RAIB

Rail Accident Investigation Branch

Rail Accident Report

Derailment of a passenger train near Dryclough Junction, Halifax
5 February 2011

Department for Transport

Report 17/2011
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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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Derailment of a passenger train near Dryclough Junction, Halifax, 5 February 2011

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Summary

At 06:07 hrs on Saturday 5 February 2011 a derailment occurred close to Dryclough Junction, in Halifax. Both vehicles of a two-car passenger train were derailed when the train ran into stone rubble on the track. The rubble had fallen from a retaining wall beside the line which had collapsed during the night. There were eight passengers and two crew members on the train and nobody was injured in the accident.

The collapse of the wall followed a period of heavy rain.

The local authority highways department had reported cracks in the pavement behind the wall to Network Rail on several occasions, most recently in October 2010, and had closed the footpath as a precaution.

The investigation found deficiencies in the examination of the wall by Network Rail's examination contractor and in the way in which Network Rail handled reports from Calderdale Metropolitan Borough Council concerning problems with the wall. The limited extent of repairs made to the wall in 2006 also contributed to its failure.

The RAIB has made five recommendations to Network Rail, relating to the structures examination process, the control of minor civil engineering construction works and the system for dealing with reports from third parties of problems with Network Rail infrastructure.

Preface

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 or liability, or carry out prosecutions.

Key Definitions

3 All dimensions and speeds in this report are given in metric units, except speed and locations on Network Rail, which are given in imperial dimensions, in accordance with normal railway practice. In this case the equivalent metric value is also given.

4 The terms left and right in this report are relative to the direction of travel of the train.

5 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.

The accident

6 At 06:07 hrs on Saturday 5 February 2011, train 2T02, the 05:55 hrs passenger service from Hebden Bridge to Leeds, derailed after striking a pile of debris as it approached Dryclough Junction (figure 1). The debris had fallen onto the track following the collapse of a *retaining wall* at the top of the cutting slope beside the line.

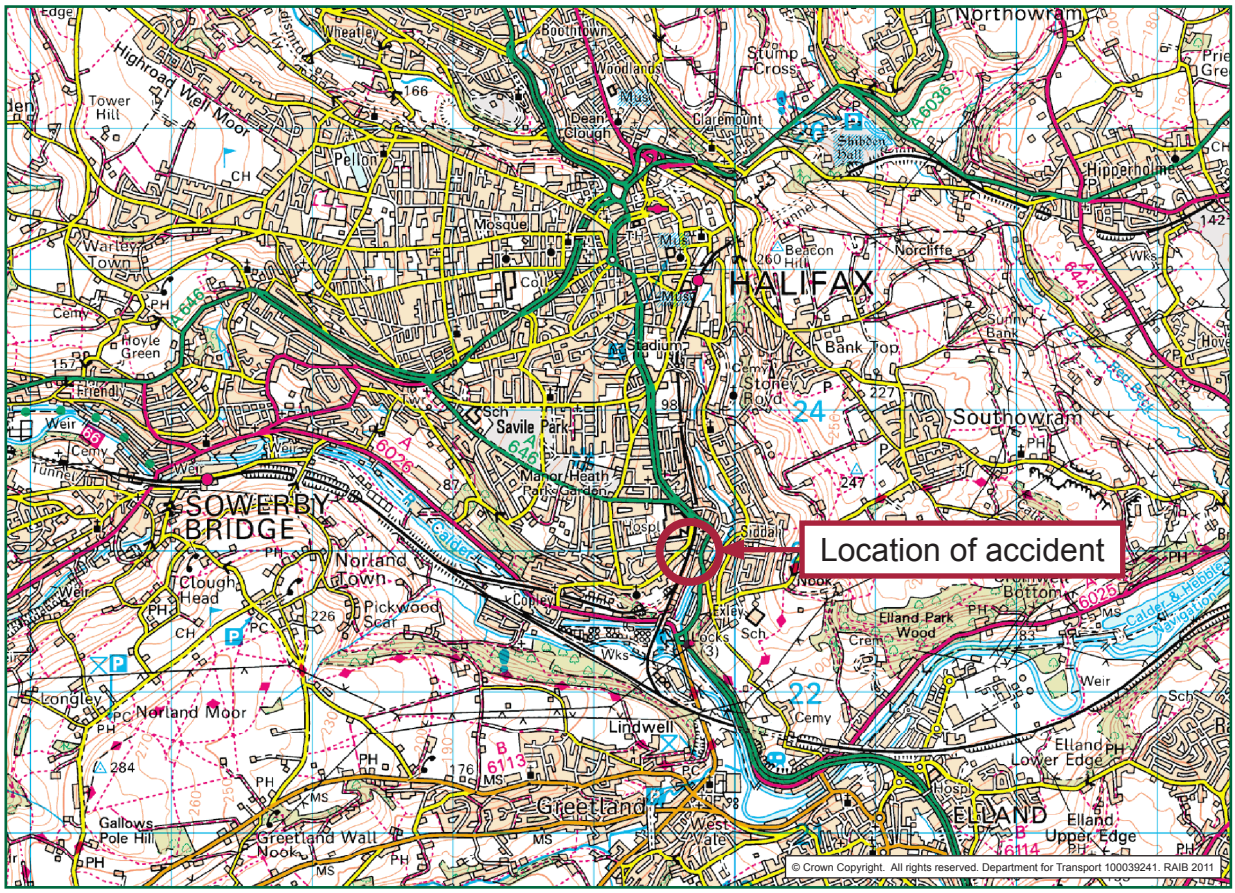

Figure 1: Extract from Ordnance Survey map showing location of accident

7 The train consisted of a two-car *diesel multiple unit* and both vehicles in the train were derailed by their leading *bogies*. The vehicles were derailed to the left and away from the other line.

8 There were eight passengers and two crew members on the train. Nobody was injured in the derailment.

9 There was extensive damage to equipment mounted on the underside of the train and to the bogies, wheels and axles. The track was also damaged over an 18 m length.

Location

10 The derailment occurred on the *down* line between Milner Royd Junction and Dryclough Junction (*engineer's line reference* MRB) at *milepost* 31 between Bank House Tunnel and Dryclough Junction. The railway at this location consists of two tracks; the *up* line and the down line (figure 2). There are another two tracks parallel to these at a lower level, which form the Greetland Junction – Dryclough Junction line. These are visible in some of the figures, but were not relevant to this accident.

