RAIB

Rail Accident Investigation Branch

Rail Accident Investigation: Interim Report

Partial failure of a structure inside Balcombe Tunnel
23 September 2011

Report IR1/2013
January 2013

Partial failure of a structure inside Balcombe Tunnel, 23 September 2011

1 This interim investigation report has been produced in accordance with Section 11(1) of The Railways (Accident Investigation and Reporting) Regulations 2005, which permits the Chief Inspector of the RAIB to provide an interim report relating to an accident or incident to such persons, and in such form and in such manner, as the Chief Inspector considers appropriate in the circumstances.

2 The report has been produced before completion of the RAIB's investigation in order to disseminate the RAIB's preliminary findings and associated safety learning. It has not been possible to complete the full RAIB investigation at this stage due to the difficulty of accessing the tunnel without disrupting planned train services. Access was required to provide the detailed information needed for the final report but disrupting regular services was not considered to be justified by the level of risk which remains after implementation of the measures described in this report.

3 The findings are subject to further review and may be amended or supplemented during the completion of the investigation.

The incident

4 At 05:24 hrs on the morning of 23 September 2011 the crew of an engineering train[1], which was passing through Balcombe Tunnel in West Sussex, observed that a part of a structure mounted in the tunnel above train roof level had deflected downwards, but remained clear of passing trains. The crew reported this to the signaller at Three Bridges Area signalling centre and the signal shift manager closed the tunnel immediately.

5 Services between Haywards Heath and Three Bridges were suspended until 03:30 hrs on Saturday 24 September, to allow an inspection of the structure and implementation of the emergency repairs assessed by Network Rail as needed to allow safe passage of trains. An RAIB inspector visited the tunnel and examined the defective structure on 2 October 2011, the earliest date when the tunnel could be closed without excessive disruption to normal train services.

6 Balcombe tunnel is in profile a horseshoe shape (figure 1) with a lining approximately 0.5 metres thick formed by seven rings (layers) of bricks. The structure inside the tunnel that was defective, and observed as such by the train crew, is one of five similar steel water catchment trays[2] attached to the tunnel's brick lining above train roof level. The trays are intended to catch water dripping from ventilation shafts[3] and water seeping through the brickwork in other areas of the tunnel. Water collected on the trays is conveyed into the tunnel drainage system.

[1] A train used for maintenance of track or other railway infrastructure.

[2] The tunnel also contains a sixth water catchment tray of a significantly different design.

[3] A shaft rising from the roof of the tunnel to ground level.

Figure 1: Balcombe tunnel (north portal) (photo courtesy of ORR)

7 The water catchment tray involved in this incident (figure 2) was installed in 1998/99 and was 72 metres long. (It was shortened after the incident.) It comprises a deck, supported by longitudinal beams which in turn rest on transverse beams. The transverse beams are about six metres long and are located at four metre intervals. The beams are bolted to brackets supported by studs which are grouted[4] into holes drilled in the tunnel brickwork, two on each side of the beam end (figure 3).

