install new drainage to prevent further failures. This work was completed during 2006. This section of cutting had been classified as 'serviceable' following its last inspection on 6 January 2004.

59 On 3 January 2007, there was a cutting failure on the north side at 90 miles 03 chains. The failure was caused by ground water discharging from the cutting face and washing out the clay layers between the limestone bands. Although none of the slipped material reached the track, there was sufficient overhanging material and risk of further slips in the area that emergency earthworks were undertaken to regrade the upper section of the slope and stabilise it with a geotextile covering and vegetation cover. The drainage system in the area needed repair. Watchmen were posted at the site 24 hours a day until the emergency works were completed. This stretch of cutting had been classified as 'serviceable' following its last inspection on 6 January 2004.

Other recent earthwork failures in Western Territory

60 Network Rail provided data to the RAIB regarding earthwork failures between 26 November 2006 and 30 January 2007. Excluding the failure at Kemble on 15 January 2007, there have been 12 other earthwork failures which required some form of intervention such as closure of the line, imposition of an emergency speed restriction, removal of tree stumps or the provision of watchmen at failure sites.

61 In three cases, trains ran into obstructions on the line and in one of those cases the train was derailed; at Pewsey on the Berks and Hants Line where a Class 67 locomotive hauling two wagons and another locomotive derailed after striking a tree which had fallen onto the line as a result of a landslip.

62 Ten of the failures were in cuttings and two were on embankments. Two were on sites classified 'serviceable', six on sites classified as 'marginal' and two on sites classified as 'poor'. A further two failures occurred at earthworks which had not been previously identified. Two points emerge from this data; most of the recent earthworks failures on the Western Territory are in cuttings and the majority of failures occurred at locations which had been classified as 'marginal' following their last examination.

The wall

63 At the location of the cutting slip, the wall rises to a height of approximately 2.4 m above rail level. Its foundation is in the cess, set 2.4 m from the cess rail (Figure 2). The crest of the cutting rises a further 6 m above the top of the wall. The wall is constructed from a double row of hollow concrete blocks filled with a *lean-mix concrete* and has an overall thickness of approximately 450 mm. The face of the wall slopes away from the track at an angle of approximately 10 degrees.

64 *Weep holes* were installed at the base of the wall, spaced approximately 3 m apart, to allow drainage of water from behind the wall. The weep holes in the portion of the wall that collapsed were destroyed. It was noted that the weep holes in the adjacent sections of wall, which remained intact, were clear at their exits but not discharging water as would be expected following the recent heavy rainfall in the area (paragraph 86), indicating that they were blocked. Such blockages are likely to cause a build up of water behind the wall, tending to destabilise it.

65 The state of the *backfill* immediately behind the collapsed section of the wall could not be assessed after the collapse. However, either side of the collapsed section the back-fill was full or almost full and there was no discernible gap between the rock face and the wall.

66 The wall is classified as a 'retaining wall' in Network Rail's database of structures in the Western Territory. However, there was no evidence of reinforcement within the wall's construction. There is now doubt within Network Rail as to whether the wall was designed as a 'retaining wall' to provide support for the lower slope of the cutting or as a 'facing wall' to protect the rock face from weathering and to prevent small sized products of weathering/rock debris from encroaching onto the line. Network Rail have not found any design or construction records for the wall.

Examination regime for the wall

67 The current Network Rail specification which defines the management of existing retaining walls is NR/SP/CIV/082 dated April 2004. Within the framework laid out in this specification, the examination regime for retaining walls is prescribed in Network Rail company standard RT/CE/S/083, dated April 2004 (which replaced Railtrack standard RT/CE/S/017, dated February 2002).

68 Both examination standards define retaining walls as 'any structure built to support ground at a higher level on one side than the other including any strutting or anchors.' Boundary and free standing walls may be classified as 'retaining walls' if so required by the Network Rail structures engineer.

69 Both standards state that one of the purposes of a structures examination is to 'identify defects and record any significant change in the condition, loading or environment that might indicate or cause deterioration'. The examination regime comprises annual *visual examinations* and 6 yearly *detailed examinations*. The maximum permitted increase in intervals is 3 months and 6 months respectively. Currently all of Network Rail's structures examinations are carried out by contractors.