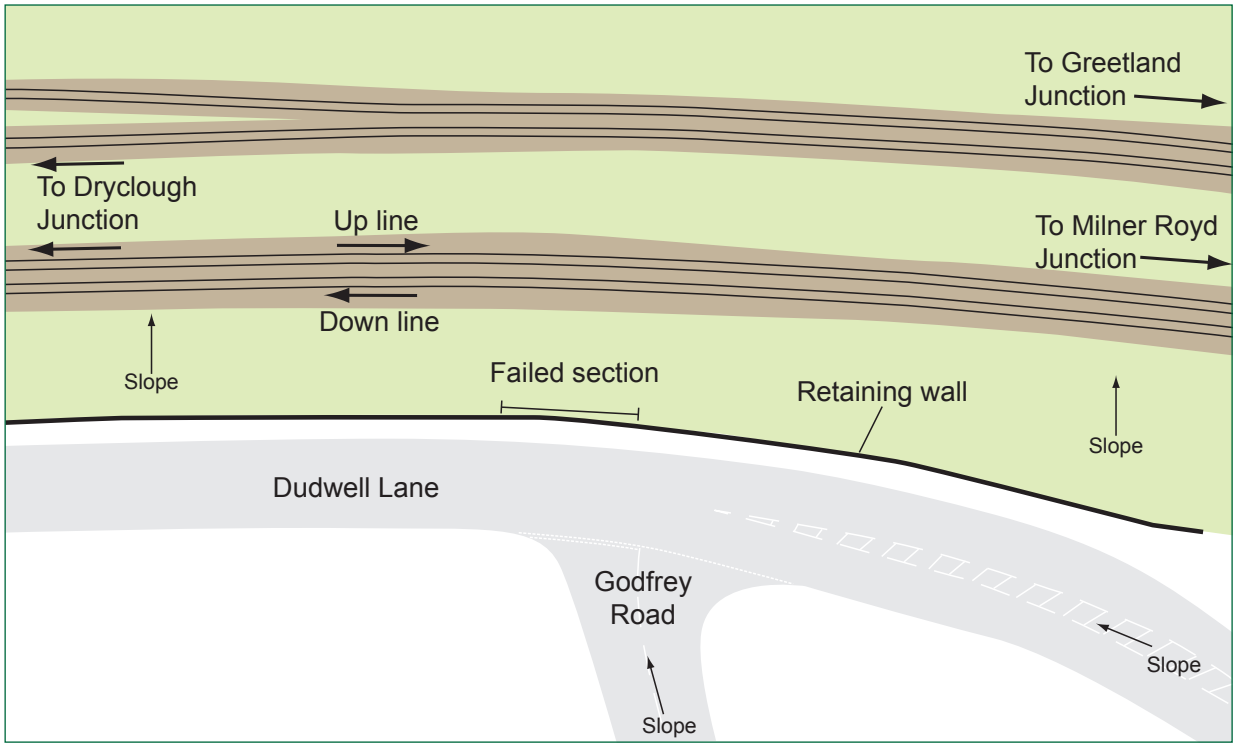

Figure 2: Plan of the area

11 The line is curved to the left in the direction of travel of the train and is cut into the hillside. The cutting slope on the left restricts forward visibility of the track. The maximum permitted speed is normally 60 mph (96 km/h). At the time of the derailment there was a temporary speed restriction of 30 mph (48 km/h) in place on the down line due to poor track condition.

12 A public road, Dudwell Lane, runs parallel to the railway at a higher level and is separated from it by the retaining wall and cutting slope. The portion of retaining wall which failed is opposite the junction between Dudwell Lane and Godfrey Road (figure 2).

The organisations involved

13 The train was operated by Northern Rail Ltd, who also employed the train driver and conductor.

14 The track was owned, operated and maintained by Network Rail. It was part of its London and North Eastern (LNE) Route.

15 The retaining wall was owned by Network Rail and was periodically examined for them by Amey under their Civil Examinations Framework Agreement (CEFA) contract. Maintenance of the wall had been undertaken for Network Rail in 2005-06 by Amco Rail under a Network Rail minor works contract. Prior to 2006 the examinations were undertaken by Owen Williams Railways. Owen Williams Railways changed its name to Amey OWR when the Owen Williams group was acquired by Amey group in February 2006.

16 The footpath and road at the top of the wall were owned by the local authority, Calderdale Metropolitan Borough Council (MBC). Calderdale MBC inspected and maintained the footpath and road.

17 Northern Rail, Network Rail, Amey, Amco Rail and Calderdale MBC freely co-operated with the investigation.

Equipment

18 The train consisted of a two-car class 158 diesel multiple unit, no. 158 851. The train was built in 1991 and was leased by Northern Rail from Angel Trains Ltd.

19 The retaining wall was known within Network Rail as retaining wall MRB/31A1. The wall varied in height along its length and the maximum height was 5.4 m. The base of the wall was approximately 9 m above the level of the railway. The top part of the wall formed a parapet wall beside the pavement. Its total length was 374 m. The wall was built from stone masonry and was originally entirely of *drystone* construction. Some areas, including the section which failed, had been repaired at various times by rebuilding with mortared joints.

External circumstances

20 The weather at the time of the accident was wet and it had rained heavily the previous day. It was dark when the previous train had passed the site and it was still dark at the time of the accident. There were strong winds with rain during the night before the accident.

Events preceding the accident

21 The train began the day's service by running empty from Leeds to Hebden Bridge. The route taken by the train on this leg of its journey did not include the Dryclough Junction to Milner Royd Junction line.

22 The train reversed at Hebden Bridge and became the 05:55 hrs service to Leeds via Bradford. The train called at Mytholmroyd and Sowerby Bridge stations then took the Bradford route towards Dryclough Junction at Milner Royd Junction. It was the first train of the day in either direction to pass over the Milner Royd Junction to Dryclough Junction line.

23 The previous train over this route was the 23:20 hrs service on 4 February from Manchester Victoria to Leeds via Halifax which had passed the site at 00:22 hrs on 5 February. The driver of this train did not report any obstruction of the line.

Events during the accident

24 The train was travelling at 30 mph (48 km/h) round the curve when the driver noticed rocks on the line in front of the train. He applied the emergency brake and pressed the emergency button on the *NRN radio*.

25 The train struck the rocks and rode up over them, derailing the leading bogie of each vehicle to the left side. The driver reported hearing several loud bangs from beneath the train as further rocks were struck. The rear bogies remained on the track.

26 The train came to a stand 60 m from the initial impact location.

Figure 3: The derailed train

Events following the accident

27 The driver's emergency NRN call was answered by the Network Rail operations controller. The driver initially gave the wrong location for the accident, stating that he had just left Summit tunnel instead of Bank House tunnel. This was due to the driver being shocked and disorientated by the accident. The controller subsequently established the correct location by speaking to the relevant Network Rail signaller.

28 The conductor went through the train to check that the passengers and driver were uninjured. The conductor then maintained contact with the controller on the NRN radio while the driver checked the damage to the train and confirmed with the Halifax signaller that *protection* was in place.

29 The driver and conductor then stayed with the passengers until the Network Rail incident officer arrived to take charge of the accident site.

30 The derailment was reported to the RAIB at 06:30 hrs and an inspector was immediately deployed to the site to conduct a preliminary examination of the accident.

31 The passengers on the train were transferred to another train brought alongside the derailed train and were taken away from site at 09:08 hrs. The train was released by the RAIB for recovery at 13:20 hrs and the train was rerailed and removed at 00:58 hrs the following day. The line reopened to traffic at 15:17 hrs that day (6 February 2011).

The Investigation

Sources of evidence

32 The following sources of evidence were used:

- examination of the site and the train;
- the train's on-train data recorder (OTDR);
- photographs taken after the derailment by the RAIB, British Transport Police and Network Rail;
- photographs of the area taken before the derailment by Owen Williams Railways/Amey, Calderdale MBC and Network Rail;
- maintenance records for the wall from Network Rail and Amco Rail;
- inspection records for the wall from Network Rail;
- documents relating to the design of repairs to the wall in 2006 from Network Rail and Amey;
- as-built drawings and records of the 2006 repair work from Network Rail and Amco Rail;
- records of inspection of the footpath and road from Calderdale MBC;
- records of communications between Calderdale MBC and Network Rail's *community relations team*;
- records from Network Rail's CARRS, MONITOR and CRM computer systems;
- Network Rail's paper files for the retaining wall; and
- witness accounts from staff involved in the inspection, maintenance and repair of the wall.

Key facts and analysis

Background information

Structures examination regime

33 The key procedures that Network Rail mandates for the management of its structures are defined in Network Rail company standard NR/L1/CIV/032 'The management of structures'. This standard defines a three part process for structures management:

- steady state management;
- option appraisal; and
- intervention.

