



Rail Accident Investigation Branch

Rail Accident Report



**Dangerous occurrence at Denmark Hill station
1 August 2013**

Report 23/2014
October 2014

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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Any enquiries about this publication should be sent to:

RAIB	Email: enquiries@raib.gov.uk
The Wharf	Telephone: 01332 253300
Stores Road	Fax: 01332 253301
Derby UK	Website: www.raib.gov.uk
DE21 4BA	

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Dangerous occurrence at Denmark Hill station, 1 August 2013

Contents

Summary	5
Preface	6
Description of the incident	7
Infrastructure	8
Network Rail's examination and maintenance regime	10
Key facts and analysis	12
Immediate cause	12
Causal factors	12
Table 1: Timeline for Atlantic Lines span and the identification of underlying factors	14
Underlying factors	19
Observation	23
Previous RAIB recommendations relevant to this investigation	24
Table 2: Previous recommendations made by the RAIB	25
Conclusions	28
Actions already taken	29
Learning point	30
Recommendation	31

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Summary

At about 16:00 hours on Thursday 1 August 2013, concrete cladding fell from the bridge spanning Denmark Hill station, London, and most of the debris landed on platform 1. The fallen concrete was reported by two train drivers and train services were stopped on the line closest to the fallen concrete. Fortunately no-one was struck and there was no damage to trains. However, train services were disrupted until 02:48 hrs the following day while emergency repairs were carried out.

The concrete cladding had been added to the bridge structure in about 1910 and fell because of gradual deterioration of the fixing arrangements. Deterioration of the cladding fixing arrangements had been reported to Network Rail over a period of at least four years but the resulting actions taken by Network Rail and its works contractor were inadequate.

The RAIB has identified several factors which led to the absence of appropriate remedial work. Urgent repairs were not implemented in a timely manner and information collected by examiners was not entered promptly onto Network Rail's asset management database (CARRS). Communications between Network Rail's asset management and works delivery team were sometimes ineffective. Remedial work was not always precisely specified, staff implementing the work sometimes lacked the necessary competencies, and processes for verifying completion of remedial work were inadequate. Repeated reports of the same defect should have, but did not, lead Network Rail to recognise that remedial works instructions were not achieving the intended effect. The high workload of some staff is a possible factor. Non-compliance with Network Rail's maximum permitted intervals between bridge examinations was noted but was not a factor in the incident.

The report contains one recommendation and one learning point in addition to referencing previous RAIB recommendations relevant to issues identified at Denmark Hill. The recommendation requires Network Rail to review its processes for evaluating reported defects and managing the associated repairs. The learning point reinforces the importance of rigorously recording structure defects reported by examiners.

Preface

- 1 The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability.
- 2 Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.
- 3 The RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of all other investigations, including those carried out by the safety authority, police or railway industry.

Description of the incident

- 4 At 16:14 hrs on 1 August 2013 the driver of train 9M44¹, the 16:00 hrs service from Clapham Junction to Highbury & Islington, reported to the signaller that there was an object hanging from a bridge at Denmark Hill station. About six minutes later, the driver of train 2U56, the 15:38 hrs service from Dartford to London Victoria, reported that a section of concrete had fallen onto platform 1 and that it was unsafe for his train to proceed (figures 1 and 2).

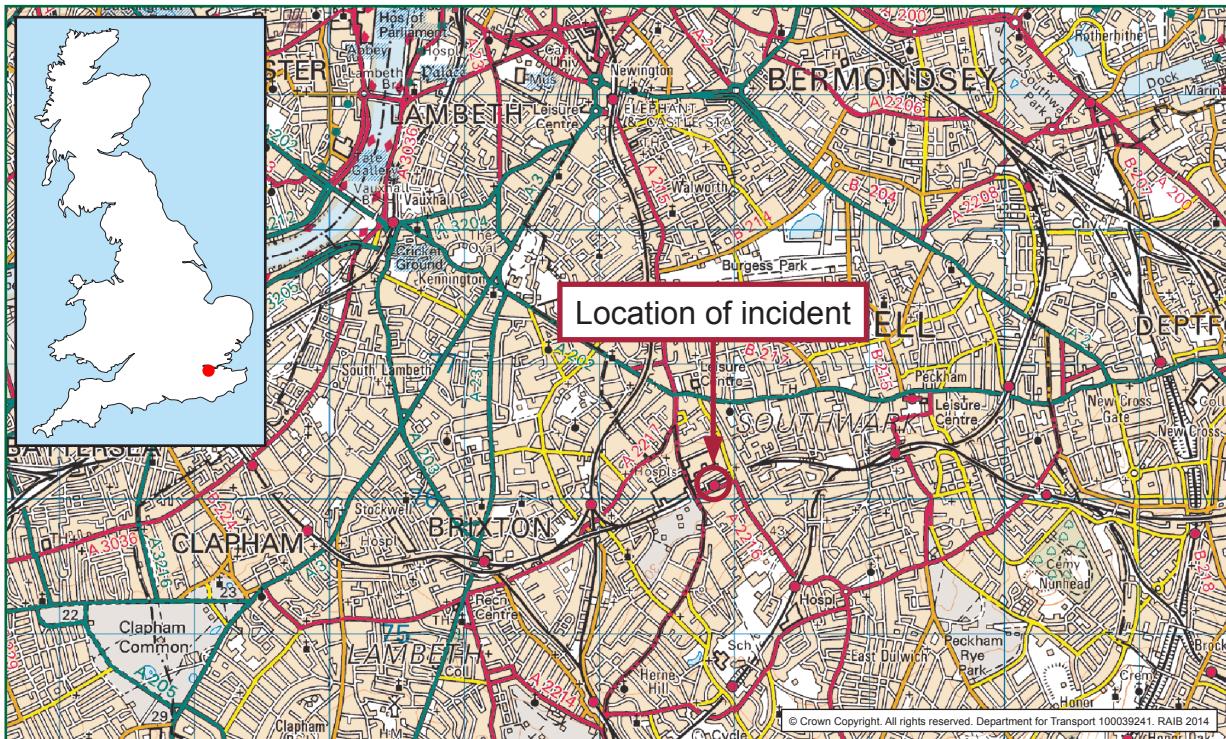


Figure 1: Extract from Ordnance Survey map showing location of incident

- 5 One line through the station was closed immediately and a second was subsequently closed to permit emergency repairs. These were completed to allow reopening of both lines at 02:48 hrs the following day. The incident caused no injuries but did result in disruption to train services. However, had the concrete fallen when a passenger was underneath, it could have caused serious injuries.

¹ An alphanumeric code, known as the 'train reporting number', is allocated to every train operating on Network Rail's infrastructure.



