The Tay Bridge disaster of 1879: a general review of the historical and engineering literature

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1. Introduction

The basic facts of the Tay Bridge disaster, in east central Scotland, are well-known. During a violent storm on Sunday 28 December 1879 the bridge collapsed as a North British Railway train with passengers from Burntisland, Fife, to Dundee passed over it. All the railway company employees present (some of whom were off-duty) and the many passengers died. The catastrophe was a matter of the first magnitude: the bridge had been presented as a state-of-the-art example of advanced British engineering, and yet the disaster gave rise immediately to concerns about other edifices designed by the same engineer, several of which had been constructed not much earlier. The completion of the bridge had been a national triumph of international interest, and so too was the disaster.

This note does *not* deal with any literature that may encompass the disaster in works of fiction, of which A.J. Cronin' novel is one of the best known.[1] Hitherto there have been a parallel set of studies or histories of the Tay Bridge disaster. First, the debate within the literature on the history of the disaster has been restricted, entirely understandably in many ways, to the engineering issues. These were settled, to a limited degree, by a Court of Inquiry that was convened with astonishing speed immediately after the disaster. That inquiry has acquired its own interest. Challenges to the established understanding of the underlying engineering issues have been made in the modern era and these were rebutted comprehensively. It is not certain that any more might be made now of any attempt to undermine the true causes and of the collapse.

Secondly, and parallel to the engineering interest, some specific histories of the Tay Bridge disaster have been published periodically concentrating principally on what may be said to be the human side of the event: 'the people's story'.[2] The pathos of the train travelling along the line to a bridge that is to collapse is accentuated by the complete loss of life. The range of the public, commercial travellers, fathers and children, workmen and so on provide a snapshot of life dependent then on the railway. Aside from these specific histories, there are the many railway histories that mention in passing the place of the Tay Bridge and the collapse as part of the development of national railways in Britain.[3] While the human history has been extended to retrieve more details, these often merely state the bare outline of the event of construction, destruction and a new beginning.

One possible new approach that might be taken to the disaster, separately from the engineering and the human interest, encompasses the wider view of the whole event, following a persuasive argument to do so in a general paper on the subject of disasters.[4] Attempts to define disasters by the amount of harm they produce fails to capture the essential features of these events.[5] Thus, with contributions grounded in, or focusing on, other disciplines, the Tay Bridge disaster is not merely to be seen as

[1] A.J. Cronin, *Hatter's Castle* (London: Gollancz, 1931) (a major character dies when present as a passenger on the train at the time the bridge collapses).
[2] David Edgerton, 'The Nationalisation of British History: Historians, Nationalism and the Myths of 1940' (2021) *English Historical Review* v.136(581) 950-985, discusses the creation of myths by historians [available online].
[3] Simon Bradley, *Bradley's Railway Guide: A Journey Through Two Centuries of British Railway History 1825-2025* (London: Profile Books, 2025), pp.116-118.
[4] Tom Horlick-Jones, 'Modern Disasters as Outrage and Betrayal' (1995) 13(3) *International Journal of Mass Emergencies and Disasters*, 305-315. The premature death of Professor Horlick-Jones has been regretted: Andy Alaszewski 'Tom Horlick-Jones and risk work' (2018) *Health, Risk & Society*, 20(1-2), pp.13-22.
[5] Horlick-Jones, 'Modern Disasters as Outrage and Betrayal', ibid, p.307.

restricted to 28 December 1879. On that approach a fuller understanding of the disaster encompasses the planning and financing of the first bridge, the immediate actions for a replacement, and the political, legal, social and economic context of the whole venture.

There is still a sense in which there is much to be discovered about the whole circumstances of the financing and construction of both Tay Bridges. That has been underpinned by research on a wider scale, included the proposition that disasters often involve regulatory failure.[6] But, what if as in regard to the Tay Bridge there was no, or merely the barest possible, regulatory involvement? The importance, hitherto overlooked it seems for the Tay Bridge, has been emphasised more recently by others of the importance of combining direct observation with other sources of data so that the accounts which individuals gave of their activities are not detached from the activities.[7] That is an emphasis on context. The sadness and pathos of the event ought not to overshadow the engineering and other construction issues. These were soon overcome after 1880 by different approaches.