The latter two parts are applicable where maintenance or renewal intervention is required. The process of steady state management defines the following activities as routine management:

- listing and identification of structures;
- examination;
- assessment;
- evaluation;
- responding to reports; and
- record keeping.

34 The requirement to list and identify the retaining wall was met by its inclusion in Network Rail's Civil Asset Register and electronic Reporting System (CARRS) and by the identification number '31A1' painted onto the wall.

35 The examination of retaining walls was specified in Network Rail specification NR/SP/CIV/083 'Examination of retaining walls'. This was issued in April 2004 and was based on parts of an earlier standard RT/CE/S/017 'Examination of Structures'. It was replaced in June 2010 by NR/L3/CIV/006/05A 'Handbook for the examination of Structures – Part 5A: Retaining Walls'. Standard NR/L3/CIV/006 'Handbook for the examination of Structures' consists of a number of parts covering different types of structure and introduced the concept of risk-based examination intervals, though risk based intervals had not yet been applied to retaining walls or earthworks.

36 Part 1B of NR/L3/CIV/006 defines the examination regime for all types of structure. For a retaining wall such as MRB/31A1 the relevant examination regime consists of:

- detailed examinations to record the condition of all accessible parts of the structure and any significant change since the last examination;
- visual examinations to identify significant visible changes in the condition of the structure since the previous detailed examination and significant defects not identified in previous examinations; and
- additional examinations when a detailed or visual examination provides insufficient information for an evaluation of the structure, or elements of the structure require monitoring.

37 Part 1C of the standard defines the process to be followed to determine the interval between detailed examinations, using a risk-based approach. As Network Rail had not yet implemented this for retaining walls since the issue of the standard in June 2010 (paragraph 35), the fixed intervals defined in the earlier standards were used at retaining wall MRB/31A1, namely detailed examination every six years and visual examination every year.

Structures management arrangements

38 Network Rail employs Amey to carry out examinations of its structures, earthworks and buildings under its CEFA contract. The CEFA contract has its own technical specification, containing conditions derived from NR/SP/CIV/083 for retaining walls, and it does not mandate compliance with Network Rail standards. For structures, the examination cycle begins in October/November of each financial year when Network Rail sends Amey a provisional list of the structures which are to be examined the following financial year (1 April to 31 March). This list is finalised before the start of the year and includes the type of examination each structure is to receive.

39 Amey's structures examiners carry out the examinations and input their reports, including photographs and sketches as required, into a computer system Amey run called ALARM. The examination reports in ALARM are then reviewed by an Amey examining engineer. The purpose of this review is to determine whether any work is required to be done to the structure to rectify defects found by the examiner. The review also checks the technical quality of the report.

40 The examining engineer risk assesses each item of work that he/she deems is required on the basis of the likelihood and consequence of an event (using a *5x5 risk matrix* specified by Network Rail). The risk scores for each item of work are recorded in the report in ALARM. The reports in ALARM are then transferred electronically to Network Rail's CARRS system (paragraph 41).

CARRS System

41 Network Rail has a computer system called CARRS to assist with the management of its structures. The system holds historic information on each structure in a database that is used by the structures management engineers when making decisions on the management of the structure. The examination reports are input to the system and can be viewed alongside other information, such as the record of repairs that have been made, when deciding what action needs to be taken to ensure the structure remains in a safe and serviceable condition.

42 A Network Rail structures management engineer views examination reports in CARRS and can list examination reports in various ways, including by maximum risk score. The structures management engineer carries out an *evaluation* of each structure to determine what work must be carried out on it to maintain acceptable levels of safety and performance. Work that he decides is required is entered into CARRS along with the timescale for completing it. These work items are then taken from CARRS and passed to the Infrastructure Projects part of Network Rail for implementation by their contractors.

Competence arrangements

43 Network Rail standard NR/SP/CTM/017 'Competence and Training in Civil Engineering' defines competencies of staff involved in the examination and management of civil engineering work (table 1). Structures examiners are required to hold a Network Rail competence, STE 4 'examine the condition of structures'. Their competence is assessed by their line manager using a combination of questioning and observation and they must first have successfully completed a structures examination course approved by Network Rail.

Competence Reference	Description
STE1	Ensure that structures remain fit and safe for use
STE2	Review results of structures examination and recommend actions where necessary
STE3	Visually examine minor structures
STE4	Examine the condition of structures
STE5	Examine the condition of station structures and buildings
STE6	Examine the condition of tunnels and shafts
STE7	Examine the condition of underwater structures

Table 1: Structures examination competencies in NR/SP/CTM/017

44 The examining engineer is required to hold competence STE 2 'review results of structures examination and recommend actions where necessary'. The structures management engineer is required to hold competence STE 1 'ensure that structures remain fit and safe for use'. Candidates for these competencies must undergo on the job training and a period of mentoring prior to being assessed as competent by their line manager.

45 Structures management engineers, examining engineers and examiners are required to perform their tasks a minimum of four times in each twelve month period in order to retain their competencies.

Identification of the immediate cause[1]

46 **The derailment was caused by the train running into debris from the collapse of 13 m of retaining wall MRB/31A1 that had slid down the cutting slope onto the track (figure 4).**

Figure 4: Collapsed section of the wall

Identification of causal factors

Examination of the wall

47 **The overall management of the retaining wall did not maintain the structure in a safe condition. This was a causal factor in this accident and was in turn due to a combination of the following linked factors:**

a) an omitted detailed examination (paragraph 48);

b) visual examinations did not report cracks in the pavement (paragraph 56);

c) the process of examination sign-off by the examining engineer was vulnerable to the risk of error by omission (paragraph 63);

d) Network Rail was not notified that an examination was overdue for 8 months (paragraph 67); and

e) the cutting slope on which the wall stood was not in the earthworks database (paragraph 69).

[1] The condition, event or behaviour that directly resulted in the occurrence.

Detailed Examinations

48 The detailed examination due in 2009 was not carried out. Its omission was a factor in this accident.

49 The most recent detailed examination prior to the accident was on 7 July 2003 and was carried out by an Owen Williams Railways structures examiner (examiner 1). The report of this examination was signed off by the Owen Williams Railways examining engineer on 30 July 2003 and the only work noted as being required were masonry repairs and removal of overhanging tree branches. Network Rail's structures management engineer wrote on the form that only the second item was to be done (removal of branches). Cracks in the pavement behind the wall were not mentioned by the examiner despite being visible in one of the photographs (figure 5). Such cracks show that there were movements in the material beneath the pavement and were an indication of a problem with the wall.

Figure 5: Pavement behind the wall in 2003 showing cracks (highlighted) from 2003 detailed exam report (courtesy of Network Rail)

50 Network Rail's CEFA contract began on 3 May 2009 and replaced the previous cost-reimbursable Structures Examination Contract (SEC). Retaining wall MRB/31A1 was included in the list of structures to receive a detailed examination that year (2009/10). Amey was the examinations contractor in LNE Territory prior to the CEFA contract and so was already aware of which retaining walls were due a detailed examination. An Amey examiner (examiner 2) visited the wall on 16 April 2009 and found that vegetation obscured it and prevented access for a detailed examination and that *roped access* would be needed. He filed a "pre-detailed inspection" (PDI – referred to as a reconnaissance visit in the CEFA contract) report recording this in Amey's ALARM system (paragraph 39). A PDI report is done when an examiner is unable to perform the detailed examination because some action is required by Network Rail first.