Figure 2: The incident

Infrastructure

- 6 Two pairs of railway tracks run through Denmark Hill station. The southern pair is known as the Atlantic Lines, and the northern pair as the Catford Loop Lines. These are served by four platforms. Platform 1, to the south of the railway, abuts the Up² Atlantic Line. Platforms 2 and 3 share an island between the Down Atlantic Line and the Up Catford Loop Line. Platform 4 is to the north of the railway track abutting the Down Catford Loop Line (figure 3). A bridge carries a roadway, Windsor Walk, and station buildings over the platforms and tracks, with Windsor Walk on the west side of the bridge. This bridge crosses the railway in two spans, one over the Atlantic Lines and the other over the Catford Loop Lines.
- 7 The bridge was built in about 1865 using metal girders to span across the railway. Drawings dated 1910 show that the girders were clad with concrete at about that time but neither the detail of the cladding, nor the reason for cladding, are given. The outermost girder adjacent to Windsor Walk is referred to as the Windsor Walk edge beam in this report.

² At Denmark Hill station, up lines normally carry trains travelling towards London Victoria and London Blackfriars while the down lines normally carry trains in the opposite direction.

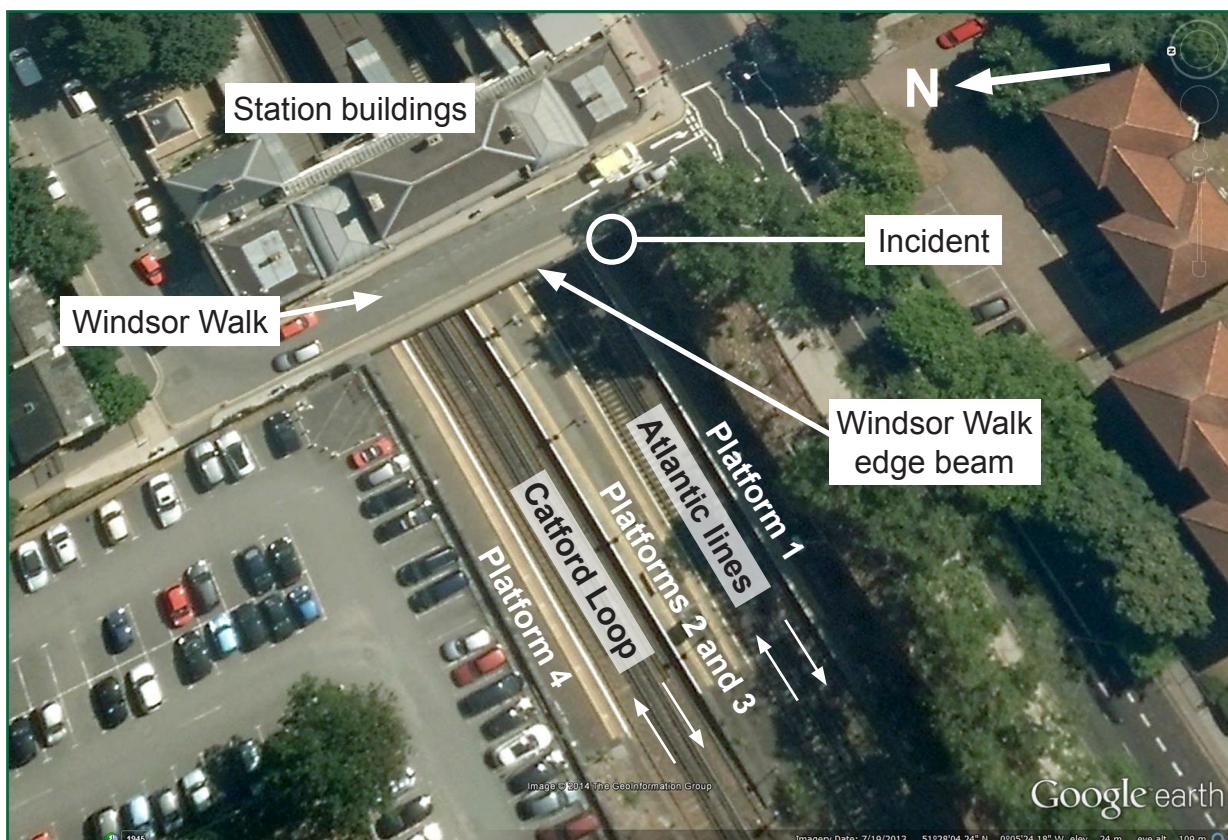


Figure 3: Denmark Hill station

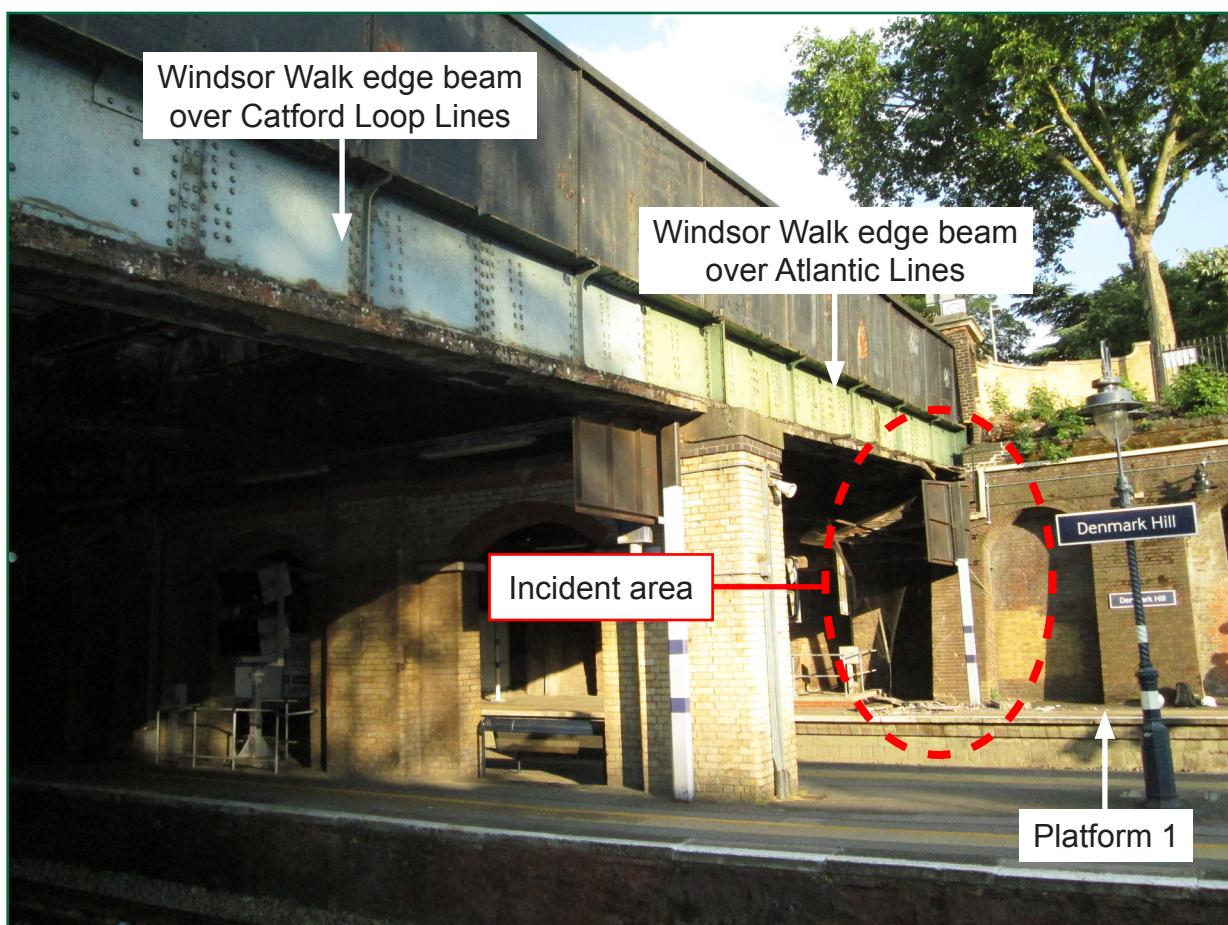


Figure 4: Windsor Walk edge beam over Catford Loop Lines

- 8 The bridge is owned by Network Rail. In this capacity, Network Rail is responsible for ensuring that the bridge is regularly inspected and maintained in accordance with its own company standards. The minor works associated with the repairs to the bridge were contracted by Network Rail to a building and civil engineering contractor, B & M McHugh Limited (the minor works contractor).