70 For inspection purposes the wall between 90 miles 03 chains and 90 miles 32.5 chains was treated as a single entity, although its construction varies along its length. It starts with 3 chains of random stone, then 11 chains of concrete blocks up to 90 miles 17 chains, 1.5 chains of stone wall and then back to concrete blocks from 18.5 chains to 32.5 chains. This last section is where the failure occurred on 15 January 2007.

71 Between 1995 and 2006, the block wall was examined annually by visual examination except in 1995 and 2001 when detailed examinations were undertaken. The inspections were undertaken on a financial year basis such that there was one inspection in each financial year. Generally, the interval between examinations was in accordance with the standard ie not more than 15 months between inspections. Two exceptions were the intervals between the 9 November 2001 and 26 February 2003 inspections and between the 28 October 2003 and 9 March 2005 inspections.

72 The most recent visual examination was on 15 March 2006. The condition of the wall was recorded as unchanged from the last inspection and the contractor's recommendation was that no action was necessary. Network Rail's engineer ratified this decision.

73 The last detailed examination was undertaken on 2 October 2001 by the same contracting company. The examiner recorded that the majority of weep holes were blocked and severely spalled. Vertical and horizontal joint fractures were noted throughout the block wall and localised displacement of the top course of blocks was also noted. The pointing was graded 'fair' and drainage as 'poor'. Again the contractor recommended no action and Network Rail also ratified this decision.

74 The previous detailed examination, undertaken on 3 July 1995, records block courses slightly overriding and mortar cracking and falling out of joints. The contractor recommended no action was necessary. The following visual examination on 24 April 1996 records that the concrete block wall beyond 18.5 chains was noted to have mortar cracking and falling out of joints throughout, with a series of open joints up to 30 mm deep. However the examination the following year on 11 April 1997 records the wall as being in good condition apart from general deterioration to stonework from scaling action and a few open joints.

75 The wall has never been subject to a quantified risk assessment. Quantified risk assessments (which are currently part of the detailed examination process) for retaining walls were introduced into the structures examination standard RT/CE/S/017 in February 2002. This post-dates the latest detailed examination of this wall in 2001.

Inspection of the track

76 Network Rail report that the section of track on which the derailment occurred was routinely patrolled on 3 and 10 January 2007.

77 Nothing was reported in the vicinity of 90 miles 28.5 chains (where the wall collapsed) on either of these dates. A minor slip was found at 90 miles 03 chains on 3 January and was reported on the same day. Nothing new was reported at this location from the patrol on 10 January.

78 The track section manager undertook a routine inspection of the same section of line on 21 December 2006 and made no report of cutting slips or problems with the wall.

Previous occurrences of a similar character

Passenger train derailment at Merstham

79 On 13 January 2007, the 10:59 hrs Southern railways train from Bognor to London Victoria, consisting of eight carriages travelling at over 80 mph, derailed in Hooley cutting near Redhill. The leading axle derailed after running into earth and parts of a protection wall which had been displaced onto the line by a tree root ball which had rolled down the cutting slope and struck the wall. The wall was constructed from heavy timber slats and steel posts. A large piece of timber from the wall caused the derailment. There were no injuries to passengers or crew. This accident was the subject of an RAIB investigation (report 05/2008)[1].

Passenger train derailment at Moy

80 On the morning of 26 November 2005, the leading vehicle of passenger train 1B08, a 3-car Class 170 DMU, travelling from Inverness to Edinburgh, derailed after encountering a *landslip* in a *cutting* north of Moy in Inverness-shire. The train subsequently made a minor glancing impact with the steelwork of an *underbridge but* remained upright throughout. Six passengers and the two train crew were injured.

81 The RAIB investigation (report 22/2006)[2] of the derailment at Moy found that the most likely cause of the landslip was a rise in groundwater, following a period of excessive rainfall over the preceding hours, to a level high enough to initially promote a small failure at the cutting slope. This caused a disruption to flow paths, which resulted in a further rise of the groundwater and the initiation of a larger failure.

Passenger train derailment at Oubeck

82 On 4 November 2005, passenger train 1C62, a three car Class 175 DMU travelling on the *down line* of the Preston to Lancaster section of the West Coast Main Line, derailed after running into a landslip in a cutting at Oubeck North.

[1] www.raib.gov.uk/publications/investigation_reports/reports_2008/report052008.cfm

[2] www.raib.gov.uk/publications/investigation_reports/reports_2006/report222006.cfm

83 Only the trailing *wheelset* on the leading bogie derailed to the outside of the curve in a similar manner to the Kemble derailment. The train travelled a further 1430 m before coming to rest in an upright position. There were no injuries as a result of this derailment. In addition to some vehicle damage which included holing of the fuel tank of the leading vehicle, there was extensive damage to the track over the derailment site.