51 The examination reports in ALARM are transferred electronically to Network Rail's CARRS system. In order for this to happen each report is required to have a CARRS examination ID number assigned to it. Network Rail have stated to the RAIB that, at the start of the CEFA contract, CARRS was not capable of accepting PDI reports. Network Rail did not want reports delivered by any means other than that through CARRS, so did not issue Amey with the necessary examination ID numbers. The PDI report for wall MRB/31A1 was therefore not transferred to CARRS. CARRS was subsequently altered to allow input of PDI reports.

52 The CEFA contract required Amey to report to Network Rail any enabling work needed before an examination could take place. The PDI report was Amey's means of doing this. Network Rail asked Amey, in October 2009, to advise them of the requirements contained in PDI reports by means of a list (known as the tracker spreadsheet). There were several versions of this list and wall MRB/31A1 was not included in any of the early versions. Its omission was not noticed until March 2010 and it was first included in the version sent to Network Rail on 11 March 2010. The entry for the wall correctly stated that vegetation clearance and roped access was needed.

53 The wall was one of 75 structures due a detailed examination in 2009/10 which were carried over into 2010/11. Network Rail stated at a meeting with Amey on 6 May 2010 that these examinations were now urgent and, where they could not be carried out before week 12 of the 2010/11 financial year (week commencing 28 June), a visual examination was to be done in the interim. Network Rail did not issue Amey with an order for this at the meeting. Network Rail issued a change request to Amey to substitute visual examination for the detailed exam in 2009/10 and to carry out the detailed examination in 2010/11. This change request was issued on 22 June 2010 and Amey conducted the visual examination on 24 June 2010.

54 Network Rail issued a work order to Amco to clear the vegetation from the wall on 28 June 2010 with a requirement to complete the work within 16 weeks. The reason for the choice of time allowed for completion is not recorded. Amco carried out vegetation clearance work on most of the wall, including the section which collapsed, in October 2010, although some vegetation remained further along the wall at the time of the accident. The order for the work required Amco to telephone Amey's examinations delivery manager to tell him when the work was complete. This call was made, but the Amey manager who received it had by then transferred the examination job to a different manager and it is not clear whether the call was passed on.

55 The detailed examination due in July 2009 had not taken place when the wall collapsed on 5 February 2011. The omission of this examination was a factor in this accident because it was a missed opportunity for the pavement cracks to be noticed.

Visual Examinations

56 The cracks in the pavement were not recorded in any of the reports from the visual examinations nor were they reported following the detailed examination report in 2003 even though they were visible in the photographs. The non reporting of cracks by the examiners was a factor in this accident.

57 Network Rail standard NR/SP/CIV/083 stated that visual examinations are required every 12 months (paragraph 37). Following the 2003 detailed examination visual examinations were carried out by examiner 1 in July 2004, August 2005, August 2006, September 2007 and August 2008. The next examination was due to be a detailed examination in July 2009 but, as described above, this was not done and a visual examination was carried out instead by a different examiner, examiner 3, in June 2010. None of these examinations reported cracks in the pavement behind the wall.

58 NR/SP/CIV/083 lists the features that should be reported in a detailed examination. This includes *'evidence of foundation movement, sliding or settlement affecting the structure'* and *'signs of subsidence, heave, misalignment, cracking or movement of the ground, track or adjacent structures'*. The standard requires that '*visual examinations shall be sufficient to identify and record:*

- *any observed defect that has not been identified in the previous Detailed Examination or subsequent Visual Examination;*
- *the development of any new defects or any worsening of previous defects, giving particular attention to any known defect to assess whether the rate of deterioration is changing;'*

The CEFA technical specification also contained these requirements, although in some cases the wording was slightly different.

59 The cracks in the pavement at the site of the wall collapse were repaired in 2006 (paragraph 89). Photographs taken on completion of this work in August 2006 showed that the footpath had been resurfaced and so these cracks were no longer present when the 2006 visual examination was carried out. There were, however, cracks in the pavement further up Dudwell Lane that appeared in one of the photographs in the 2003 examination report that were still present after the accident.

60 Calderdale MBC reported new cracks in the pavement behind the wall at the site of the 2006 repair to Network Rail in April 2008. They were not mentioned in the report of the visual examination in August 2008 or in the 2010 visual examination report.

61 Network Rail standard NR/SP/CTM/017 defines competencies of staff involved in the examination and management of civil engineering work (paragraphs 43 to 45). Examiner 1 was certified as competent to the previous standard, RT/CE/S/047 in March 2004. His most recent reappraisal prior to his last examination of wall MRB/31A1 was in April 2007 when he was assessed as competent to STE 4 of NR/SP/CTM/017. Examiner 1 retired in 2008. Examiner 3, who carried out the 2010 visual examination of the wall, was certified as competent to RT/CE/S/047 in April 2004. He underwent annual reappraisals, the most recent of which prior to the 2010 visual examination was on 26 April 2010 when he was assessed as competent to STE 4 of NR/SP/CTM/017.

62 The non reporting of the cracks by the examiner was a factor in this accident because the cracks were clear indications of a problem with the wall. Network Rail's system for managing its structures was dependent on complete and reliable condition information being provided by the examiners in the examination reports.

Evaluation by the examining engineer

63 As the examining engineer worked from photographs and the examination report, the process was dependent on the examiner's ability to identify new defects, and was vulnerable to the risk of error by omission. This dependency combined with the insufficient independent checking was a factor in this accident.

64 The Amey examining engineer marked the 2010 visual examination report 'No action required at present' and wrote 'none' in the 'Notes for Attention' box. The examining engineer did not visit the site and was not required to do so. The competence required for an examining engineer is STE 2 'Review the results of structure examination and recommend actions where necessary'. The engineer who dealt with the 2010 report was assessed as competent to STE 2 in November 2006. His last annual reappraisal of this competency prior to the 2010 visual examination was in April 2010, when he was assessed as competent.

65 As the examining engineer reviews a large number of reports each day[2] and must make a judgement on whether the structure will remain safe for the next 12 months with only the information in the report, the process relies on the examiner noting all of the defects. Although there are some technical audits, there is generally no independent checking of the examiner's work on site unless the examining engineer notices a defect that happens to be picked up in the photographs. The examiner is required to always submit photographs with a detailed examination report but only with a visual examination report if there are significant defects. The examiner is expected to identify the defects and photograph them. The process is therefore vulnerable to the risk of error by omission. This was a factor in this accident because Network Rail's system for managing its structures was dependent on complete and reliable condition information being provided in the examination reports.

66 This same issue was also noted by the RAIB as being an underlying factor in the incident that occurred at a bridge in Feltham (paragraph 108).

Identification of late/missing examinations and reports

67 Network Rail was not notified that an examination was overdue and that a report had not been submitted until March 2010. This was a factor in this accident.

68 Network Rail's CARRS system contains copies of the detailed and visual examination reports for their structures. The dates of these examinations are recorded and also the interval between examinations. There is, however, no facility in the system to compute the date when the next examination is due or to identify to the structures management engineer when this date has been passed and no report has been received. This was a factor in this accident because had he been aware of this it may have prevented the detailed examination due in 2009 being omitted.

[2] The RAIB investigation into the failure of bridge RDG1 48 (River Crane) between Whitton and Feltham on 14 November 2009 (report 17/2010) found that the examining engineer reviewed an average of 70 reports per day.

Examination of the cutting slope

69 The cutting slope on which the wall stood was not in the Network Rail earthworks database and so had not been examined. If it had been examined, it is probable that the earthworks examiner would have noticed the pavement cracks. The omission of the slope from the database was a factor in this accident.