Network Rail's examination and maintenance regime

- 9 Network Rail's routine inspection and maintenance process for bridges such as that at Denmark Hill is based on examinations undertaken by a Network Rail examination contractor at nominally annual intervals and is shown diagrammatically on figure 5. A bridge examiner visits the site and describes their findings in a report which is reviewed by an examining engineer. If the examining engineer considers that any repairs are necessary, they add appropriate recommendations to the report including a timeframe within which the repairs should be completed.
- 10 An asset manager (normally a Network Rail engineer assigned to the asset management team) evaluates the report and, provided that they agree with the content, enters details of any recommended repair work onto the Network Rail CARRS database. They also give an instruction for the repair to Network Rail's works delivery team which is responsible for procuring the work from a minor works contractor. The procurement process is tracked by the works delivery team who make entries on Network Rail's Monitor database. These entries include the date that the request is entered on Monitor, and the subsequent completion of site work and associated commercial processes. CARRS should also then be updated by an asset manager to show that repair work has been completed after the commercial processes are shown as complete in Monitor.
- 11 Examinations of the two spans of the Denmark Hill bridge are carried out at different times because one span is examined as part of the Atlantic Lines examination programme and the other span is part of the Catford Loop programme. However, Network Rail asset management engineers consider information about both spans when instructing maintenance work, and a single work item often includes work on both spans.

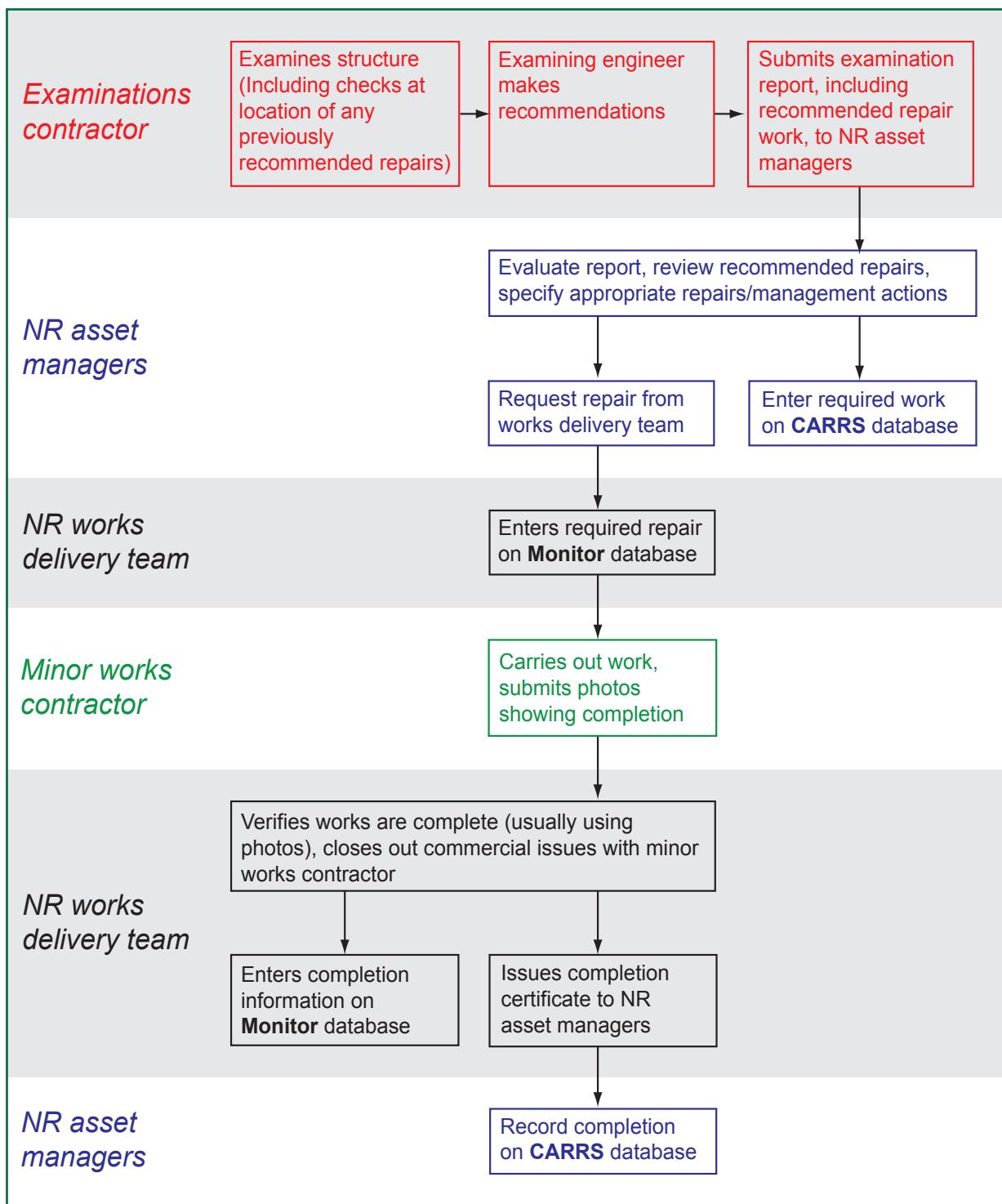


Figure 5: Examination and maintenance regime

Key facts and analysis

Immediate cause³

- 12 The concrete and steel components of the cladding failed, which caused a section of reinforced concrete to drop onto the platform below.

Causal factors⁴

The long term deterioration of the cladding

- 13 The concrete and steel components of the cladding deteriorated to the point where a part became detached from the metal beam [causal factor 1].
- 14 A simplified illustration of the likely construction sequence for cladding the underside of the metal beams is shown in figure 6, based on typical bridge construction details provided by Network Rail. Short lengths of concrete trough were pre-cast⁵ with metal rods protruding from the upper side of the troughs. The troughs were then placed against the underside of the girder and the metal rods bent over the underside (the lower flange) of the beam. Concrete was then placed above the web to encase the metal rods. This form of construction is illustrated in figure 7.
- 15 It is likely that there was poor adhesion at the joints between the trough and the upper concrete, and that water subsequently seeped along these joints. It is possible that these joints were sometimes widened by the expansion of water in the joint when it froze during cold weather (figure 8).
- 16 The presence of open joints meant that the metal rods were more susceptible to corrosion. It is the view of the RAIB that corrosion of the rods over many years caused a gradual weakening of the cladding until it reached the point when the trough was no longer adequately supported.
- 17 It is possible that the failure was triggered on 1 August 2013 by the normal small movements of the bridge due to thermal expansion and contraction on a particularly hot day (a maximum temperature of 33°C was recorded in central London).