84 The RAIB investigation (report 19/2006)[3] into the derailment at Oubeck (November 2005) found that the cutting slope failed due to the volume of water flowing through a field drain, which had been hidden from view, into the body of the cutting slope. This followed an unusually wet period over the preceding two weeks.

Other incidents involving landslips

85 The Rail Safety and Standards Board (RSSB) holds data on failures of cuttings where debris (including trees) was run into by trains. Between 2 January 2001 and 24 September 2007 this data shows that there were a total of 46 landslips, excluding those at Kemble, Merstham, Moy and Oubeck summarised above. Two resulted in derailments of passenger trains, without significant injury.

Rainfall data at Kemble

86 Monthly rainfall data for the period January 2006 to February 2007 and daily rainfall data for the period 1 December 2006 to 31 January 2007 for the Kemble area were obtained from the Environment Agency. The measurements were recorded at Shorncote, located approximately 3.4 km due east of the derailment site.

87 The monthly figures for January 2007 and the preceding 3 months, and the corresponding long term averages for the period 1941 – 1970 are given in the table below. After a drier than average November 2006, monthly rainfall in December and January was higher than the long term average. The total rainfall figure in 2006 was slightly less (at 718.6 mm) than the long term average (at 751 mm). The spring and summer months of 2006 were a mixture of drier and wetter than average months. Notable dry months in the area were January, June and August 2006.

Month	Rainfall (mm)	Met. Office long term average (1941-1970) (mm)
October 2006	71.0	63.0
November 2006	67.8	77.0
December 2006	90.2	73.0
January 2007	91.2	68.0

88 The daily rainfall data shows a mixture of wet and dry days preceding the date of the derailment. Over the last seven days, 9 and 10 January had the greatest amount of rainfall at 12.8 and 16.0 mm respectively, the remaining days had little (< 3 mm) or no rainfall. The rainfall data for Shorncote is recorded as zero on 14 and 15 January. However, it was reported to RAIB by people at the site of the derailment that there had been heavy showers in the area during the days preceding the derailment.

89 The environment agency advised that one flood watch notice was issued on 8th January 2007 for the River Thames from its source just North of Kemble. No other flood notices were issued in January 2007.

[3] www.raib.gov.uk/publications/investigation_reports/reports_2006/report192006.cfm

Analysis

Identification of the immediate cause

90 The damage to the track started immediately after the 14 m long pile of concrete blocks and it was clear that the immediate cause of the derailment was the leading vehicle striking the blocks which had fallen from the collapsed wall adjacent to right hand cess. The impact resulted in the trailing wheelset of the leading bogie derailing to the outside of the right hand curve. It then continued close to the running rails until the train came to controlled stop.

91 It was not possible to determine the precise mechanism of derailment. The observed damage to the axle mounted brake discs and equipment attached to the bogie frame indicated that there were, very likely, upward acting vertical components of the impact forces, which could have unloaded the trailing wheelset. At the same time the bogie was probably forced to yaw to the right due to the greater depth of blocks and higher drag forces on this side. The right hand side of the bogie sustained greater damage than the left side.

Identification of causal and contributory factors

92 For the derailment to have taken place it was necessary for the concrete blocks to have reached the track. For this to happen two events had to happen; both of these events were necessary.

93 The manner in which the wall collapsed and the number of blocks strewn onto the line indicates that the wall did not collapse simply by itself but that it had been subjected to overload from the prior failure of the cutting. Therefore the failure of the cutting was a causal factor.

94 Very little of the material from the slope reached the line when the wall collapsed on 15 January 2007. Had the wall not been present, it is probable that the volume of slope material that would have reached the line would not have been sufficient to cause a train to derail. Therefore the collapse of the wall probably posed a greater risk to the railway than the cutting failure and was also a causal factor.

<u>The failure of the cutting</u>

95 The RAIB, after its investigation, concurs with the view of Network Rail's Western Territory contractor for special examinations, who prepared a report based on a visual inspection and analysis of the stability of the wall under water pressure. It concluded that the slip appeared to have been caused by local softening of the clay to a point where it failed and slid over the underlying rock. The failed mass from the upper section of the cutting overloaded the wall in a direction perpendicular to its face, causing it to collapse onto the track.