70 Network Rail standard NR/L1/CIV/032 includes earthworks in its definition of a 'structure' and specifies that the steady state management activities are also to be applied to earthworks over 3 m high or whose failure might pose an unacceptable risk to the railway. The cutting slope beside the line at Dryclough junction qualified on both these criteria. NR/L1/CIV/032 was first issued in April 2004 and was revised and reissued in September 2009. The 2009 version had a compliance date of 5 December 2009.

71 The first stage of the management process in NR/L1/CIV/032, 'listing and identification of structures', was not carried out for the slope on which this wall stood. The other stages depend on this first stage. The RAIB has been unable to determine why the cutting was not in the Network Rail earthworks database.

72 No earthworks examinations had taken place on this cutting slope. Network Rail's standard for earthworks examination, NR/L3/CIV/065, states that where safe to do so, observation of the earthwork shall be made from both the toe and the crest. As access to this slope was easy from the crest, examination of this cutting slope would have included it. If earthworks examinations had taken place here, the significance of the pavement cracks may have been noticed and acted upon. This omission was a probable factor in this accident.

The way Network Rail dealt with third party reports of infrastructure problems

73 **Calderdale MBC had reported problems with the wall to Network Rail on several occasions, the most recent prior to the accident being in October 2010. Network Rail did not deal effectively with this information and did not have an adequate process for dealing with it. This was a causal factor in this accident. The reduced level of staffing in the route geotechnical engineer's team at the time was also a possible factor.**

74 Network Rail publishes the telephone number of a national help line on their website for members of the public to contact them regarding their infrastructure. There is no special arrangement for other infrastructure owners, such as highway authorities (Calderdale MBC was the highway authority for Dudwell Lane) to contact Network Rail; they use the public help line. The help line is manned continuously allowing urgent problems to be passed on to Network Rail's route control offices at any time of day or night. Management of the help line service is the responsibility of Network Rail's community relations team. Most enquiries to this line are from lineside neighbours and concern Network Rail's boundary fences or overhanging vegetation, which are dealt with by Network Rail's maintenance organisation. The community relations team liaises with infrastructure maintenance protection coordinators (MPCs) in each infrastructure maintenance depot to deal with these issues.

75 The community relations team used a computer system known as the customer relationship management (CRM) system to track these reports. The report by Calderdale MBC in 2005 was not dealt with in this way as the community relations CRM system had not been introduced at that time.

76 Calderdale MBC contacted the help line on 29 April 2008 to report that the footpath was cracked behind the retaining wall at the site where the 2006 repairs had been made. Network Rail community relations passed the report to the local MPC who asked for more information on the fault from Calderdale MBC. Having obtained this information, the MPC passed the details to Network Rail's route geotechnical engineer. The route geotechnical engineer was not aware of the 2006 repairs and neither was the member of his team that he asked. There is no record of any further action taken in response to this report.

77 Following a footpath inspection, a Calderdale MBC highways inspector contacted the Network Rail help line on 28 July 2010 to report cracking in the pavement behind the wall at the same location as had been previously reported by the council in 2008. The help line operator who received the call on 28 July 2010 was unable to find the previous report from 2008.

78 The report was passed on to the local MPC who visited the site on 4 August 2010. The details given to the MPC stated that there was a problem with the wall and the MPC understood that he was looking for a breach in it. He found that there were no breaches in the wall but saw evidence of repair at the site of the 2006 work. He reported back to community relations on 5 August that there were no breaches in the wall and that it was intact and fit for purpose. The CRM system records that a letter was sent to Calderdale MBC's highways inspector to this effect but the RAIB has been unable to find a copy of the letter.

79 Calderdale MBC's highways inspector recalled being told by Network Rail that there was no problem with the wall, but did not have a copy of the letter. He issued a work request to fill the pavement cracks with bitumen to seal them. This work was done by the council's contractor on 22 October 2010.

80 The contractor sealing the pavement cracks on 22 October 2010 found that they were much deeper than anticipated and contacted the highways inspector. He visited the site that day with his manager. They considered that the cracking was evidence of a significant structural problem and they arranged an urgent footpath closure. They noted that Amco were on site clearing vegetation from the wall at the same time. This was the vegetation clearance work ordered by Network Rail in June 2010 (paragraph 54).

81 Calderdale MBC's highways inspector contacted the Network Rail help line on 26 October, quoting the reference number of the July 2010 report. He stated that the council did not agree that there was not a problem with the wall and described how the cracks had consumed a relatively large volume of bitumen and that they thought that this was evidence of a significant structural problem. He sent a photograph of the pavement to Network Rail's community relations operator by email (figure 6). Having had no reply from Network Rail, he called again on 28 October.

Figure 6: Pavement behind the wall in October 2010 showing cracks (courtesy of Calderdale MBC)

82 Community relations recognised that the second call on 28 October was about the same matter as the first and closed down the second report. The first report was then passed to the MPC who visited the site on 1 November. He saw that vegetation clearance work had been done recently and thought that it was likely that the route geotechnical engineer was carrying out investigation work. He asked community relations to pass the report on to an earthworks engineer (engineer 1) in the route geotechnical engineer's team.

83 Engineer 1 checked what information was available in the earthworks database for this area and discovered that none of the earthworks slopes at this location were registered in the database and so there was no information and no earthworks examinations had taken place. Engineer 1 was about to start a period of extended absence and so emailed the report to another earthworks engineer, engineer 2, for him to deal with.

84 Engineer 2 was covering the absence of another earthworks engineer, engineer 3, as well as his normal duties. Network Rail did not have a process for assigning a priority to these reports. Engineer 2 was unable to deal with the report immediately due to other work commitments and visited the site on 22 December 2010 when there was a layer of snow and ice completely covering the footpath. Engineer 2 was preoccupied by the need to record the earthwork slopes at the site and forgot about the pavement cracks which were in any case hidden beneath the snow. There was no formal system for ensuring that the assigned examination activities were undertaken.

85 When engineer 1 passed on the report to engineer 2, community relations was informed. As it appeared that the route geotechnical engineer's team was dealing with the problem, community relations closed the report. Network Rail did not contact Calderdale MBC to inform them that the report had been closed. There was no formal system for following up actions taken by Network Rail in response to third party reports, other than for actions taken by community relations staff.

86 Network Rail took no further action regarding the wall or the earthworks slopes prior to the collapse of the wall on 5 February 2011.

87 The reduced staffing level in the route geotechnical engineer's organisation at the time of the report of the pavement cracking was a factor that possibly contributed to no clear priority being given to the task of investigating the report. There was no system to record, trace or prioritise such problems and so it was not prioritised and investigated effectively. Even when the site was visited the actual problem was overlooked.

88 The RAIB observes that the MPC had received no training or guidance on how to determine whether the report of a problem should be passed to the earthworks or structures engineer. In most cases this choice is obvious, but in cases like this where the problem involves a structure (the retaining wall) and an earthwork, there was no guidance.

Previous wall repair did not fully address the problem

89 **A repair made to the wall in 2006 was of limited extent and did not fully address its underlying stability problem. The repaired section of wall then failed in 2011. This was a causal factor in this accident and the following factors contributed to the outcome:**

- **the lower section of the wall was assumed to be sound and no monitoring or investigation was carried out to verify this in 2005-06;**
- **the design of the wall repair was changed on site without full consideration of whether it was still appropriate;**
- **a specified drainage layer behind the repaired wall was omitted; and**
- **site inspections by Network Rail's site construction engineer did not identify that the wall was not being built according to the design drawing.**

90 The wall was originally of drystone construction and dated from the time of construction of the railway in the 19th century. The wall had suffered problems in the past and a short section at the Milner Royd Junction end collapsed and was rebuilt by British Rail in 1984. The section opposite Godfrey Road which failed in 2011 had been repaired prior to 2005 as photographs taken at that time showed repaired areas, but the RAIB could not find any record of these repairs.