Actions taken to address the deterioration of the concrete cladding on the parts of the bridge over the Atlantic Lines

- 18 Although examiners identified the deterioration of the concrete cladding, neither Network Rail nor its minor works contractor took effective action to prevent it failing [causal factor 2].
- 19 A timeline of the key events associated with the management of the concrete casing over the Atlantic Lines is shown in table 1. This identifies a series of actions and inactions which, over time, contributed to the eventual failure of the cladding. The underlying management factors are noted in table 1 and described at paragraphs 26 to 48.

³ The condition, event or behaviour that directly resulted in the occurrence.

⁴ Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

⁵ Cast in moulds at a convenient location and then transported to the bridge

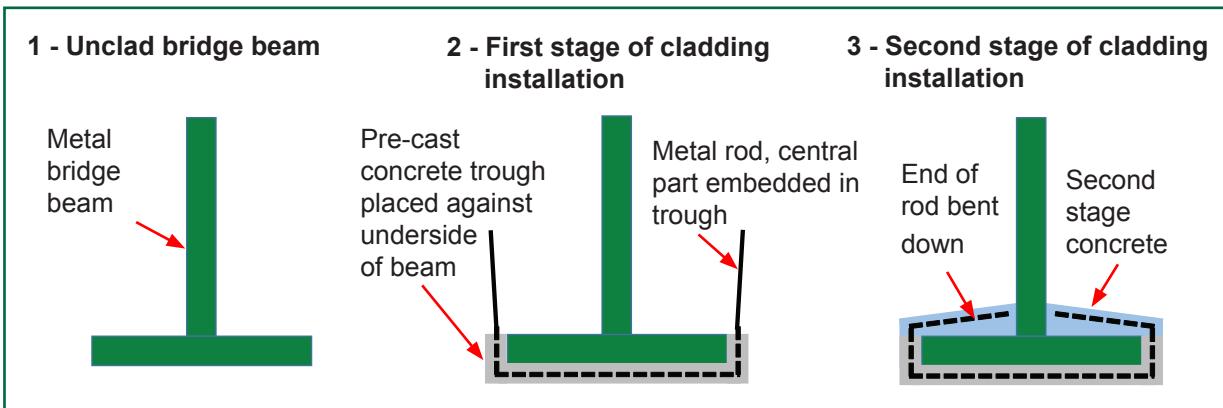


Figure 6: Likely construction sequence

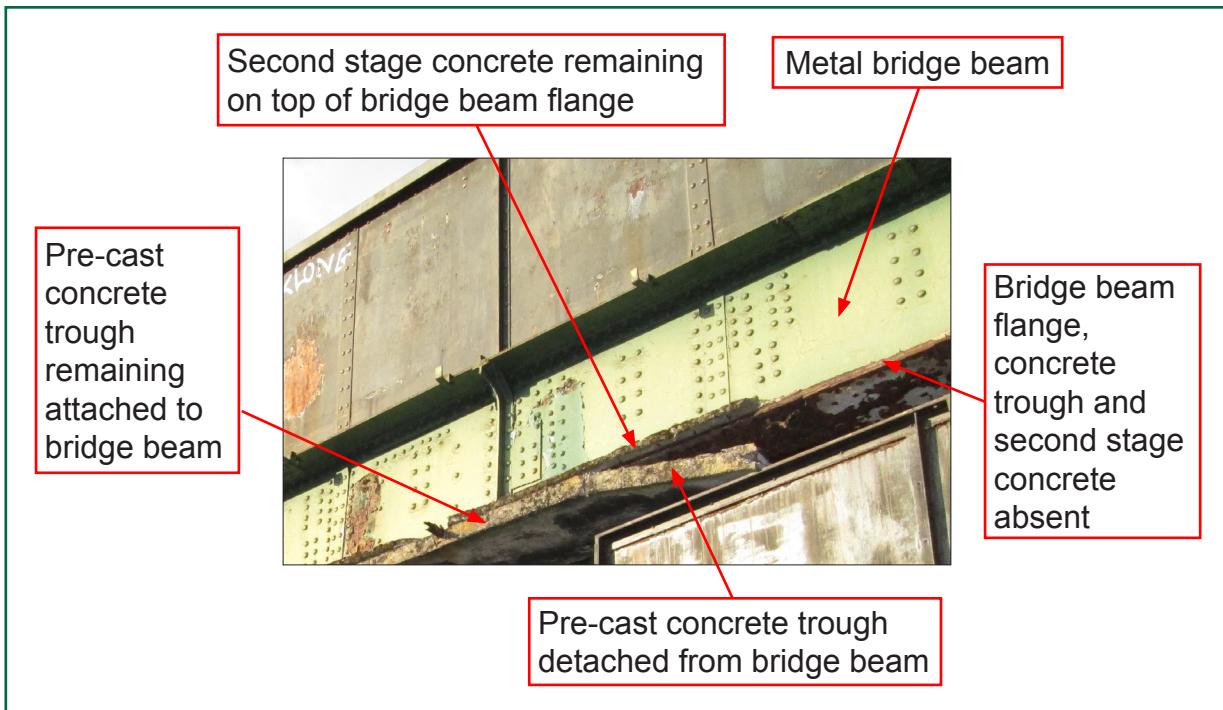


Figure 7: Cladding components

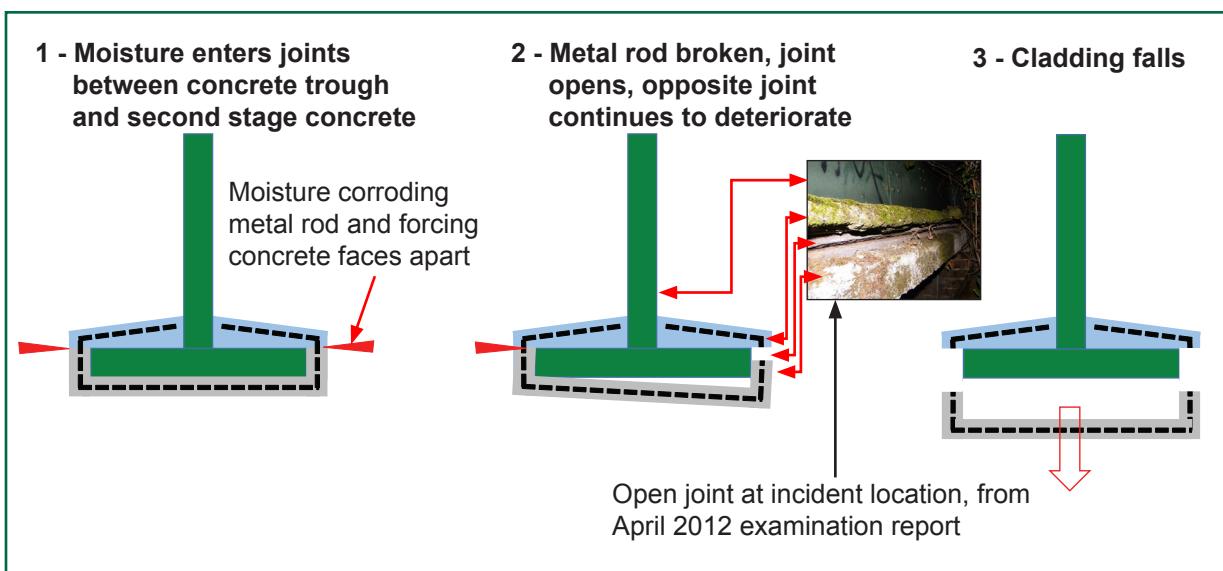


Figure 8: Failure mode

Table 1: Timeline for Atlantic Lines span and the identification of underlying factors

Date	Event	RAIB Note	Linked underlying management factors
14 February 2009	Examination of the span over the Atlantic Lines identifies the need for the removal of ' <i>loose concrete</i> ' from the bottom flange of the Windsor Walk edge beam (the examination report includes a photograph of loose concrete above platform 1, figure 9a). This work item is allocated a risk score of 15 (priority item).	Examiner correctly recorded the need for urgent action by allocating a risk score indicating need for immediate consideration/action by Network Rail. Subsequent evaluation of this report did not result in any repair being undertaken for reasons explained below.	No repair despite need for immediate action [underlying factor 1]
8 February 2010	Network Rail's asset management team enter details of the above repair requirement into Network Rail's database that is used to manage civil engineering assets (CARRS).	It took almost a year before the findings of the examination on 14 February 2009 were entered into CARRS.	Long delay before data entered into CARRS [underlying factor 2] High workload [underlying factor 7]
8 and 18 February 2010	CARRS records state that Network Rail's works delivery team have been requested to undertake remedial works.	No corresponding entry was made in Network Rail's database that records the status of work activities (Monitor). No repair work was carried out.	Ineffective communications between asset management and works delivery teams (and their computer systems) [underlying factor 3]
29 October 2010	Examination notes that concrete above platform 1 is in poor condition and records the need to ' <i>remove loose portion of concrete on bottom flange to prevent falling onto platform</i> '. The risk score is assessed to be S20 ('immediate priority')	Examination took place about 20 months after the previous examination (as compared to the nominal interval of 12 months) Examiner correctly recorded the need for urgent action. No corresponding entry made in CARRS. This was possibly because the asset engineer saw the work as a 'duplicate' of the entry made on 8 Feb 2010 and still open (ie repair had been instructed but not yet reported as complete). No repair work was carried out.	Excessive period between examinations [observation at paragraph 49] No immediate repair despite need for urgent action. [underlying factor 1] Data not entered into CARRS [underlying factor 2]
15 March 2011	The asset management team again request removal of loose concrete to bottom flanges throughout the structure.		

Date	Event	RAIB Note	Linked underlying management factors
1 April 2011	The above request results in the creation of a work item in Monitor. Scope of work is recorded as ' <i>break off loose concrete over all lines and platforms</i> '. A 16 week period for completion is recorded in Monitor for this work item.	Timescale for completion (16 weeks) does not reflect urgency given in the examination report dated 29 October 2010. The reasons for this have not been established.	No immediate repair despite need for urgent action. [underlying factor 1]
