

Lessons from the Malahide



Sean Brady investigates the contribution of 'corporate memory loss' to the failure of a railway bridge near Dublin, Ireland.

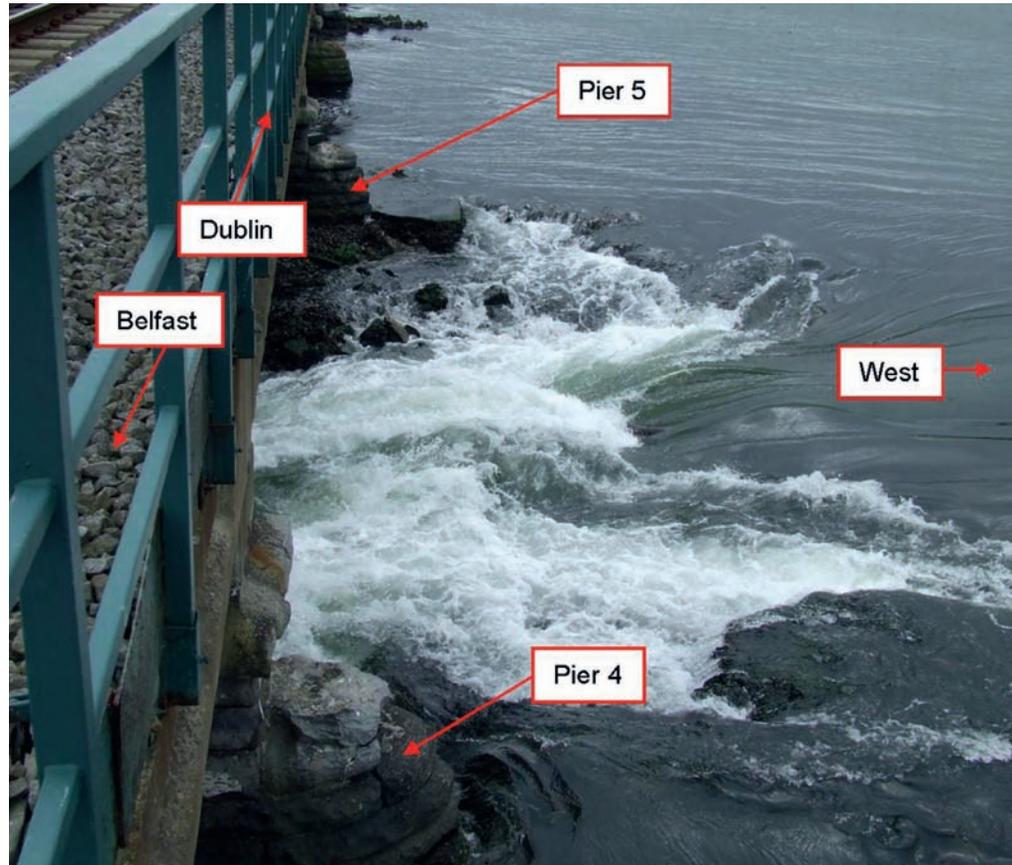
At 6:22pm on 21 August 2009, an Iarnród Éireann train was travelling across the Malahide Viaduct (14.5km north of Dublin, Ireland) when the train driver noticed a portion of the viaduct beginning to collapse. The train safely crossed the viaduct, stopping at Malahide Station where the driver alerted the controlling signalman. The controlling signalman set all signals to 'Danger', preventing further trains from crossing the viaduct. The train driver walked back up the line to discover that Pier 4 of the viaduct, along with the post-tensioned concrete beams of Spans 4 and 5, had collapsed into the Broadmeadow Estuary.

Unsurprisingly, the subsequent investigation, conducted by the Railway Accident Investigation Unit (RAIU), concluded that scour action had undermined the foundations of Pier 4, leading to the collapse. While the cause of the failure was technical, the non-technical lessons from this collapse serve as a reminder of the importance of knowledge and information for organisations involved in the management of structural assets.

The Malahide Viaduct is owned and operated by Iarnród Éireann and was constructed in 1844 to provide a rail link across the Broadmeadow Estuary. The original 176m long viaduct was comprised of eleven timber spans, each approximately 16m long, and it was supported on ten timber piles driven into the estuary bed.

Scour action

Soon after its construction, the structure was found to be susceptible to scour action due to tidal flow in and out of the estuary. To address this issue, a stone weir was constructed along the length of the structure in 1846, which not only directly protected the piles from scour action, but



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also maintained a constant level of water in the estuary (thus reducing the volume of tidal flow). In order to maintain the weir's integrity, stones had to be continually discharged along the viaduct to replace those lost through scour action.

In 1860 the timber piles were replaced with masonry piers, which were

supported on top of the stone weir, and the superstructure was replaced with wrought iron lattice girder beams. Further weir maintenance continued in 1922, with 5,200t of stone being discharged along the viaduct. In 1965, the lattice girder beams were replaced with post-tensioned concrete beams, with a specific design requirement being the easy removal of the superstructure's hand rails to facilitate the future discharge of stones along the weir. A grouting program was undertaken in 1967-68 to inject concrete into the weir, and subsequent grouting was also undertaken in 1972-73. Further discharge of stones occurred in 1976, with the final documented discharge of stones occurring in 1996.