91 In April 2005, a member of the public reported cracks in the pavement behind the wall to Calderdale MBC. Calderdale MBC's structural engineering consultant was asked to investigate and he visited the site on 25 April 2005. He was concerned by the cracking and arranged for part of the footpath to be closed to pedestrians. He then contacted Network Rail's structures management engineer to report the problem. These cracks had not been reported by Network Rail's own examinations. The structures management engineer asked the examinations contractor, Owen Williams Railways, to send a geotechnical engineer to investigate and to monitor the wall. Owen Williams Railways began weekly additional examinations monitoring the width of the cracks in the pavement. Network Rail also asked their minor works contractor, Amco, to design and build a permanent repair for the damaged section of wall and to have Owen Williams Railways prepare the design.

92 Owen Williams Railways carried out a *soils investigation* of the ground around the wall as the first stage of the scheme to design the permanent repair. This reported that the wall appeared to be stable below the level of a *string course* of larger stone blocks. The level of this string course was not precisely defined.

93 The weekly additional examinations showed that the cracks in the pavement became wider following heavy rain and Network Rail issued a works request to Amco on 29 July 2005 to take down the top section of the wall within 7 days to prevent the risk of it collapsing onto the line. The wall was taken down to pavement level by 5 August and some more of the wall was removed the following week.

94 Network Rail approved the design of the repair scheme on 18 January 2006 and instructed Amco to proceed with the works. The repair works consisted of excavating the fill material behind the wall down to the string course level then replacing it with concrete backed by a drainage layer.

95 Amco began the repair work on site on 25 March 2006. When excavation started Amco discovered that the string course was much closer to the surface of the pavement than had been anticipated. Figure 7 presents a cross section of the wall with the original and revised extent of the repair, the position of the pavement cracks and the 2011 failure surface indicated. Amco asked Amey (Owen Williams Railways was acquired by Amey in February 2006) whether the design of the repair would still be satisfactory with a reduced depth of concrete above the string course. Witness evidence indicated that Amey's designer considered it would be satisfactory as the resulting new section of wall would not be so tall as originally designed and therefore would be more stable. The stability of the wall below the level of the repair was not considered, neither was consideration given to the matter of whether the repair was still appropriate given the reduced depth.

96 The contract for the repair of the wall was let by Network Rail's Major Projects and Investment (MP&I) organisation. MP&I had site construction engineers who visited sites where work was being carried out. One of the site construction engineers visited the retaining wall repair works every week during the work to check that the works were being carried out safely and in accordance with the design. His reports stated that the work was being carried out in accordance with the design and did not mention the omission of the drainage layer behind the wall.

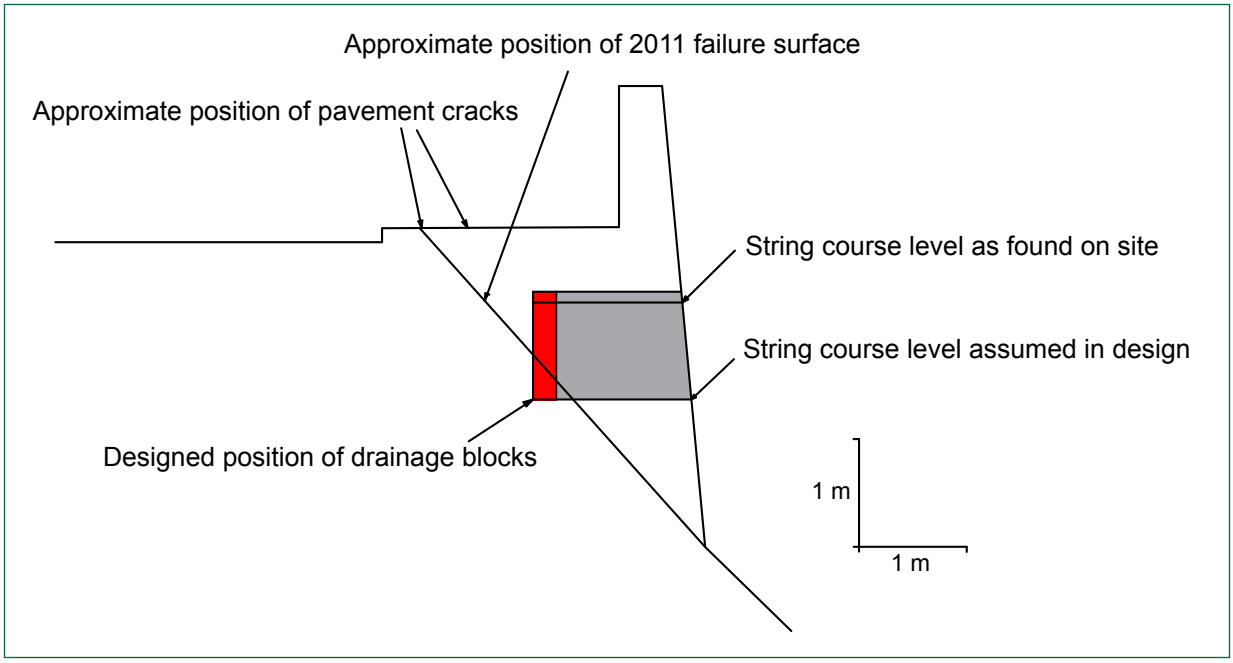

Figure 7: Cross-section of the wall and pavement

97 The 2006 repair of the wall was not backed up by any monitoring or investigation into the stability of the lower section of the wall. Therefore the design probably did not address the underlying stability problem as the repair was confined to the upper section of the wall. Similarly if the redesign due to the shallower string course had considered the relative position of the actual string course level to the pavement cracks it is likely that the need for a more extensive repair would have been recognised.

Environmental factors

98 The calculated capacity of the wall was very close to the applied load from the ground behind it. The presence of an increased amount of water in the ground behind the retaining wall would have increased the load on the wall and was the most likely factor to have triggered the wall to fail when it did.

99 Heavy rain had fallen in the area during the 24 hours prior to the wall's failure. The pipe connecting the road drains behind the wall was broken in several places and was leaking. The presence of this additional water, either as a result of heavy rain or the broken pipe, was a probable factor to the accident occurring when it did.

100 The additional examinations undertaken in 2005 showed that the cracks in the pavement opened up after periods of heavy rain. The local weather on the day before the accident was heavy rain and there was further heavy rain and strong winds during the night of 4/5 February 2011. Dudwell Lane is situated on a hillside which slopes down towards the railway and Godfrey Road also slopes down towards the line. Water running down these roads was directed towards the site of the wall.

101 After the accident Network Rail commissioned a CCTV survey of the pipe which connects the road drains on Dudwell Lane. This found that the pipe was extensively fractured from a point approximately 46 m upstream from the wall collapse to a point approximately 12 m upstream from the wall. The damage to the pipe would have reduced its capacity and led to water backing up and finding alternative drainage paths, possibly through the soil, at times of heavy rainfall. Figure 8 shows water flowing over a road drainage gulley in Dudwell Lane shortly after the derailment, showing that it was unable to handle the flow of water. All of the gullies were able to handle the reduced flow of water after the rain had stopped falling later that day.