11 September 2011	According to Monitor record, site works were completed on 11 September 2011. Photographs taken before and after this work indicate that the large pieces of loose concrete seen by the examiners had not been removed. Small amounts of concrete may have been removed in some areas.	Witness evidence suggests that the presence of loose concrete was checked by tapping it with a hammer, a test unlikely to identify the concrete which the asset manager wanted to be removed. There is no evidence that using a hammer to identify loose concrete was agreed or discussed with the asset management team. Completion of the works to Network Rail's satisfaction was based on certification and photographs provided by the minor works contractor. Examination of the photographs was undertaken by Network Rail's site manager (part of the works delivery team).	Imprecise specification of the works and site staff not identifying appropriate methodology. [underlying factor 4] There was no adequate process to confirm that the intended work had been completed [underlying factor 5]
22 April 2012	An examiner again records the need to remove loose/dropped concrete on the bottom flange of the Windsor Walk edge beam over platform 1. The examination report allocates this an 'immediate priority'.	Examination took place about 18 months after the previous examination (as compared to the nominal interval of 12 months). No immediate action was taken despite the examination report identifying the need for urgent action.	Excessive period between examinations [observation at paragraph 49] No immediate repair despite need for urgent action. [underlying factor 1]
19 June 2012	A Network Rail asset manager evaluates the structure and issues an instruction for emergency repair works to be carried out within 24 hours.	This evaluation was not carried out until 2 months after the examination.	Data not promptly entered into CARRS [underlying factor 2]

Date	Event	RAIB Note	Linked underlying management factors
19 June 2012	To provide short term mitigation: An on-site meeting is held with the asset manager. The minor works contractor agrees to remove any loose concrete and install scaffold tube frames to prevent concreting falling onto platforms 1 and 4.	During the next two nights some sections of loose concrete were removed and scaffolding supports erected to prevent loose concrete falling. The majority of the concrete casing remained in place.	
19 June 2012	To provide long term mitigation: The same asset management engineer also issues a work scope for the total removal of the concrete casing from the Windsor Walk beam above platforms 1 and 4 (and platforms 2 and 3 if time allowed).	This request was entered into Monitor by the works delivery team for action by the minor works contractor.	
27 June 2012	In response to concerns raised by two ORR inspectors visiting Denmark Hill on 14 June for an unrelated reason, a Network Rail asset management engineer confirms to ORR that loose concrete will be removed by November 2012	The risk was appreciated by both ORR inspectors, one a qualified civil engineer and the other without specific civil engineering qualifications.	
4 October 2012	The minor works contractor submits an estimate for undertaking the long term mitigation works which includes an item for breaking out 150m ² of spalled concrete to ' <i>expose the soffit of steelwork</i> '	<p>The contractor's estimate clearly indicated an intent to remove the concrete casing on the underside of the beams. Elsewhere in the contract documentation, the proposed scope (signed retrospectively by Network Rail and the contractor's representatives on 15 January 2014) also refers to '<i>break off loose concrete as required</i>'.</p> <p>A repeat of previous '<i>loose concrete</i>' wording indicates that some people are recognising this as a repeat fault but without highlighting the need to take different action to ensure that an appropriate outcome is achieved.</p>	<p>Imprecise specification of the works. [underlying factor 4]</p> <p>The significance of repeat defect reports from the same location was not recognised. [underlying factor 6]</p>