In particular, one point that might be made of the new approach to the Tay Bridge disaster is suggested: it is to be recalled that the bridge allowed for better movement to and from Dundee, and the east coast generally, as well as straight through the area on the way from Aberdeen to London. A wider understanding of the Tay Bridge disaster requires essentially greater regard paid, as has not been done to date, to the political and economic conditions, both in Dundee and the surrounding area. The transport revolution following from the growth of the railways was so important (and lucrative) that the disaster of 1879 was soon overcome.

Further, in a review of a new book then published in 2006 about the Tay Bridge disaster the two reviewers noted succinctly: '***Modern writers want to have their own theory for the collapse and are prepared to neglect information which stands in the way of such aspiration'***.[8] It would seem that most of the modern history of the Tay Bridge disaster has been written with a view to discovering a new engineering aspect explaining the collapse; and, in any event, that the pathos of the whole event is overwhelming. Much of the surrounding detail is attributable to railway historians, although their concentration is directed, entirely understandably, at the bridge in the context of railway history.[9]

Finally, the report of the Court of Inquiry of 1880 is a subject worthy of its own study. The tendency is to accept at face value the technical results of those who, in Scots law at least, would be referred to as skilled witnesses. Yet, such an administrative investigation is authorised by the government of the day and ought to be seen as an official history of the bridge and the causes of its demise. To the modern historian now, the idea of 'official history' is one that gives rise to, or ought to give rise to, an immediate scepticism of the whole venture.[10]

The basis of an historian raising such doubts about the tribunal is a 'hostility towards, and suspicion of, what officialdom tells us and, above all, what it does not want us to know'.[11] This is not to suggest

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[6] Iain McLean and Martin Johnes, '"Regulation Run Mad": The Board of Trade and the Loss of the *Titanic*' (2000) 78(4) *Public Administration* pp.729-749.
[7] Alaszewski, 'Tom Horlick-Jones and risk work', ibid, p.21.
[8] T. Martin and Iain MacLeod, 'Book Review' *Panel for Historical Engineering Works Newsletter: ICE* (Sept., 2006) Issue 111, pp.5-6.
[9] E.g., John Thomas and David Turnock, *A Regional History of the Railways of Great Britain: Volume 15: North of Scotland* (David St John Thomas: Nairn, 2nd ed., 1993), Chapter IV, Tayside Region: Perth and Dundee, see esp. pp.131-136.
[10] Patrick Salmon, *The Control of the Past: Herbert Butterfield and the Pitfalls of Official History* (London: University of London Press, 2021). This book is one available under the open access arrangements: The Control of the Past | University of London Press
[11] Salmon, *The Control of the Past,* ibid, Prologue.

'a conspiracy' of sorts; merely, showing a self-protecting mechanism, that the Board of Trade and others were concerned, as they should have been, with the implications for engineering across the United Kingdom and the Empire, and national reputations elsewhere in that regard. The point is emphasised by the fact that the Tay Bridge collapsed so soon after an formal inspection by one acting for the Board of Trade. The political history of the construction of two large bridges and the collapse of one as a matter of international interest has been neglected.

2. <u>Conventional history</u>

One notable description of the Tay Bridge followed from the grand opening, but before the disaster, that by Albert Grothe. It was intended as a historic statement of the great achievement. His note of description of the first bridge in its pristine state served as a model for what might and could be done. The second bridge, which seldom receives much attention in its own right, served to show what could be done better.

Some narratives particularly in railway history books simply state the event of 1879 in cryptic terms, avoiding the engineering aspects, for example:

> 'What happened at 7.20 pm, when the Edinburgh train moved on to the stressed and shaking structure, will for ever be a matter of conjecture, perhaps best saved for elsewhere. Whether the trembling girders finally shook their last, a coach was blown off the track and collided with the high girders or was derailed, or even a combination of those and other factors may forever remain a riddle.' [12]

The following books are the principal ones dealing explicitly, or in notable detail, with the bridge, its construction, and, separately, the disaster. The numerous novels have been omitted from consideration here. The descriptions are indicative of the approach of the individual author to the collapse as a matter of history, and a close textual analysis is not intended.

(i) ***Grothe*****:** an article was written to confirm the completion of the Tay Bridge and the opening of the structure for use by trains.[13] The general features of local conditions and construction were described with illustrations. It is not difficult to imagine the industrialists, engineers and politicians internationally seizing on copies of a more substantial anonymous version of the structure, with an introduction by Grothe: in short, Grothe provided what may be seen as the baseline official construction history of the bridge up to the point at which it was open for commercial business.