96 The failure appears to have been triggered by the heavier than average rainfall during the past months and a half (paragraph 86). This increased the water pressures within the upper slope which already had local pockets of instability resulting from the accumulation of loose clayey products of weathering which were already applying pressure to the wall. The recent heavy rainfall was therefore a contributory factor.

97 Although the rainfall during December 2006 and January 2007 had been higher than average, the drainage of the slope was also poor. There was standing water in the field adjacent to the crest but no functional crest drain, although there was evidence of an old crest drain which appears to have fallen into disrepair a long time ago. Additionally, the weep holes in the wall, which provide an outlet for water draining from the slope into the track cess, had been blocked since before 2001 (paragraph 73). Without proper drainage, the stability of the slope during wet periods would have been adversely affected. Therefore the poor drainage of the cutting at the failure location was a contributory factor. Drainage problems were also found to be key factors in the previous derailments at Moy (paragraph 80) and Oubeck (paragraph 82), in particular water from adjoining land.

98 The cutting was last inspected on 6 January 2004 and subsequently upgraded from 'poor' to 'marginal' on the basis of extensive vegetation clearance to remove trees from the north side cutting. This upgraded classification moved the cutting from an annual to a five yearly examination cycle.

99 It is not possible to say with certainty whether an annual inspection cycle, had it been continued, would have detected any signs that the cutting was becoming increasingly unstable. However, it was noted that the date of the derailment was soon after the third anniversary of the last inspection at which time the rainfall was still higher than average. Had the inspection continued annually, it is possible that signs of slope instability could have been picked up, during the wet period, and action taken before a derailment occurred. Therefore the increase in inspection interval from 1 to 5 years, for a cutting previously classified as 'poor', is possibly a contributory factor.

100 There is an issue regarding the accurate classification of earthworks and the setting of appropriate examination intervals. Other earthworks in the Kemble area that have failed (paragraphs 57 - 59) had been classified as 'serviceable'. Data from other earthwork failures on the Western Region (paragraph 60) also show the total number of earthwork failures within sites classified as 'serviceable' plus those classified as 'marginal' is greater than those classified as 'poor'.

101 The current processes for the management of earthworks on Network Rail have been developed over recent years and some earthworks which have failed were classified at a time when assessment methods were in their infancy. The information obtained during this investigation indicates that the classification of earthworks and the examination regime should be reviewed in the light of operational experience. Comparison between accidents involving cuttings indicates some of the key factors are state of the slope drainage, wetness of the adjoining land and the examination interval. Additionally, the time of year when an examination is undertaken on a given earthwork may affect how it is classified. These issues will be further considered in the RAIB report referenced at paragraph 3, where any necessary recommendations will be made.

<u>Collapse of the wall</u>

102 Inspection records for the wall show that it was judged to be in a satisfactory condition for its age and no repairs were deemed necessary by the examiners who undertook the periodic inspections.

103 The manner in which the wall collapsed and the fact that there was very little slope material deposited on the track indicates that the structural stability of the wall itself was marginal. The inspection analysis of the wall (paragraph 95) also suggested that influencing factors on the stability of the wall are likely to have been the increased water pressure behind it and the volume of accumulated fill.

104 On the day after the derailment, it was noted that there was little or no water flowing from the weep holes in the vicinity of the failure although the clayey slurry which flowed out from behind the collapsed wall indicated there was a high water content. The weep holes were therefore probably blocked. The detailed wall inspection on 2 October 2001 noted the weep holes were blocked but there is no evidence of remedial action taken to clear them out. Therefore the blocked weep holes were a contributory factor in the collapse of the wall.

105 The wall was classified as a 'retaining wall' in the structures database and all the inspection records. However, there is now some doubt within Network Rail about the purpose of the wall, for which there are no available design or construction details. The relatively low strength of the wall suggests that its purpose may have been to act as a 'facing wall' to protect the rock face from weathering and hold back small volumes of soil and/or spalled rock fragments from falling onto the line and not to provide structural support to the rock cutting. If the wall had been built as a 'facing wall' there would have been clearance between it and the rock face it was protecting.