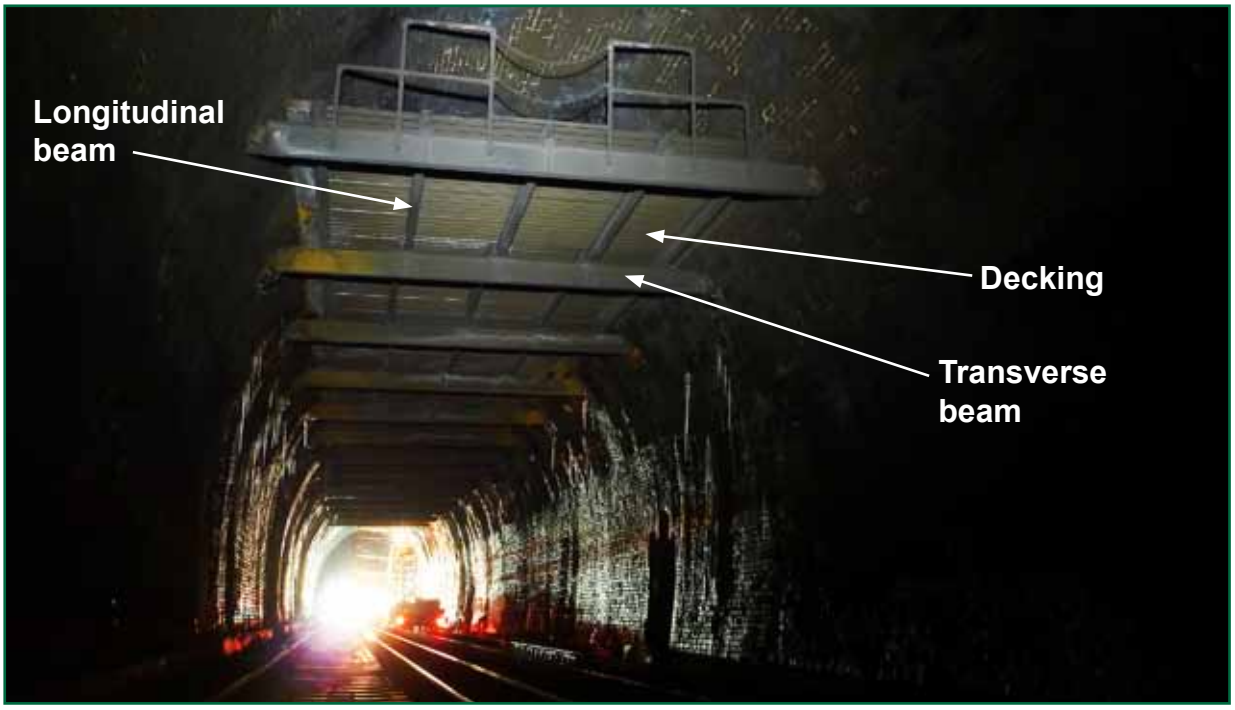

Figure 2: Water catchment tray structure

[4] The grout comprised a polyester material intended to bond the studs into the holes.