(ii) ***Prebble***: the modest history by John Prebble, a journalist, seems to have been the first book specifically on the disaster despite many generations since the disaster. First published in 1956 it was reprinted in 1966.[14] It was re-issued, with a foreword and new illustrations in 1975.[15] It was probably the focus of the modern interest for many years. The book could hardly be described as an objective history of the disaster, with no sources or authorities cited (and no bibliography or index).

The inherent drama of the disaster was written up by Prebble, apparently, mainly for effect: in presentational terms, the narrative suggests an evolving plot or story for a film. Conversations between members of the public are narrated although the basis for these remains unknown. Moreover, the *Foreword* sets out an example of superficiality of comments: 'Something more was destroyed in the

[12] Peter F. Marshall, *The Railways of Dundee* (Oxford: The Oakwood Press, 1996), p.75.
[13] A. Grothe, 'The Tay Bridge', (1878) *Nature* vol.18, pp.361–368.
[14] John Prebble, *The High Girders: Tay Bridge Disaster, 1879* (London: Penguin Books, 1959).
[15] John Prebble, *The High Girders* (London: Secker & Warburg, 1975).

darkness of those terrible seconds: the Victorians' smug pride in their industrial supremacy, and their belief in their creative infallibility'.

Prebble does not seem to offer any description of the actual collapse of the bridge but rather he attempts to show the reaction of the few members of the public watching the event and the reactions of the rest of the local and wider population. His story ends with a brief summary of the conclusions of the Court of Inquiry, and the effect of the whole event on Sir Thomas Bouch who designed the bridge and whose failings were specified by the investigation.[16]

(iii) ***Thomas***: John Thomas was a railwayman who lived in Springburn, Glasgow. He became, apparently without any formal training in history generally, a very prominent railway historian for Scotland. The continuity of general interest in the collapse of the bridge was probably assisted by the publication of his book in 1979.[17] It is not without reason that the first chapter is headed 'An Oft Told Tale'. The majority of the narrative is focused on the nature of the problems faced by the engineers and the construction of the bridge itself. There is an index but no specification of sources of information and their whereabouts, only general and unhelpful references; e.g., 'Letters of application to the chairman of the Tay Bridge Disaster Relief Fund'.[18]

Thomas offers some description of the dynamics of the collapse, although no sources are cited.

> 'The terrific blasting of the gale set up a violent racking motion between the two groups of columns forming hexagonal piers. The lugs on the columns fractured and fell away, and bracing bars swung loose. Bolts sheared away from the flanged joints of the columns. The added weight of the train was too much for the tottering structure'.
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> 'As No. 224 [the train reference] neared the northern end of the fourth high girder the iron towers began to double about their lower joints. The spans they supported tilted over to the east, slowly at first but quickly gathering momentum. … the spans broke away from the crumbling piers and hurtled towards the water with the train in their midst.'[19]

Thomas gives ample space to the Court of Inquiry and the outcome. His principal novel point, the 'new light' in the title, seems to be his discussion of a kink in the rails at the south end of the high girders. The existence of that phenomenon was quite common knowledge at the time of the collapse.[20] Precognitions (statements taken from witnesses in anticipation of what they might say in a court) were referred to by Thomas although the source of these is not given.

The problem in considering this allegedly significant fact of a kink in the rails was, and is, that while descriptions are quite explicit, no skilled witness has opined on the consequences of the suggested imperfection. It is not made clear in a technical or engineering sense how it relates to the collapse of the bridge. From the inequality of the rails it was said to cause the train itself and carriages to 'jerk into it', but it was also said by a railwayman at the time that the kink was 'not perceptible through any motion of the train'.[21] It is difficult to see then how the kink or misalignment was of relevance. That particular matter was not raised at the Court of Inquiry and was never made an issue then or

[16] Prebble, *The High Girders* (1975), Chapter X, pp.210-213.
[17] John Thomas: *Tay Bridge Disaster: New Light on the 1879* Tragedy (Newton Abbot: David and Charles, 1972).
[18] Thomas: *Tay Bridge Disaster,* ibid, p.203.
[19] Thomas: *Tay Bridge Disaster,* ibid, pp.87 and 90.
[20] Thomas: *Tay Bridge Disaster,* ibid, pp.199 -121.
[21] Thomas: *Tay Bridge Disaster,* ibid, p.200. That is an ambiguous phrase, it appears to mean that those travelling on the train did not notice anything adverse in the movement of the train due to the kink.

afterwards in litigation. Nor is it said anywhere with evidence that, knowing the misalignment existed, the railways company did nothing.