Date	Event	RAIB Note	Linked underlying management factors
4 November 2012	<p>Site works triggered by 19 June 2012 instruction completed.</p> <p>Network Rail's site manager verified the extent of work undertaken by reviewing photographs submitted by the minor works contractor in accordance with normal practice (figure 9b).</p> <p>NOTE: <i>Commercial issues were not closed out, and the completion pack was not marked as complete in Monitor, until 22 January 2013.</i></p>	<p>The photographs show that, contrary to the Network Rail's work scope (which is referenced on the completion certificate), concrete had not been removed from the Windsor Walk beam over platforms 1 and 4.</p> <p>Although the contractor had been paid for the work based on the completion certificate (referencing Network Rail's scope of works), neither the site manager nor the contractor had checked how much concrete had been removed until the RAIB asked for clarification of the work scope on 24 September 2013.</p> <p>Despite the end of site activities, this is not recorded on CARRS until 26 February 2013.</p>	<p>No adequate process to confirm intended work had been completed (over-reliance on photographs and lack of site visits)</p> <p>[underlying factor 5]</p> <p>Ineffective communication between asset management and works delivery teams (and their computer systems)</p> <p>[underlying factor 3]</p> <p>High workload</p> <p>[underlying factor 7]</p>
27 December 2012	An examination identifies that the defect above platform 4 that had been recorded on 22 April 2012 had not been actioned. A risk score of 15 was given.	The risk score reflected the need for urgent repair work.	
15 January 2013	Consultant acting as Network Rail's asset manager completes review of 27 Dec 2012 examination report but does not instruct repair work.	The consultant did not initiate a repair because they considered that the works instructed on 19 June 2012 were intended to address the defect and noted that CARRS showed that this repair was still in progress. The consultant did not have access to Monitor and had no other way of knowing that the site work triggered on 19 June 2012 had actually been completed on 4 November 2012, before the examination.	<p>Ineffective communication between asset management and works delivery teams (and their computer systems)</p> <p>[underlying factor 3]</p>
31 May 2013	In response to a member of the public reporting loose concrete over the track, Network Rail initiates an emergency call-out of their minor works contractor to ' <i>remove loose concrete from bottom flanges of main girders, above rails [and] check for any more loose sections under this bridge.</i> '	Photographs show some concrete was removed from above the tracks. Witness evidence indicates that tapping with a hammer was again used to determine whether concrete was loose.	<p>Imprecise specification of the works and site staff not identifying appropriate methodology</p> <p>[underlying factor 4]</p> <p>The significance of repeat defects was not recognised</p> <p>[underlying factor 6]</p>

Date	Event	RAIB Note	Linked underlying management factors
1 August 2013	A 5 metre long section of concrete trough falls from the underside of the bridge and lands on platform 1 (figure 9c).		
Post-incident	Network Rail implements a nationwide programme to identify structures with similar concrete cladding, to review the condition of this cladding and to carry out any necessary remedial work. This activity has resulted in work being carried out at several sites.		



Figure 9: Windsor Walk edge beam above platform 1

Actions taken to address the deterioration of the concrete cladding on the parts of the bridge over the Catford Loop Lines

- 20 The RAIB has also investigated the actions that were taken by Network Rail and its minor works contractor in relation to the parts of the bridge that spanned the Catford Loop Lines. It found all of the same underlying factors as have been identified for the part of the bridge spanning the Atlantic Lines.
- 21 This part of the RAIB's investigation also identified that, on 19 June 2013, loose concrete cladding was observed above platform 4 by Network Rail's Director Route Asset Management (Kent), a chartered civil engineer with experience of bridge maintenance. Although visiting Denmark Hill station for unrelated reasons, he immediately contacted the asset management team and raised safety concerns about the loose concrete.
- 22 In response to this, an asset management engineer instructed the minor works contractor to ascertain if the concrete above platform 4 was loose and in danger of falling (he did this in accordance with the established emergency call-out arrangements).
- 23 The contractor subsequently reported to Network Rail that the people who attended the site had hit the concrete with hammers, and in their opinion it was in no danger of falling.
- 24 The people who attended site were not qualified as structures examiners. The minor works contractor has stated that people that are called out in an emergency are appropriate tradesmen who are available at short notice [see underlying factors 4, 5 and 6].
- 25 The loose concrete cladding at this location was removed as part of the works undertaken by Network Rail after the incident.

Underlying factors⁶

- 26 In some cases the exact reasons for the actions, or inactions, of the staff involved have not been identified. However, the investigation has been able to identify a number of underlying management factors which are known to have played a role, and it is these factors which form the basis of the RAIB's recommendations.
- 27 The underlying factors relevant to each aspect of this incident are identified in the last column of table 1 and paragraph 24. They are discussed in the following paragraphs.

⁶ Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

Underlying Factor 1

- 28 No immediate actions were taken to address the condition of the concrete cladding despite examiners repeatedly identifying the need for urgent action.
- 29 The Network Rail standards applicable to all examinations described in this report⁷ required examiners to inform structures asset managers (or their equivalent) immediately when examinations identified defects requiring immediate action. The Network Rail standards applying to management of structures during this period⁸ required appropriate action in response to examinations. The process for achieving prompt action in response to priority defects was formalised by Network Rail's letter of instruction NR/BS/LI/176, issued in May 2010 with a compliance date of 1 June 2010.
- 30 Despite these requirements, no immediate repair actions were taken following the examinations in October 2010, April 2012 and December 2012. The RAIB has not been able to ascertain the exact reasons for this repeated inaction. However, in some cases it appears likely that the existence of a pre-existing defect report in CARRS may have caused asset engineers to believe that action was already planned, and that immediate action to deal with the defect report was not required. It is also possible that a lack of appreciation of the risk, and high workload, were also factors that reduced the likelihood that asset management engineers would initiate immediate actions (see paragraphs 44 and 47).

Underlying Factor 2

- 31 Key information was missing from the asset management database (CARRS), or was only entered after a long delay.
- 32 This factor recurs throughout the timeline at table 1, and also applied to the management of the part of the bridge spanning the Catford Lines.
- 33 It is probable that the record keeping lapsed due to a combination of oversight, high workload and a view held by some staff that it was not necessary to make duplicate entries for defects that had already been entered into CARRS.

Underlying Factor 3

- 34 Ineffective communication between asset management and works delivery teams (and their computer systems).
- 35 On a number of occasions entries were made in the asset management database (CARRS) that were not reflected in the system that was designed to manage work tasks (Monitor), or were only reflected after significant time had elapsed. Similarly, CARRS did not always reflect the actual status of works. One consequence of this was that requests for work to be undertaken were not logged in Monitor. Conversely, the status of works reported as complete by the contractor was shown incorrectly in CARRS for a considerable period of time.

⁷ RT/CE/S/017, 'Examination of structures', (issue 2, April 2004) until this was replaced by NR/L3/CIV/006, 'Handbook for the examination of structures' (first issued in several parts during 2009 and 2010).

⁸ RT/CE/P/032, 'The management of structures', subsequently renumbered NR/CS/CIV/032 and NR/L1/CIV/032; issue 1 (April 2004) and issue 2 (compliance required on 5 December 2009).

- 36 Had the asset management and works delivery management teams, and their computer systems, been better integrated it is probable that inadequate responses to defects included in examination reports, and the inadequacy of the works reported as complete in Monitor, would have been spotted.