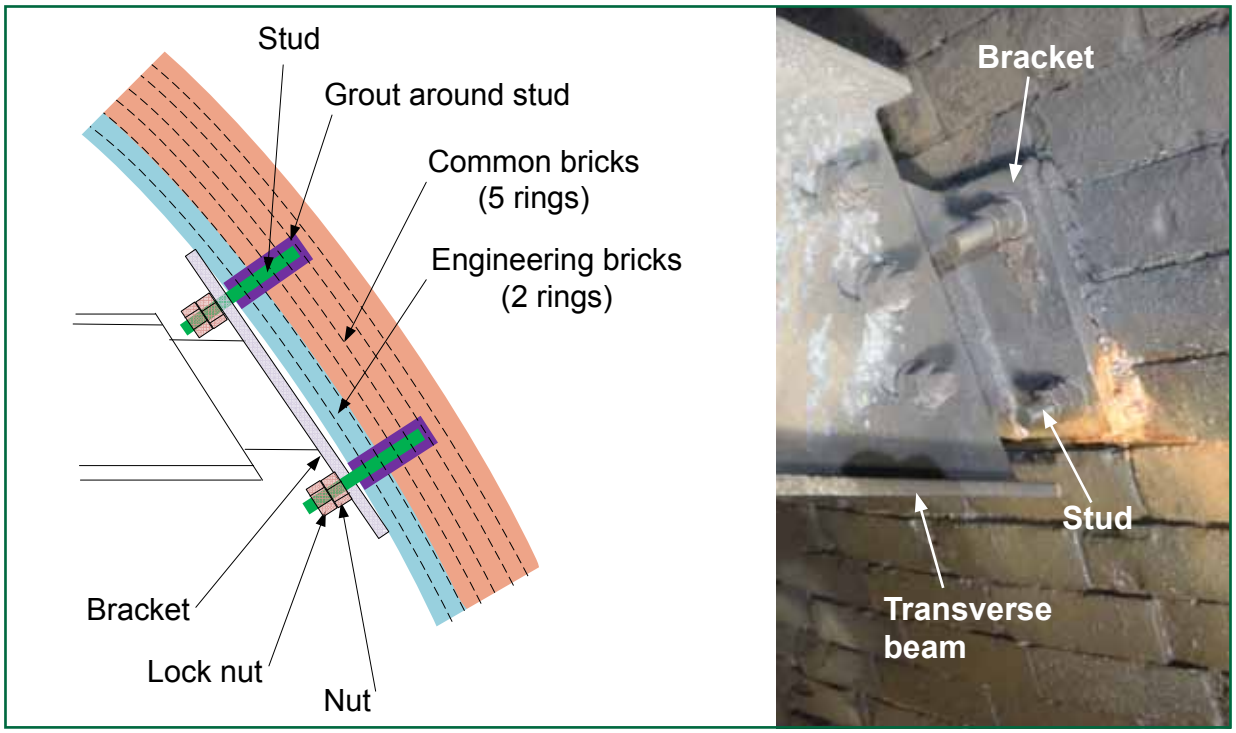

Figure 3: End fixing detail (photo courtesy of Amey)

8 Following the train crew's earlier report a Network Rail inspection on 23 September established that, on one side of the tunnel, three adjacent transverse beams were detached from the tunnel wall. At these locations, the beam ends had dropped about 0.5 metres (figure 4). The beams were not fouling the path of a train but there was risk of them moving until they did so. The beam ends had become detached because the four studs at each beam end (a total of 12 studs) had fallen from the tunnel wall.

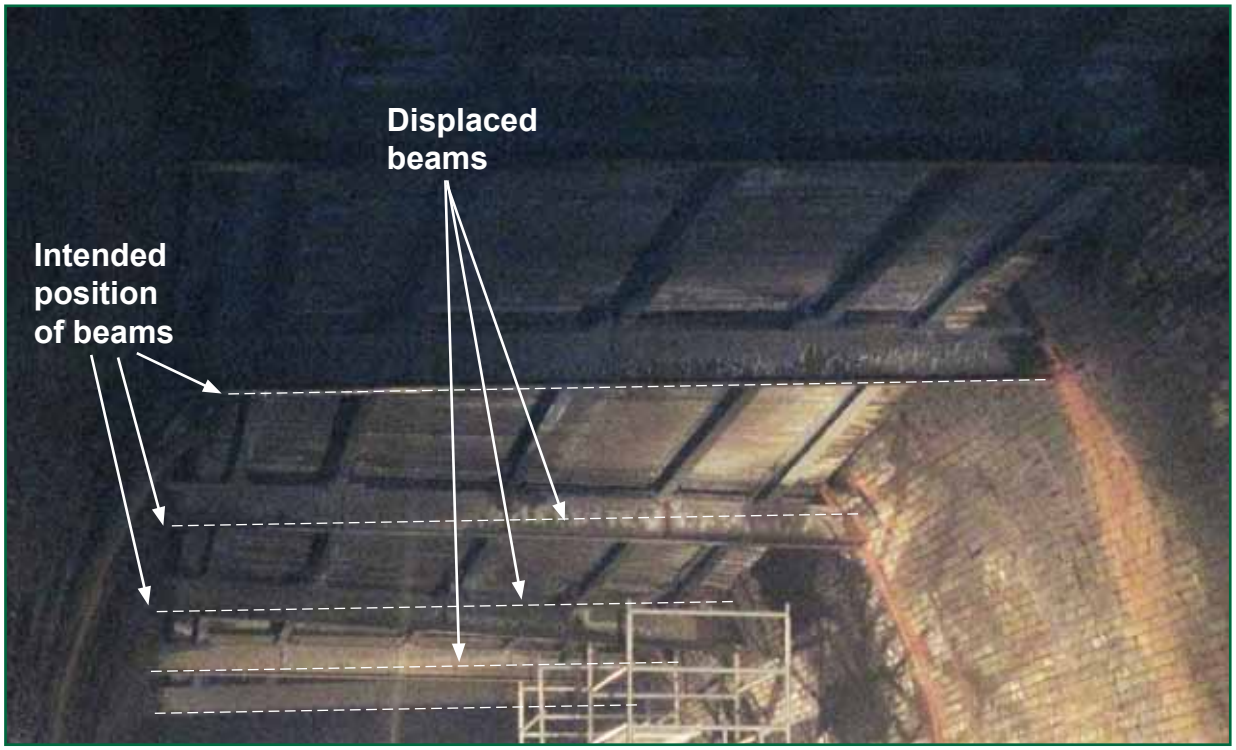

Figure 4: Deflected structure (photo courtesy of ORR)

9 All similar beam ends supporting water catchment structures in the tunnel were also inspected on the 23 September with the exception of ten beam ends which could not be inspected because they were close to the displaced beams. This inspection showed that, in addition to the 12 studs missing at the detached beam ends, at least six other studs were missing, at least five were loose, and nuts were loose or missing on at least 29 other studs (figure 5).