(iv) ***Holt***: LTC Holt in the first considered railway accidents in his work dedicated to the theme in 1955, and the book went through a large number of publishers and editions, and latterly, it was reprinted in 2009.[22] Holt's view was that the collapse had been brought about by:

> 'the failure to test the design of the structure adequately against the force of the wind, which blew with a well-known violence down the river, by scandalously bad manufacture of the iron used in it, and by the poor maintenance of the bridge while it was in service'.[23]

(v) ***McKean***: it is entirely understandable that Professor Charles McKean, Professor of Scottish Architectural History at the University of Dundee, should link the building of the Tay Bridge and that of the Forth Bridge some years later given the business development idea behind both bridges.[24] However, his explanation of the collapse is a dramatic one:

> 'Barely a minute after leaving Barclay's cabin on the south shore, passengers on the train had probably felt an unusual jolt or bounce - a very sharp on in the case of the second-class carriage at the rear of the train – and then perhaps a dragging motion accompanied by the squealing of wheels against rails. The second-class carriage then came to an abrupt halt, smacking into a girder tie-bar, and was immediately annihilated by the heavier Guard's Van behind, which mounted up over it crushing David Jobson and his companion to death. The force caused the cast-iron columns below to fracture, and the bridge to begin to topple downstream into the foam'.[25]

Notably the explanation has, as well as a 'probably' and a 'perhaps' both indicative of speculation, no real evidence to support what is a colourful account of the last few seconds of the journey.

The professor thought that the theories as to the reasons for the collapse fell into three categories:

> '[first,] poor construction and inadequate supervision; second, exceptional wind pressure leading to structural failure; and - most recently – metal fatigue.'[26]

After considering aspects of each of these possible causes, the professor then opines:

> 'The problem with each theory – wind pressure, poor construction or metal fatigue – is that while it might explain some of the evidence, it does not explain it all'.[27]

The professor does not seem to have considered that a conclusive explanation may encompass all of the possible causes, or some varying combination of them, with degrees of emphasis for each part identified.

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[22] L.T.C. Holt, *Red for Danger: The Classic History of British Railway Disasters* (Stroud: The History Press, 2009), Chapter 4 is entitled 'Bridge Failures – Storm and Tempest'.
[23] Jack Simmons, *The Victorian Railway* (London: Thames and Hudson, pb. 1995), citing Holt, *Red for Danger*, (4th edn., 1982), p.181. Simmons, a distinguished railway historian, wrote an Introduction for Holt's book later and Simmons did not challenge Holt's description.
[24] Charles McKean*, Battle for the North: The Tay and Forth Bridges and the 19th -Century Railway Wars* (London: Granta, 2006).
[25] McKean*, Battle for the North:* ibid, p.5.
[26] McKean*, Battle for the North:* ibid, p.213.
[27] McKean*, Battle for the North:* ibid, p.215.

(vi) ***Swinfen***: the first edition of this modern history of the disaster held its place for many years as the principal narrative.[28] It later was followed with a second edition.[29] The credibility of the book is emphasised by David Swinfen having held the position of Professor of Modern History at the University of Dundee. A crucial professional summary in the second edition is that in the *Foreword* written by Professor Roland Paxton, Professor of Civil Engineering at Heriot-Watt University:

> 'Most previous books on the subject [of the Tay Bridge] have promoted the hypothesis that collapse occurred not primarily from the inherent weakness of the structure to extreme wind force, but from damage caused by the derailed train, or, uncharacteristically for cast iron, fatigue'.
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> 'When writing history it is important to seek after truth. In a technical context, such as the reason why the Tay Bridge fell, this is best done from an understanding of material properties and the forces at play in its parts under various loading conditions. Previous writers on the Tay Bridge disaster tended not to address these issues in a comprehensive way'.[30]

The work of Professor Swinfen, a professional historian, is then suggested by Professor Paxton, a civil engineer, as being the last word on the subject. A whole chapter is devoted to the reason why the bridge collapsed, and there it is said that both at the time of the collapse and in subsequent years differences of opinion as to the cause or causes of the disaster have arisen.[31]