106 The only classification option for walls of this type on Network Rail is 'retaining wall', even though the wall may possibly have been designed as a 'facing wall'. Structures examiners inspecting a 'retaining wall' would expect to see backfill up as high as the top of the wall. However, if a wall was classified and subsequently viewed as a 'facing wall', the presence of backfill and blocked weep holes should have raised issues about the build up of fill and water pressures acting on the rear of the wall and the implications of this on its stability. No concerns about the stability of the wall were raised in the inspections over many years, possibly because the examiners believed they were looking at a structural retaining wall, as denoted on the records. Therefore the classification of the wall at Kemble as a 'retaining wall' probably prevented a correct assessment of the wall's condition against the loading and is considered to have been a contributory factor.

Severity of consequences

107 Despite the derailment occurring on a curve, the outcome of the derailment in terms of casualties was favourable for several reasons:

- the speed of the train was 51 mph (82 km/h) when it derailed because the driver had begun braking for the stop at Kemble;
- the leading wheelset was not derailed, probably due to the protection afforded by the lifeguards;
- the concrete blocks were relatively lightweight and easy to crush or knock out of the way; and
- there were no facing points or other obstruction in the post derailment path.

Conclusions

Immediate cause

108 The immediate cause of the derailment was the leading vehicle of train 2G93 striking a large number of concrete blocks which had fallen onto the line from the collapsed wall adjacent to right hand cess.

Causal factors and contributory factors

109 There were two causal factors leading to the derailment, associated with the cutting slope and the wall. Both factors were necessary for the derailment to occur.

110 The first causal factor was the failure of the cutting, which caused the overloading of the wall and its subsequent collapse, spilling a large number of concrete blocks onto the line (paragraph 93).

111 The contributory factors which led to this were:

- the heavier than average rainfall during December 2006 and January 2007 (paragraph 96);
- the poor drainage of the cutting slope resulting from the lack of a functioning crest drain (paragraph 97); and
- the reclassification of the cutting as 'marginal' in 2004 from 'poor' which effectively increased its inspection interval from annually to 5 yearly (paragraph 99).

112 The second causal factor was the collapse of the wall. Although this was a consequence of the cutting failure, the wall itself probably posed a greater risk to the railway than the cutting failure and for this reason was itself a causal factor (paragraph 103, Recommendation 1).

113 In addition to the failure of the cutting, the contributory factors which led to the collapse of the wall under the loading imposed by the cutting slip were:

- the blocked weep holes which allowed water pressure to build up at the back of the wall in addition to pressure from the build up of slope material against the back of the wall (paragraph 104 , Recommendation 1) and;
- the classification of the wall at Kemble as a 'retaining wall' probably prevented a correct assessment of the wall's condition against the loading (paragraph 106, Recommendation 2).

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

114 Between 16 January 2007 and 17 August 2007, Network Rail carried out extensive remedial work at the site of the cutting slip and the surrounding area firstly to clear the track and then to stabilise the cutting to prevent recurrence of a similar incident.

115 An initial programme of works was undertaken prior to removal of emergency speed restriction on 28 February 2007 to stabilise the slope by installing shear keys, regrading to reduce the slope, rock combing, removal of loose material behind the wall, removal of rock overhangs and pumping out of standing water. Watchmen were posted around the clock and instructed to walk the stretch of track between the overbridge and tunnel several times a day during these works:

116 Further works were then carried out to complete the stabilisation of the cutting and comprised completion of a crest line cut-off drain, demolition of a further section of wall (90 miles 28.5 to 33 chains) and removal of loose material behind the back of the wall, stabilising the rock overhangs along the cutting. To improve drainage material was removed from behind the wall and backfilled with granular material and additional weep holes were drilled in the wall. A number of other works were carried out between 90 miles 03 chains and the derailment site.

Recommendations

117 The RAIB's further investigation report referenced in paragraph 3 will contain recommendations relevant to the causal and contributory factors associated with the earthworks issues of this investigation together with those which have a wider applicability to the management of earthworks across Network Rail. This reports recommendations deal only with other issues specific to this investigation.

118 The following safety recommendations are made[4]:

Recommendations to address causal and contributory factors

1 Network Rail should identify, through the examination process, any other wall on the network which has a similar construction to the block wall at Kemble, and is also a free standing wall in front of a natural slope. Network Rail should consider the stability of such walls against any likely loading, taking due account of the blockage of weep holes and other drainage problems. Network Rail should instigate remedial action as appropriate (paragraphs 112, 113).