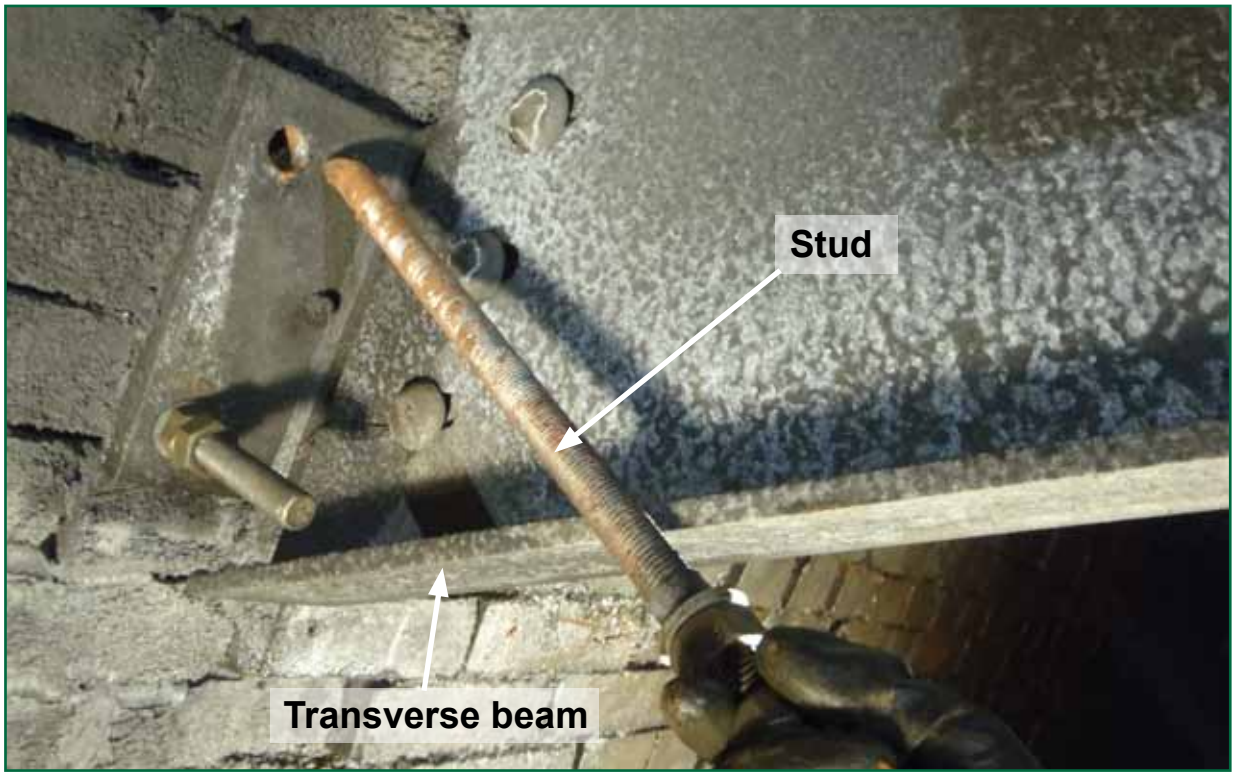

Figure 5: Loose stud outside incident area removed by hand during inspection on 23 September 2011 (photo courtesy of Amey)

Summary of preliminary findings to date

10 It is probable that the studs were displaced as the structure vibrated due to the aerodynamic (wind) forces caused by passing trains. This was probably because, for reasons explained below, some studs were not adequately bonded to the brickwork by grout.

11 Post incident testing has shown that the grout used to fix the studs into the brickwork did not bond with the engineering bricks[5] which form the innermost rings of brickwork (figure 3). This testing also showed that, in some locations, the grout was only poorly bonded to the remaining brickwork.

12 Witness evidence suggests that a volume of grout used around each stud had been pre-calculated. Post incident testing showed that

- grout was missing along parts of some studs;
- some grout had escaped into gaps where mortar had been lost from the brickwork; and
- some holes had been drilled longer than the nominal length.