Professor Swinfen in considering all the explanations of the bridge failure which have been advanced, there remain essentially ***two school of thought*** – those who argue that the bridge was brought down by the train (which either canted over against the side of the girders, or actually left the track), and those who believe that the bridge itself collapsed under the force of the storm (taking the train down with it).[32]

The arguments for either view lie in the details of the collapse itself. By reference to the various authors cited below and their technical papers, Professor Swinfen identifies the proponents of the ***first theory*** as Albert Grothe, Sir Thomas Bouch, William Dow, and Professor Charles McKean. A variation of the first theory lies in the modern concept of metal fatigue, identified in some of the parts of the bridge. That idea has been promoted by William Dow, Dr Peter Lewis, and Ken Reynolds. Those in support of the ***second theory*** were Dr David W. Smith, Dr. Paul Sibley, Tom Martin and Professor Iain McLeod, a mathematician and structural engineer respectively.

Professor Swinfen stresses in seeking an explanation for the collapse the need to focus on two issues: *first*, the pressure of the wind on the night of the collapse, and *secondly*, the evidence for metal fatigue.[33] It is thought, by the professor, not possible to reconcile the two rival interpretations by explaining the vulnerability of the bridge to severe wind pressure as due to the inherent weakness of the specific parts susceptible to metal fatigue.[34] The broad conclusion is that the fundamental errors were to make inadequate allowance for wind pressure in design and in the specification of the parts identified as having metal fatigue. [35]

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[28] David Swinfen, *The Fall of the Tay Bridge* (Edinburgh: Mercat Press, 1994).
[29] David Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), p.102.
[30] Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), Foreword.
[31] Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), Chapter 7, p.95.
[32] Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), p.97.
[33] Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), p.109.
[34] Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), p.110.
[35] Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), p.111.

(vii) ***Nicoll, Nicoll and Buttars***: this publication, Murray Nicoll, Claire Nicoll and Grant Buttars, *Victims of the Tay Bridge Disaster of Sunday 28 December 1879,* is very notable for the extent of the detail, and other simple matters of fact, that may have been known to a few other historians earlier but which had not been published for a wider interested readership.[36] The cause of the disaster is not the focus in this volume, but rather the consequences of it. Several distinct factual matters presented by the authors are worth recalling, and may well justify further examination: first, the 'format of death certificates' are given, and these show the causes of death, hardly a revelation as 'drowning' but nevertheless indicative of a uniform approach by the authorities.[37]

Secondly, the details of the individuals making claims on the national disaster fund are identified, with their relationship to the deceased.[38] There is much more that may be made of the details presented; for example, (i) what was the total raised by the fund, and; (ii) who across the United Kingdom donated to the fund; and (iii) how much was claimed by individuals and how much was paid? These are not irrelevant matters so late after the event, as they would reveal the extent of financial dependency and immediate need. Further, the history of the fund suggests that it is an early example and it may be of interest because as late as 1988 there remained a surplus of £4,068 held by the local authority and that was passed to the Piper Alpha Oil Rig disaster fund.[39]

(viii) ***Wragg***: the idea of competition amongst railway companies was restated by David Wragg in, *The Race of the North*.[40] This is a general narrative account of the development of the railways with particular attention to routes leading to and from the east coast and east central Scotland, with the Tay and the Forth being seen as barriers to progress. The Tay Bridge disaster is covered briefly: however, it has to be doubted that Queen Victoria travelled by train across the 'to bestow a knighthood' on Thomas Bouch.[41] She first travelled by train southwards across the bridge on a journey from Aberdeen back to London, and later Bouch was knighted.[42] Wragg's explanation of the cause of the collapse of the bridge is superficial and no source is cited for the reasons for the disaster: 'it is believed that a third-class carriage derailed, and was then stopped when it hit a girder tie-bar. The heavy guard's van immediately behind it then rode over it, crushing the occupants, and the vibration caused the cast iron columns under the bridge to fracture and collapse.'[43]

(ix) ***Gren***: After Swinfen's second edition, the history of the disaster was developed by Andre Gren, *The Bridge is Down!*[44] The author emphasises that his book is about real people, the dead of the disaster.[45] However, notwithstanding that, a large part of the book covers the more technical aspects of the construction, and the collapse, all as discovered by the contemporary Court of Inquiry. Gren does not seem to offer his own explanation of the collapse. He does assert from the outset, and in keeping with the evidence of the time, that Sir Thomas Bouch 'gained a reputation for cheapness of construction,