In summary, the ongoing management of the structure's susceptibility to scour action was a key requirement since its original construction, with the 1965 handrail design indicating that the bridge owners anticipated that stone discharge would continue into the future.

Viaduct collapse

← **Figure 1**
Evidence of erosion around Pier 4 three days prior to collapse

Corporate memory loss

Despite this long history of scour awareness and prevention, scour was indeed the technical cause of the 2009 failure. Why did Iarnród Éireann not anticipate the potential for such a failure?

While the RAIU investigation identified many contributing factors (such as poor training provided to bridge inspectors, shortfalls in structural inspection standards, and Iarnród Éireann's failure to develop a scour management plan), the investigation also highlighted the role played by 'corporate memory loss' in hampering Iarnród Éireann's ability to foresee the failure.

The RAIU investigation report defines corporate memory as "knowledge and information from the company's past which can be accessed and used for present and future company activities". With respect to the Malahide Viaduct, a critical piece of "knowledge and information" was the structure's susceptibility to scour action and its historic maintenance program. But the RAIU investigation concluded that the engineers responsible for the structure in 2009 were unaware of the scour issue.

At the time of the failure, Iarnród Éireann managed their asset management data in their IAMS system, which was introduced in January 2005. It was envisaged that civil asset information, such as the information contained in Bridge Inspection Cards, would be uploaded into this system for future use. However the RAIU investigation found that this had not occurred, nor was there widespread acceptance and enforcement of the IAMS system. In the case of the Malahide Viaduct, there was no information to highlight the structure's susceptibility to scour - the only information uploaded was the viaduct's number and mileage. Even at a basic level, there were no construction drawings relating to the viaduct's foundations and, in the absence of this information, the engineers incorrectly assumed that the masonry piers were founded on bedrock - and were thus unaware that the integrity of the structure as a whole was dependant on the integrity of the weir.

Indeed, a key piece of information unavailable to the engineers responsible for the structure in 2009, was a report prepared by North East Diving Services in 1997, 12 years prior to the failure. North East Diving Services were engaged to remove a derelict barge from the site and to conduct an inspection of the viaduct. Included in their findings was the observation of significant deterioration of the grout in the weir as a whole, with the scour protection being "too light for the job", and that scouring had already commenced at Pier 4 (the pier that collapsed in 2009). Not only was this document not uploaded on the IAMS system, it was also not filed with the Bridge Inspection Cards, and it only came to light in 2010, a year after the failure, when it was discovered by Iarnród Éireann personnel clearing out an office. Thus, the engineers responsible for the structure were missing a key document that specifically identified scour as a risk to the viaduct, and in particular, that scour damage in the vicinity of Pier 4 had already commenced in 1997. The RAIU investigation found no evidence to suggest that any works were carried out on the weir following this inspection and assumes that the weir was allowed to deteriorate further.

Similar issues were evident with respect to the documentation of the viaduct's maintenance regime. The engineers responsible for the structure in 2009 were not aware that continuous maintenance to the weir was required to prevent deterioration. To illustrate this point, much of the information relied upon by the RAIU investigators pertaining to the viaduct's maintenance regime was not gleaned from Iarnród Éireann asset management documents, but rather from third party correspondence between Iarnród Éireann and others.

Furthermore, the RAIU investigation found that former Iarnród Éireann staff were indeed aware of the viaduct's scour susceptibility and maintenance regime. However, these staff members had since left the division, and the two district engineers and two assistant district

engineers who worked in the division between 2002 and the time of the failure informed the RAIU investigators that they had no knowledge of the scour risk to the structure.

Finally, as with all significant failures, opportunities to identify the potential for failure were missed. For example, four days prior to the collapse, on the 17 August, a group leader of the Malahide Sea Scouts, who was a regular canoeist on the estuary, noticed that some of the stones around the base of Pier 4 had been washed away. He informed Iarnród Éireann, and an assistant engineer investigated. The engineer carried out the inspection on the viaduct the following day and identified that some of the masonry pier's stonework was missing or cracked, assuming this was the issue reported by the Scout's leader, and reported that he found no major structural defects.

However, during the inspection the engineer took a photograph (Figure 1) which clearly indicates the presence of some serious erosion around Pier 4. Not only does this incident highlight a missed opportunity to identify the potential for failure, but it also highlights the poor training the inspectors received in the identification of scour related issues.

In closure, this failure is a reminder of the mundane but typically critical role played by human factors in structural collapse. By 2009, it appears that the knowledge and information relating to the scour susceptibility of the Malahide Viaduct resided in the heads of a number of individuals who had left the division, rather than in a formal system that was accessible to the engineers responsible for the structure. In an era where the concept of a 'job for life' is becoming more uncommon, and with engineers moving ever more frequently from job to job and role to role, often taking corporate knowledge with them, this failure highlights the very real risks faced by asset management organisations, due to the threat of corporate memory loss.

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1) Railway Accident Investigation Unit (2010) *Investigation Report No. 2010-R004: Malahide Viaduct Collapse on the Dublin to Belfast Line on the 21st August 2009* [Online]. Available at: www.raiu.ie/download/pdf/accident_malahide.pdf (Accessed: June 2013)