[5] Engineering bricks are harder and stronger than the common brick typically used for house building.

13 Witness evidence suggests that the amount of brickwork testing undertaken before installation of the studs was probably insufficient to establish whether the grout was compatible with the tunnel brickwork.

14 The extent to which design and/or installation contributed to the unsatisfactory stud fixing cannot be determined because records of design requirements, design loads, construction methodology etc are no longer available. This is partly a normal consequence of the length of time since the structure was installed. It is also partly because Network Rail cannot locate the Health and Safety file which should provide a permanent record of design, construction and maintenance issues[6].

15 The intensive use of the tunnel by regular train services, and prioritising other engineering work in the tunnel, meant that some of the routine tunnel examinations required annually by Network Rail procedures, were curtailed, omitted or delayed resulting in reduced opportunities to find defective stud fixings.

16 A routine tunnel examination undertaken on behalf of Network Rail in November 2008 noted missing studs outside the incident area. These were immediately marked on the tunnel wall with large yellow arrows and reported to Network Rail. The missing studs were also recorded in a formal report to Network Rail dated March 2009. The yellow arrows and formal report should have prompted subsequent examiners to pay particular attention to this issue. They did not do so, partly because computer software problems meant that the formal report was not seen by subsequent examiners.

17 Although a Network Rail engineer was aware that studs had fallen from another part of the incident structure in 2008, actions were not taken to determine whether this indicated a more widespread problem. Network Rail's management system did not provide sufficient technical support to take account of the limited experience of this engineer.

18 Almost all the studs which had fallen from the area of the September 2011 incident had been found at track level by railway staff before the incident, but this information had not been passed to the asset management engineers responsible for managing the tunnel structure. It is possible that the staff who found these studs did not appreciate where they had come from and/or did not realise their significance.

19 In March 2011, a train conductor reported an unusual noise as their train passed through the tunnel and an inspection by track staff the following night found two studs in the tunnel at track level. An examination undertaken the next night did not identify the source of these studs because the examiner was neither shown the studs nor given an adequate description of them. As a result, the Network Rail team responsible for the tunnel remained unaware that studs were falling from the water catchment tray in the area of the incident.

20 The condition of the water catchment trays was being reported as part of the tunnel examination process because the structures were within a tunnel. Network Rail's processes, and the associated competency management regime, recognise that tunnel examinations and structure examinations require different skills. There is no requirement for tunnel examiners to have the skills needed to examine structures.

[6] The health and safety file should have been retained in accordance with the Construction (Design & Management) Regulations (1994, updated 2007).

21 The defect was detected by the crew of an engineering train which was passing through the tunnel in connection with work unrelated to maintenance of the tunnel. It is possible that the defect would have remained undetected for longer, and possibly developed further, if the engineering train had not passed through the tunnel. This is because the powerful lights needed to notice the defect are only provided on some engineering trains and are not provided on freight or passenger trains.

Safety lessons

22 Based on the findings to date the RAIB has highlighted the following issues to those organisations responsible for safety:

- the importance of timely and effective examination of structures and the need for management systems that ensure this (paragraphs 15 and 16);
- the need for an effective competency management system for asset management staff undertaking day to day management of tunnels (paragraph 17);
- the need for effective reporting of all unusual objects found on the track (paragraph 18);
- the need for tunnel examiners to be provided with comprehensive briefings when sent to investigate reported defects (paragraph 19); and
- the need for an effective examination system for structures which are within tunnels but are not fully encompassed by the normal tunnel management regime (paragraph 20).

The findings presented above are subject to further review and may be amended or supplemented during the completion of the investigation.

Industry actions

23 Network Rail undertook emergency repairs to the defective part of the structure before train services resumed on 24 September 2011. Subsequently the defective part of the structure has been removed and additional support brackets have been installed under all similar water catchment trays in Balcombe tunnel. Network Rail has established that there are no other similar structures on their infrastructure.

RAIB actions

24 The RAIB has discussed the emerging findings with Network Rail and the organisations who undertook the design and installation of the incident structure.

25 The RAIB is currently completing its investigation and formal recommendations.

This interim report is published by the Rail Accident Investigation Branch, Department for Transport.

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