[36] Murray Nicoll, Claire Nicoll and Grant Buttars, *Victims of the Tay Bridge Disaster of Sunday 28 December 1879* (Tay Valley Family History Society, pb., 2005).
[37] Nicoll, Nicoll and Buttars, *Victims*, ibid, p.76.
[38] Nicoll, Nicoll and Buttars, *Victims*, ibid, p.83.
[39] Robin Lumley, *Tay Bridge Disaster: The People's Story* (Stroud: The History Press, pb. 2013), p.181, fn.1.
[40] David Wragg, *The Race to the North: Rivalry and Record-breaking in the Golden Age of Steam* (Barnsley: Pen and Sword, 2013.
[41] Wragg, *The Race to the North,* ibid, p.71.
[42] McKean*, Battle for the North:* ibid, p.147.
[43] Wragg, *The Race to the North,* ibid, p.72.
[44] Andre Gren, *The Bridge is Down! Dramatic eye-witness accounts of the day the Tay Bridge went down, Sunday 28 December 1879* (Kettering: Silver Link, pb. 2008).
[45] Gren, *The Bridge is Down!,* ibid, 'Acknowledgements'.

which often needed remedial work later'.[46] The 'badly designed, badly constructed and badly maintained' bridge, citing the conclusion of the Court of Inquiry, meant that the 'downfall was due to inherent defects in the structure' that had 'sooner or later, have brought it down'.[47]

The brief Introduction provides some history of the bridge and the works, and the bulk of the work is devoted to the statements of the crucial 102 witnesses called to the statutory Court of Inquiry.[48] This history is focused on the evidence of the Court of Inquiry, and follows on from the investigative work of Nicoll, Nicoll and Buttars. Nevertheless, Gren does pay close attention to the inspections of the structure before the collapse and the reasons for the collapse, and the Court of Inquiry.[49] The uncertainty of the numbers of victims of the collapse is considered along with names and some other personal details of the known deceased.[50]

(x) ***Lumley***: the short 'Introduction' in Lumley's book attempts to place the disaster in its much wider context.[51] Regrettably, that includes a succession of a large number of barely coincidental and certainly irrelevant facts, such as the birth that year of 'some significant people'. [52] His explanation of the collapse is that the:

> 'entire bridge, already in deep resonance and fatal oscillation and with wind's energy adding every second to the swaying motion, finally succumbed to the metal fatigue it had been undergoing for nineteenth months, especially the case-iron lugs holding the tie bars. It was the camel's back-breaking straw. Below the bridge decking, the tortured ill-fitting iron columns, the fatigued lugs and their tie-bars finally gave up the ghost. Everything simply failed at once. The high girders and the piers below them fell outwards in a truncated arc to the downside of the bridge, probably going down with the extra vicious gust at around 7.16 pm.'[53]

The narrative of the event focuses understandably on the known individuals who were involved in the crucial actions. These seem not to have pursued in quite such detail before Lumley, as for example with the background details of one of the deceased passengers, William Henry Beynon, a commercial traveller from 'far-off Cheltenham, Gloucestershire (England)'.[54] There is reason for considering this man a little longer: Lumley records that when the body of Mr Beynon was recovered and taken from the river he was found to be without his heavy overcoat: 'He'd obviously shrugged this off in the river to help him swim'.[55] The suggestion following from that was that Mr Beynon had survived the fall into the river and at least managed to get out of his carriage.

Yet, there is no evidence that the deceased had been wearing his coat at the precise time of the accident, and it is entirely possible as a matter of common practice, that he had removed the coat for the duration of the journey and intended putting it back on at the end of his journey. The recovered remains of Mr Beynon included, remarkably, a 'pocketbook' (meaning a wallet, perhaps) which contained £18/5/8, a modern value of the simple purchasing power would be about £2,300.[56] These