Underlying Factor 4

- 37 **The scope of work activities, and the methods of work to be adopted, were imprecisely specified and staff undertaking the work were not always competent to identify an appropriate method to adopt.**
- 38 The RAIB has identified at least three occasions where the minor works contractor was simply instructed to check for loose concrete. In these cases, the instruction was interpreted by the minor works contractor to mean that staff should hit the concrete with hammers in order to gauge its robustness and that anything that sounded 'drummy' (ie hollow) should be removed.
- 39 This crude method is not defined in Network Rail's procedures and had not been endorsed by the asset management engineers. However, no alternative method of checking for loose concrete had been specified for the guidance of the minor works contractors. Although this test could identify relatively small pieces of loose concrete (figure 10), it is unlikely to identify large pieces of loose concrete (eg the partially detached trough shown in figure 7) which the asset management engineers intended to be removed.
- 40 In none of these cases did the minor works contractor query the method to be adopted or raise any concerns about the security of the cladding. By contrast, all four formal examinations of the Atlantic Lines span carried out between 2009 and 2012 by qualified examiners had identified the imminent risk of the concrete cladding failing. A risk of concrete falling had also been recorded during the four examinations of the Catford Loop span undertaken by qualified examiners in the same period.



Dashed lines show areas from which concrete debris has fallen, or been removed. It is probable that this happened due to cracking which developed within the concrete so, when partially detached, the portion of concrete now missing is likely to have given a hollow (drummy) sound when struck with a hammer. The photographs were taken during the May 2013 callout but records do not show the extent to which concrete debris fell in an uncontrolled manner and/or the extent to which it was deliberately removed.

Figure 10: Defects possibly capable of identification by hammer test

Underlying Factor 5

- 41 There was no adequate process in place to confirm that works had been carried out as intended.
- 42 Network Rail relied heavily on the review of photographs as a means of assessing the adequacy of safety related works undertaken by its minor works contractor. However, when reviewing the same photographs during the investigation, qualified civil engineers working for the RAIB often found it difficult to judge the location and condition of concrete cladding shown in the photographs. They also found it very difficult to judge the amount of work that had been carried out by comparing photographs taken before and after work activities.
- 43 It is almost certain that a site inspection, by a suitably qualified engineer, of the completed works over platform 1 in November 2012 would have identified that the necessary work had not been completed, and that the asset remained in an unsafe condition.

Underlying Factor 6

- 44 The significance of repeat defects, of the same type and at the same location, was not recognised.
- 45 Network Rail had no defined process for managing repeat defect reports of the same type at the same location. In the case of the bridge over Denmark Hill station (over both spans), there had been numerous reports of failing cladding, including eight formal examinations and interventions by a member of the public and by a senior Network Rail manager. Taken together these should have led to a recognition that the risk of concrete falling from the bridge was not being effectively managed at this location.
- 46 Had the Network Rail asset management team carefully reviewed the evidence of repeat defects involving the concrete cladding, and sought to understand the underlying problem, it is possible that asset managers would have appreciated, and taken action to deal with, the difference between their understanding of '*loose concrete*' and the understanding of the minor works contractor (paragraphs 38 and 39). It is also possible that further works would have been instructed and completed in time to prevent the incident.

Underlying Factor 7

- 47 Workload is a possible factor in some of the shortcomings identified above.
- 48 A number of witnesses cited a shortage of staff and the consequent high workload as factors affecting management of the structure. Network Rail has stated that the site manager responsible for signing off the minor works at Denmark Hill was required to manage 350 jobs in 2012, rising to 650 in 2013.

Observation⁹

- 49 There were excessive intervals between examinations and undue delay in processing examination reports.
- 50 Network Rail standards require bridges such as that at Denmark Hill to be examined at nominal intervals of one year. Examination reports should then be submitted and evaluated in a timely manner. The examinations and evaluations described in this report often did not meet these requirements. In one instance the interval between examinations on the Atlantic Lines span was about 20 months, and in another 18 months. This was probably at least in part because a contract between Network Rail and the examination contractor required annual examinations to be carried out once in each financial year. This allowed an interval of almost 24 months between successive examinations instead of the 12 month interval given in Network Rail standards.

⁹ An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

Previous RAIB recommendations relevant to this investigation

- 51 The RAIB has mapped each of the underlying management factors against recommendations that addressed similar areas of risk in previous investigations. The output of this exercise is shown at table 2. Also shown for each of the previous recommendations is:
- the current status of actions taken in response (as reported by ORR);
 - an assessment of whether full and timely implementation of the previous recommendation could have avoided the conditions that led to the failure at Denmark Hill; and
 - an assessment of the need for an additional recommendation.
- 52 Table 2 shows that there are two previous recommendations that have particular relevance to this investigation. These are:
- Balcombe Tunnel, recommendation 4 (report 13/2013)

Scope

This recommendation is concerned with improving the effectiveness of the asset management response to structure defects.

Action taken by Network Rail (as reported to RAIB by ORR)

ORR has reported to the RAIB, in a letter dated 18 August 2014, that Network Rail is taking action to implement this recommendation.

- Dryclough Junction, recommendation 2 (report 17/2011)

Scope

This recommendation is concerned with the identification and highlighting of overdue examinations and subsequent management of the associated risk.

Action taken by Network Rail (as reported to RAIB by ORR)

Network Rail has produced a system accessible by all routes called 'The Bridge'. This system identifies compliance dates for all structure examinations across the network and prompts for a risk assessment to be carried out for all examinations which are delayed beyond the requirements of Network Rail's standards.

ORR has reported that it is satisfied that the recent introduction of the 'The Bridge' system meets the requirements of the recommendation.

Table 2: Previous recommendations made by the RAIB

Factor identified in current investigation	Previous RAIB recommendations that have already addressed the factor (in full or substantial part)			Current status of recommendation (as reported by the Office of Rail Regulation)	In the view of RAIB, could full and timely implementation of the previous recommendation have avoided the conditions that led to the failure at Denmark Hill?	Is there a need for an additional RAIB recommendation?
	Reference	Text	Date made			
Underlying factor 1 - no immediate actions were taken to address the condition of the concrete cladding despite examiners repeatedly identifying the need for urgent action	13/2013, Balcombe Tunnel, Recommendation 4	Network Rail should review and, if necessary, modify the management arrangements that are now in place to provide an appropriate engineering response when structure defects are reported. This should include assessing the risk in the period prior to rectification, the means to verify that work requested has been carried out, and whether the reported defect is an indication of a wider problem.	August 2013	ORR has reported that Network Rail is taking action to implement this recommendation (ORR letter to the RAIB dated 18 August 2014).	No (recommendation post-dates Denmark Hill)	No (if fully implemented, the Balcombe recommendation should address the risk identified in the Denmark Hill investigation. However, there is a need for a learning point to reinforce good practice relating to the recording of repeat recommendations)
Underlying factor 2 - key information was missing from the asset management database (CARRS), or was only entered after a long delay						