Figure 8: Road drain in Dudwell Lane shortly after the derailment (Courtesy of BTP)

102 While the cracks in the pavement were most pronounced at the site of the failure, there were also cracks in the pavement at other places behind the wall (figure 9). After the accident Network Rail's geotechnical consultants calculated that the *factor of safety* of the wall was close to 1.0. A typical value for a retaining wall would be between 1.5 and 2.0[3]. The additional load caused by the soil behind the wall becoming more waterlogged after heavy rain may have been sufficient to overcome this small margin.

[3] This is the ratio of the probable load to the probable resistance of the wall.

Figure 9: Pavement cracks behind a different section of the wall after the derailment (courtesy of Network Rail)

103 The pavement cracks in figure 6 are in a similar position to those which appear in the 2003 detailed examination report photographs (figure 5 and paragraph 49). The cracks show that the wall has been moving, albeit very slowly, since at least 2003. Network Rail's regular examination process of the wall should have detected this, allowing investigation of the reason for the movement and the necessary repairs to be carried out. These repairs may have included repairing the leaking pipe. Although the Water Industries Act 1991 obliges sewerage undertakers to maintain the sewerage system, the RAIB has not investigated the ownership, maintenance or inspection of the road drainage. Whilst the leaking pipe may have contributed to the accident, the regular inspection process of the retaining wall should have detected the problem in time to allow effective repairs to take place.

Previous occurrences of a similar character

104 Derailments due to the failure of civil engineering structures are infrequent, but the following recent incidents have occurred where a civil engineering structure failed and the regular inspection process did not provide an effective warning.

105 On 15 January 2007 a passenger train was derailed when it ran into debris from the collapse of a retaining wall at Kemble in Gloucestershire. The retaining wall was sited at the foot of a soil slope which had failed. This failure led to overloading of the retaining wall which subsequently collapsed onto the track. The RAIB investigated this accident (report 07/2008 available at www.raib.gov.uk) and made two recommendations. Neither of these recommendations were relevant to the derailment at Dryclough Junction.

106 On 27 January 2009 bridge no. 88 between Stewarton and Kilmarnock collapsed as a train of loaded tank wagons, each weighing 102 tonnes, was crossing it. A major fire and pollution incident ensued. The collapse was due to the poor condition of the main girders of the bridge. The centre main girder webs had not been examined and the examination contractor had warned Network Rail of the poor condition of the outer main girder but Network Rail had taken no action in response. The RAIB investigated this accident (report 02/2010 available at www.raib.gov.uk) and made twelve recommendations. None of these recommendations were relevant to the derailment at Dryclough Junction.

107 A train driver reported a dip in the track on Enterkin Burn viaduct on the Kilmarnock to Gretna line on 20 June 2009. The structure is a curved four span masonry viaduct and staff sent to investigate the report found that longitudinal cracks up to 90 mm wide were present between the *spandrel* and the *arch barrels*. The previous visual examination of the structure on 28 July 2008 had not reported cracking and the previous detailed examination on 14 February 2004 did not report *'anything untoward for a structure of this age'*. Network Rail closed one of the lines over the viaduct and carried out emergency repairs before reopening it. A programme of special inspections of similar structures was instigated and another viaduct on the same line was also found to require special monitoring and stabilisation works.

108 A brick arch bridge carrying the railway over a river at Feltham partially collapsed on 14 November 2009 leading to a dip in the track which was reported by a train driver. The collapse was due to *scour* of the material beneath one of the abutments. The scour had been made worse by obstruction of the river by trees and other debris. A tree and other debris was present on 20 August 2009. The visual examination undertaken on 2 October 2009 did not report any obstruction of the river but by 28 October 2009 there was a larger accumulation of trees and debris than in August. The bridge was reconstructed before the tracks were reinstated over it. The RAIB investigated this incident (report 17/2010 available at www.raib.gov.uk) and made six recommendations. One of these was relevant to the derailment at Dryclough Junction (paragraph 110).

109 Part of a small bridge spanning a watercourse beneath the railway near Bromsgrove was discovered to have collapsed on 6 April 2011. Network Rail track maintenance staff had noticed an ongoing loss of ballast beneath a running line during the preceding days, and on 6 April this was traced to a hidden underline structure. The lines over the structure were closed to traffic while emergency repairs were carried out. The previous detailed examination in 2005 did not include examination of the section under the running lines due to access difficulties, but the examination report was marked as 'complete/visual examination only' and Network Rail did not identify that a significant part of the structure had been omitted. The annual visual examinations did not look inside the culvert. The RAIB are investigating this incident.

Previous recommendations relevant to this investigation

110 Recommendation 3 of the RAIB report into the Feltham partial bridge collapse (paragraph 108) stated;

'Network Rail should re-consider the purpose of the role currently performed by the examining engineer and then identify the information and resources (including time) that are required to undertake the task effectively. This may include:

a. requiring bridge examiners positively to confirm that particular requirements for different types of bridge have been considered during an examination, for example by means of a checklist within the examination report;

b. requiring bridge examiners to submit elevation photographs of bridges spanning watercourses, which show the surface of the water at each pier and abutment, and direction of flow for the purpose of identifying obstructions; and

c. requiring bridge examiners to submit supplementary photographs in support of a visual examination report to enhance the level of information available to the examining engineer.'

111 Part c. of this recommendation, as an example of the information and resources that should be provided to the examining engineer, is relevant to this accident as the examining engineer cannot identify defects which the examiner missed without such photographs. The recommendation refers to bridge examiners, but implementation of it will also be applicable to examiners of retaining walls because the Network Rail competence requirements cover both bridges and retaining walls.

112 This recommendation is not remade here to avoid duplication.

Summary of Conclusions

Immediate cause

113 The derailment occurred because the adjacent wall was unable to retain the fill material behind it after heavy rain and it collapsed onto the track where it remained undetected until the train arrived (**paragraphs 46 and 98**).

Causal factors

114 The overall management of the retaining wall did not maintain the structure in a safe condition (**paragraph 47 and Recommendation 3**). This was due to a combination of the following linked factors:

a) the detailed examination of the wall due in 2009 was not carried out (**paragraph 48**);

b) the visual examinations did not report the cracks in the pavement behind the wall (**paragraph 56 and Recommendation 3**);

c) the process of examination sign-off was vulnerable to the risk of error by omission (**paragraph 63 and Recommendation 3**);

d) missing examinations or examination reports were not reported to the structures maintenance engineers (**paragraph 67 and Recommendation 2**); and

e) the cutting slope on which the wall stood was not in the Network Rail earthworks database and had not been examined (**paragraphs 69 and 123 and Recommendation 5**).

115 The way in which Network Rail dealt with reports of pavement cracking from Calderdale MBC was a causal factor (**paragraphs 73 - 86 and Recommendation 4**). The reduced level of staffing in the route geotechnical engineer's organisation at the time was also a possible linked factor (**paragraph 87 and Recommendation 4**).

116 The repair made to the wall in 2006 was of limited extent and did not fully address the underlying stability problem. This was a causal factor (**paragraph 89 and Recommendation 1**).

Environmental factors

117 The presence of water in the material behind the wall was a probable factor. This would have been made worse by the recent heavy rain and the damage to the road drainage pipe nearby (**paragraph 98**).

Underlying Factors

118 The system of regular examinations made no recommendations for action that would have maintained the wall in a safe condition. The examination reports produced by the examiner did not mention the cracking in the pavement and the examining engineer did not notice their omission. The process is dependent on the examiner identifying new defects. There is generally no independent checking of the examiner's work and therefore it is vulnerable to the risk of error by omission. This was an underlying factor in this accident and was also an underlying factor in the Feltham incident (**paragraph 47 and Recommendation 3**).