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[46] Gren, *The Bridge is Down!,* ibid, p.8.
[47] Gren, *The Bridge is Down!,* ibid, p.135.
[48] Gren, *The Bridge is Down!,* ibid, Appendix 3: pp.169 – 172, lists the witnesses.
[49] Gren, *The Bridge is Down!,* ibid, Chapter 10, pp.116 – 139.
[50] Gren, *The Bridge is Down!,* ibid, 'Postscript', pp.141 – 147.
[51] Robin Lumley, *Tay Bridge Disaster: The People's Story* (Stroud: The History Press, pb., 2013).
[52] Lumley, *Tay Bridge Disaster,* ibid, pp.17-18.
[53] Lumley, *Tay Bridge Disaster,* ibid, p.149.
[54] Lumley, *Tay Bridge Disaster,* ibid, p.49.
[55] Lumley, *Tay Bridge Disaster,* ibid, p.49.
[56] Lumley, *Tay Bridge Disaster,* ibid, p.49: Measuring Worth - Purchase Power of the Pound (accessed March, 2025).

details add to the point of extreme irony in Mr Beynon having taken the place of his local agent, and erroneously having left the train involved in the disaster at Ladybank, and then returned to it.[57]

Lumley has offered a broad narrative for the general reading public and he has uncovered some new personal details, as might be expected of a 'people's story'. There is more than mere explanation with considerable 'padding': for example, an explanation of the history of 'meteorology', with a definition, seems superfluous.[58] The same might be said of some of what are called 'chapter notes', essentially background explanations of peripheral (and some highly so) subject-matters.

(xi) ***Wolmar***: the context of the Tay Bridge disaster is considered by Christian Wolmar.[59] The Tay Bridge disaster 'not only highlighted the risks of taking short cuts in engineering, but also ensured that the much more ambitious project of crossing the Firth of Forth was carried out successfully'.[60] The concluded view is that the precise cause was never ascertained by contemporaries, although Sir Thomas Bouch 'appeared to have greatly under-estimated the structural requirements needed to resist the Force 10 gales that blow regularly in the Firth of Tay area'.[61]

3. <u>Engineering debate</u>

What precisely is meant by 'the engineering debate'? Those with an interest in the technical aspects of the construction of the bridge have agreed on many details, and differed markedly on others, the latter being crucial, as are the inferences that may be drawn from them. The point of the discussion was to settle on those events that caused, or contributed substantially, to the collapse. These points encompass the effects of the adverse weather conditions, the manner in which the bridge was constructed, and the quality of the materials used in the construction. Discussion has also focused on the train and the carriages and their relevance to the action of collapsing.

Views are considered by the name of the commentators. It would be advantageous at this juncture to point out the difference between a structural engineer and a materials scientist as most of the commentators belong to one of these two professions. Structural engineers analyse, design, plan, and research structural components and structural systems (buildings, bridges, tunnels etc) to achieve design goals and ensure the safety and comfort of users or occupants.

A materials scientist specializes in the interdisciplinary field of materials science, which involves the study and manipulation of the properties, structure, and applications of different materials. These materials can include metals, ceramics, polymers, composites, and more. The role also includes the investigation of materials, products, structures or components that fail or do not operate or function as intended, causing personal injury, damage to property or economic loss. The person who specialises in this is called a forensic engineer/scientist. The forensic engineer may frequently find himself/herself involved in the legal process, acting as an expert witness in both civil and criminal cases.

The list below gives the *technical background* of each of the commentators, and that designation implies their particular skill or expertise:

- The **Court of Inquiry Commissioners** consisted of a lawyer and two civil engineers one of whom was the President of the Institute of Civil Engineers.

[57] Lumley, *Tay Bridge Disaster,* ibid, p.105-106.
[58] Lumley, *Tay Bridge Disaster,* ibid, p.106.
[59] Christian Wolmar, *Fire and Steam: How the Railways Transformed Britain* (London: Atlantic Books, 2nd ed., 2024), pp.170-173.
[60] Wolmar, *Fire and Steam,* ibid, p.170.
[61] Wolmar, *Fire and Steam,* ibid, p.171.

- **Smith** was a civil engineering lecturer.
- **Sibley** is a structural engineer.
- **Walker** is a structural engineer.
- **Dow** was a physics lecturer.
- **Jones** is a material/forensic scientist whose work has centred on the failure mechanisms of materials, and the analysis and prevention of failures in structures and components -he has acted as an expert witness in legal cases involving the failure of materials.
- **Lewis** was a materials/forensic scientist who specialised in polymers and composite materials - he also has acted as an expert witness in legal cases involving the failure of materials.
- **Reynolds** was a forensic metallurgist.
- **Gagg** is a forensic engineer.
- **Burt** is a biometeorologist.
- **Martin** is an applied mathematician with a specific interest in wind effects on structures.
- **MacLeod** was a professor of structural engineering.
- **Åkesson** is a consulting structural engineer.
- **Petroski** was a professor both of civil engineering and history specializing in failure analysis.