Factor identified in current investigation	Previous RAIB recommendations that have already addressed the factor (in full or substantial part)			Current status of recommendation (as reported by the Office of Rail Regulation)	In the view of RAIB, could full and timely implementation of the previous recommendation have avoided the conditions that led to the failure at Denmark Hill?	Is there a need for an additional RAIB recommendation?
	Reference	Text	Date made			
Underlying factor 3 - ineffective communication between asset management and works delivery management teams (and their computer systems)	13/2013, Balcombe Tunnel, Recommendation 4	Network Rail should review and, if necessary, modify the management arrangements that are now in place to provide an appropriate engineering response when structure defects are reported. This should include assessing the risk in the period prior to rectification, the means to verify that work requested has been carried out, and whether the reported defect is an indication of a wider problem.	August 2013	ORR has reported that Network Rail is taking action to implement this recommendation (ORR letter to RAIB dated 18 August 2014).	No (recommendation post-dates Denmark Hill)	YES (to reinforce the need for better integration of asset management and works delivery management systems, see Recommendation 1a)
Underlying factor 4 - the scope of work activities, and the methods of work to be adopted, were imprecise; and staff not always competent to judge the best method to adopt	None					YES (to address the requirement for a precise specification of works, competency of staff and a robust process to verify that works have been completed as intended, see Recommendation 1b/c)

Factor identified in current investigation	Previous RAIB recommendations that have already addressed the factor (in full or substantial part)			Current status of recommendation (as reported by the Office of Rail Regulation)	In the view of RAIB, could full and timely implementation of the previous recommendation have avoided the conditions that led to the failure at Denmark Hill?	Is there a need for an additional RAIB recommendation?
	Reference	Text	Date made			
Underlying factor 6 - the significance of repeat defects, of the same type and at the same location, was not recognised	None					YES (see Recommendation 1d)
Observation - there were excessive intervals between examinations and undue delay in processing examination reports	17/2011, Dryclough Junction, Recommendation 2	<p>Network Rail should implement a process that:</p> <ul style="list-style-type: none"> • 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. 	October 2011	Implemented	No (delayed examinations are not considered to be a causal factor relevant to the incident at Denmark Hill)	NO (action to improve compliance with the requirement for regular examinations is reported to have already been taken in response to recommendation 2 of the <i>Dryclough Junction</i> report and an ORR Improvement Notice)

Conclusions

- 53 The immediate cause of the incident was a failure of the concrete and steel components of the cladding which resulted in a section of reinforced concrete dropping onto the platform below. Two causal factors have been identified:

Causal factor 1

The concrete and steel components of the cladding deteriorated to the point where a part of it became detached from the metal beam.

Causal factor 2

Although examiners identified the deterioration of the concrete cladding, neither Network Rail nor its minor works contractor took effective action to prevent it failing. Underlying this causal factor were a number of factors associated with Network Rail's management of structures and the minor repair works. These were:

- No immediate actions were taken to address the condition of the concrete cladding despite examiners repeatedly identifying the need for urgent action [underlying factor 1, paragraph 28] (**already addressed by recommendation 4 in report 13/2013, Balcombe Tunnel**).
- Key information was missing from the asset management database (CARRS), or was only entered after a long delay [underlying factor 2, paragraph 31] (**addressed by Learning point at paragraph 59**).
- Ineffective communication between asset management and works delivery management teams and their computer systems [underlying factor 3, paragraph 34] (**addressed by Recommendation 1a**).
- The scope of work activities, and the methods of work to be adopted, were imprecise; and staff were not always competent to judge the best method to adopt [underlying factor 4, paragraph 37] (**addressed by Recommendation 1b**).
- There was no adequate process in place to confirm that works had been carried out as intended [underlying factor 5, paragraph 41] (**addressed by Recommendation 1c**).
- The significance of repeat defects, of the same type and at the same location, was not recognised [underlying factor 6, paragraph 44] (**addressed by Recommendation 1d**).
- High workload is a possible explanation for some of the shortcomings identified above [underlying factor 7, paragraph 47] (**addressed partly by action taken, paragraph 56, and partly by Recommendation 1a/c**).

Observation

The RAIB also observed that there were excessive intervals between examinations and undue delay in processing examination reports [paragraph 49] (**already addressed by recommendation 2 in report 17/2011, Dryclough Junction; and also the subject of ORR Improvement Notice (I/303293339/JPMcG)**).

Actions already taken

Actions which would otherwise have led to a RAIB recommendation

- 54 After the incident, all concrete was removed from beneath the Windsor Walk edge beam and significant amounts of concrete were removed from beneath other parts of the bridge. Network Rail reports that all areas of concrete 'with fractures' were removed.
- 55 Network Rail has undertaken a nationwide programme to identify, to review and, where it considered it necessary, to repair structures with cladding similar to that which failed at Denmark Hill.
- 56 Network Rail has, in response to an action arising from an ORR National Rail Inspection Programme, completed a nationwide review of resources required to meet its asset management obligations. Network Rail reports that the number of staff now available in the former Kent and Sussex routes (recently combined as the South East route and covering Denmark Hill station) now meets the requirements identified by this review. Some routes have not yet met the review requirements but Network Rail reports it is implementing time bound recruitment plans intended to meet the requirements.

Other action

- 57 Network Rail have stated that, at least on the South East route, asset management engineers now review photographs showing work reported as complete.
- 58 The incident bridge was closed to road traffic by Network Rail in August 2014, and remained closed to road traffic at the publication date of this RAIB report, for a reason which is unrelated to defects in the concrete cladding of the bridge beams.

Learning point¹⁰

59 The RAIB has identified a key learning point for the railway industry:

- 1 It is vital that structures asset managers rigorously record, all defects that have been observed by examiners. The creation of a new record of the same defect, even if duplicating a previous entry, can be vital for understanding and so for managing safety risk.

¹⁰ ‘Learning points’ are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Recommendation

60 The following recommendation is made¹¹:

- 1 Network Rail should carry out a review of the means by which defects identified by the structures examination process are evaluated by asset managers, and repairs actioned. Network Rail should then make the improvements necessary. As a minimum, this review should consider:
 - a. ways of improving the integration of asset management and works delivery management systems (by means of technology and/or improved management arrangements) [underlying factors 3 and 7];
 - b. the ways in which contractors are remitted to carry out work, particularly for works reliant on the application of judgement, and the degree of supervision that is required [underlying factor 4];
 - c. the robustness of processes for confirming that works with an impact on safety have been completed in the manner intended by asset managers [underlying factors 5 and 7]; and
 - d. the process for assessing the implications of repeat, or similar, defects at the same location [underlying factor 6].

¹¹ The organisation identified in the recommendation, has a general and ongoing obligation to comply with health and safety legislation and need to take this recommendation 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, this recommendation is addressed to the Office of Rail Regulation to enable it to carry out its duties under regulation 12(2) to:

- (a) ensure that recommendations are duly considered and where appropriate acted upon; and
- (b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

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

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Any enquiries about this publication should be sent to:

RAIB	Telephone: 01332 253300
The Wharf	Fax: 01332 253301
Stores Road	Email: enquiries@raib.gov.uk
Derby UK	Website: www.raib.gov.uk
DE21 4BA	