Observations

MPC's training

119 The MPC was not given any training or guidance on how to determine which part of Network Rail is best placed to deal with a problem relating to a structure or earthwork (**paragraph 88 and Recommendation 4**).

Contract and compliance

120 The CEFA (paragraph 15) contract does not mandate compliance with Network Rail company standards. The contract instead contains conditions which are derived from the Network Rail standards that were current at the time the contract was being drafted (late 2008). For retaining walls this was NR/SP/CIV/083. The contract requires that Network Rail provide the contractor with a list of structures to be examined each year. This list includes the type of examination to be done and the due date. The requirement in NR/SP/CIV/083 for a maximum interval of six years between detailed examinations is not included in the contract and the contractor was free to conduct the examination at any time in that financial year (April 1 to March 31). This matter is included in an improvement notice which the Office of Rail Regulation (ORR) has served on Network Rail (paragraph 122) and consequently the RAIB makes no recommendation.

Actions reported as already taken or in progress relevant to this report which would otherwise have lead to a recommendation being made

121 Following the previous incidents relating to structures (paragraphs 106 to 108), the ORR investigated Network Rail's structures management process and produced a report 'STR 10.1 Structures'. The ORR found a number of shortcomings in Network Rail's management of its structures and, of relevance to this accident, found that Network Rail had no effective means of identifying which structures examinations were overdue or had not been reported (paragraph 67). The ORR made a recommendation, reference Sc N5, that '*Network Rail establish how many structures are more than 3 or 6 months past their due examination date and have not been examined or have not had their examination report loaded in the CARRS system'*. Network Rail undertook to implement this recommendation by 30 June 2011. As Network Rail has already undertaken to determine which structures are overdue examinations, the RAIB makes no further recommendation in this area.

122 The ORR issued Improvement Notice I/303293339/JPMcG to Network Rail on 20 May 2011 regarding its structures management process. The notice includes the following requirements which were relevant to this accident:

- [item 1] define maximum permissible limits by which examination intervals may exceed the stated interval (paragraph 120); and
- [item 6] produce an action plan including, if necessary, arrangements for amending the CEFA contract so that timescales for undertaking examinations imposed under the contract align with those defined in item 1 (paragraph 120).

As Network Rail must comply with this improvement notice by 30 November 2011, the RAIB makes no recommendation in this area.

123 The route geotechnical engineer has added the cutting slopes at Dryclough Junction to the earthworks database and arranged for their inclusion in the list of earthworks to be examined by Amey (paragraph 69).

Recommendations

124 The following safety recommendations are made[4]:

1 *The purpose of this recommendation is to improve control of minor civil engineering works schemes to ensure that changes to the design made during the implementation phase do not compromise the effectiveness of the works.*

Network Rail should review its arrangements for controlling the implementation of minor civil engineering works. This should include consideration of how deviations from the design are identified, assessed and accepted, and by whom, so that the original intent of the civil engineering work is not compromised. Any necessary improvements should be implemented.

2 *The purpose of this recommendation is to provide Network Rail staff with a means to identify structures whose examination has been missed or has not been loaded into CARRS and define how they should deal with the risks this may pose. The system should also assist in preventing examinations from being missed.*

Network Rail should implement a process that:

- identifies and highlights structures examinations that are overdue, or whose examination report has not been effectively transferred to Network Rail's computer system;
- defines what action is to be taken regarding these missing examination reports; and
- identifies and highlights structures whose examination due date is imminent but no examination has been scheduled.

continued

[4] 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 ORR 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 167 to 171) can be found on RAIB's web site at www.raib.gov.uk.

3 *The purpose of this recommendation is to increase the likelihood of long running or significant defects in a structure being identified by the engineers responsible for its management.*

In conjunction with its examination contractor, Amey, Network Rail should review the effectiveness of the existing structures examination regime and implement any changes found necessary. The review should include, as a minimum:

- consideration of why examiners do not always report persistent defects; and
- a consideration of whether the examination system should be enhanced to require supervisors and/or engineers to periodically inspect structures.

4 *The purpose of this recommendation is to provide support to the MPCs to allow them to determine who is best placed to deal with problems reported via community relations concerning structures and earthworks and to define a system, including time limits, so that structures and earthworks staff can correctly prioritise their work.*

Network Rail should put in place adequate arrangements for dealing with external reports on possible problems with its structures and earthworks, and provide appropriate training and guidance to its community relations staff (including MPCs). The arrangements should include guidance on appropriate response times for both community relations and structures and earthworks staff when dealing with these reports, the basis upon which the reports should be prioritised and a system to ensure that defects identified are followed through.

5 *The purpose of this recommendation is to check whether there are any other earthworks missing from Network Rail LNE Route's earthworks database, and hence are not being examined.*

Network Rail LNE Route should check whether there are any earthworks missing from their examinations database. Any such earthworks found to be missing should be inserted into the database and arrangements made to examine them.

Appendices

Appendix A - Glossary of abbreviations and acronyms

ALARM	Amey's system for managing structures examinations
CARRS	Civil Asset Register and electronic Reporting System
CCTV	Closed circuit television
CEFA	Civil examinations framework agreement
CRM	Customer relationship management (computer system)
MBC	(Calderdale) Metropolitan Borough Council
MONITOR	Network Rail computer system for minor works
MP&I	Major Projects and Investment
MPC	Maintenance protection coordinator
NRN	National radio network
ORR	Office of Rail Regulation
OTDR	On-train data recorder
PDI	Pre-detailed inspection
SEC	Structures examination contract

Appendix B - Glossary of terms

5x5 risk matrix	A means of indicating risk on the basis of likelihood and consequence of an event. The matrix has axes of likelihood and consequence severity, each divided into five categories and the risk is read from the body of the matrix. The risk is based on the score of likelihood multiplied by consequence severity; the higher the score the higher the risk.
Arch barrel	The load bearing part of an arch bridge.
Bogie	An assembly of four wheels on a frame pivoted beneath the coach.
Community relations team	The group of people within Network Rail who deal with issues relating to line side neighbours and others.
Diesel multiple unit	A diesel powered passenger train able to run as part of a train with other similar vehicles.
Down	The name generally given to lines used by trains travelling in the direction away from London. In this case it is from Milner Royd Junction towards Dryclough Junction.
Drystone	A method of construction where individual pieces of stone are placed together to form a wall without the use of mortar in the joints.
Engineers' line reference	A short alphanumeric label applied to a section of railway to aid identification of civil engineering assets on that line.
Evaluation	An appraisal of all relevant information regarding the stability, load-bearing capacity, condition and use of a structure to determine the actions required to maintain acceptable levels of safety and performance. (Definition from Network Rail standard NR/L1/CIV/032.)
Factor of safety	The ratio of the calculated capacity of a structure divided by the load applied to it. A factor of 1.0 implies that there is no margin between the applied load and the structure's capacity.
Milepost	A post at the side of the line which indicates the distance from a datum point, usually the start point of that line.
NRN Radio	National radio network radio. The national radio network is a railway network for communication between trains and controllers.
Protection	The means by which other trains are prevented from approaching a disabled train.
Retaining wall	A structure intended to retain soil at a higher level on one side than the other.
Roped access	A means of gaining access to elevated areas using abseil techniques.

Scour	The erosion of material from beneath a structure by the action of running water.
Soils investigation	A type of site investigation which involves sampling the material which makes up the ground around and beneath a structure.
Spandrel	The part of an arch bridge which forms the side wall and retains the fill material beneath the track.
String course	A horizontal layer of masonry which projects slightly from a wall.
Up	The name generally given to lines used by trains travelling in the direction of London. In this case it is towards Milner Royd Junction.

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