2 Network Rail should undertake a review of the classification of walls on their infrastructure so that the purpose of each wall is correctly identified in the records and notified to structures examiners. Network Rail should inform structures examiners about any changes in the classification of structures that they are to examine in the current programme (paragraph 113).

[4] Duty holders, 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 ORR (HMRI) to enable them to carry out their 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 167 to 171) can be found on RAIB's website at www.raib.gov.uk

Appendices

Glossary of abbreviations and acronyms — Appendix A

DMU	Diesel multiple unit
OTMR	On train monitoring recorder
POD	Point of derailment
PSR	Permanent speed restriction

Glossary of terms — Appendix B

All definitions marked with an asterisk, thus (*), have been taken from Ellis' British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com

Backfill	Material which fills the gap between the wall and the adjacent rock face.
Cess	The area either side of the railway immediately off the ballast shoulder.
Cutting	An excavation that allows railway lines to pass through surrounding ground at an acceptable level and gradient.
Crest (wrt a cutting)	The top of a cutting slope.
Chains	1 chain = 22 yards or 1/80th of a mile.
Detailed examination (of structures) as defined in NR company standard RT/CE/S/083	A close examination of all accessible parts of a structure, generally within touching distance, of sufficient quality to produce a record that includes the condition of all parts of the structure, the uses to which the structure is being put, recommendations for remedial action and any other relevant facts.
Earthwork	An embankment, cutting or natural slope.
Emergency brake	A brake application that uses a more direct and separate part of the control system, that as a result may be quicker, to signal the requirement for a brake application, than that used for the full service application. On certain vehicles, the retardation rate may be specified to be higher than that of the full service application and is described as 'enhanced emergency braking'.
Evaluation	An appraisal of all relevant information and circumstances relating to an earthwork including its condition, use and location to establish whether action is required to ensure that the level of safety and serviceability of an earthwork remain acceptable.
Examination (wrt earthworks)	A regular visual examination of an earthwork to identify and record signs of slope instability.
Landslip	A slide of a large mass of dirt and rock down a mountain or cliff.
Lean-mix concrete	Low strength concrete which contains a smaller proportion of cement.
Lifeguard	Heavy metal brackets fitted vertically immediately in front of the leading end wheels of a rail vehicle, one over each rail. Their purpose is to deflect small objects away from the path of the wheels.*
'Marginal' (wrt earthwork condition)	The mid-risk categorisation (between poor and serviceable) of an embankment, cutting or natural slope in accordance with NR/SP/CIV/065.
Mobile Operations Manager	A Network Rail operations manager who provides first line response to incidents.*
Overbridge	A bridge that allows passage over the railway.*

Permanent speed restriction	A speed restriction applied permanently to a length of Track because it has a maximum Permissible Speed lower than the Linespeed for that Route.*
'Poor' (wrt earthwork condition)	The highest risk categorisation of an embankment, cutting or natural slope in accordance with NR/SP/CIV/065.
Regrade	To amend the angle of an earthwork slope by removing or redistributing material.
Rock combing	A process of identification and removal of loose rock elements form a rock face (to prevent such debris falling onto the railway).
Scar	The surface within the bank that is left exposed following a landslip.
'Serviceable' (wrt earthwork condition)	The lowest risk categorisation of an embankment, cutting or natural slope in accordance with NR/SP/CIV/065.
Slip (wrt earthworks)	A slide of a large mass of dirt and rock down a mountain or cliff.
Slope stability hazard index	Quantitative method for determining the failure risk of an earthwork.
Special examination (wrt earthworks)	An out of course examination of an earthwork undertaken where there is concern regarding its stability or following a failure.
Structures (wrt Network Rail)	Any construction such as a Bridge, Tunnel or Retaining Wall, but excluding Embankment and Cutting slopes, which are Earthworks.*
Up	The railway line that is predominantly used by trains travelling in the direction towards London.
Visual examination (of structures) defined in NR company standard RT/CE/S/083	An examination to identify changes in the condition of a structure carried out from a safe observation location, without using special as access equipment but using permanent access ladders and walkways, binoculars and hand held lighting where necessary.
Watchman	A person employed specifically to observe the condition of an element of infrastructure and report or take other specified action in the event of undesirable movement.
Weep hole	A hole or pipe provided at or near ground level to allow water to escape.*
Wheelset	The combination of two wheels and axle.
Wheel skates	A device to enable a vehicle with damaged wheels or wheelset to be moved on the rails at slow speed as part of a recovery operation.

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