(i) **The Court of Inquiry** (1880): The inquiry report [62] concluded that 'The fall of the bridge was occasioned by the insufficiency of the cross bracing to sustain the force of the gale'. It speculated that the bridge may have survived the storm if the high girder piers had been properly constructed albeit with a reduced factor of safety. Bouch's theory that the train was necessary for the collapse of the bridge was rejected by the Court.

(ii) **Smith** (1976): This paper [63] examines several bridge failures one of which is the Tay bridge disaster. He surmises that the 'diagonal ties were too weak because they had not been designed to resist wind force. This weakness was almost certainly the sole cause of the failure'. Utilising the wind loading code he estimates the bracing would fail at 28 lbsf/ft^2 This equates to a wind speed of 60 m/hr. The modern computer analysis (see **Martin & MacLeod**) shows that at 60 m/hr the diagonal bracing is safe and requires a wind velocity of at least 75 m/hr for the bracing to fail.

(iii) **Sibley & Walker** (1977): Several bridge failures are examined in this paper[64] one of which is the Tay Bridge. Using the modern wind loading code (CP3) they show that the true loading on the bridge was 7 times greater than the wind loading used by Bouch. Surveying the knowledge of wind loading in Britain at that time they think that Bouch was harshly dealt on this issue. They also report American engineers had experienced several bridge failures due to underestimating wind loading in the previous 20 years prior to the Tay Bridge disaster. Due to these failures, they made significant allowance for wind loading. They suggest that had records of such disasters been widely available the Tay Bridge disaster could have been avoided.

(iv) ***Dow*** (1979): This theory [65], in many ways like Bouch's, postulates that the train came off the track due to a kink in the rails with uplift of the train attributed to aerodynamic forces. In consequence, one

[62] Court of Inquiry, *Report upon the circumstances attending the fall of a portion of the Tay Bridge.* (London: HMSO, 1880)
[63] D.W. Smith *Bridge Failures,* Proc. Instn Civ. Engrs. Part 1, (1976) vol.60, Aug pp.367-382
[64] P. G. Sibley, A. C. Walker, Structural accidents and their causes, Proc. Instn Civ. Engrs. Part 1, (1977) vol.62, May pp.191-208
[65] W.M. Dow (1979) 'Destined for disaster', *Scots Magazine*, pp.175-186.

of the carriages hits the bridge and the shock experienced by the pier causes the cast iron lugs connecting the wind bracing members to the columns to fracture leading to the subsequent collapse of the pier structure. There is no technical analysis to back up the theory.

(v) ***Duck and Dow*** (1984): This paper [66] reports on submerged remains of the first Tay Railway Bridge using side-scan sonar technology. It does not attempt to shed any new light on why the bridge fell.

(vi) ***Jones*** (1994): This theory [67], based on some simple calculations and utilising the current wind loading code concludes that, 'We thus have the ironic situation where the structure was able to withstand the gale on its own but collapsed as soon as the train ran on to it'. In other words, the train was necessary for the collapse.

(vii) ***Martin and MacLeod*** (1995): This paper [68] re-examined the failure using modern computer structural analysis in conjunction with up-to-date knowledge on wind loading to see if any new light could be shed on the disaster. The analysis showed that good construction could not have saved the bridge from the storm on the night of the disaster. In addition, the analysis shows the train was not necessary for the collapse. Also, a possible collapse mechanism was presented. A website dedicated to this study includes a simulation of the predicted collapse mechanism. The website also addresses Dow's and Lewis's theory in the light of the modern computer structural analysis.

(viii) ***Lewis and Reynolds*** (2002): This paper [69] claims that dynamic effects caused the fatigue failure of the cast iron lugs was the reason for the collapse. The evidence for the dynamic effects is based on the eyewitness reports from painters and fitters that the high girders piers oscillated from side to side whenever a train crossed the bridge. Based on close inspection of high-quality photographs (which show some limited evidence of crack arrest lines) of the failed parts it is claimed that the failure of the cast iron lugs was due to fatigue rather than overstressing due to wind loading.

(ix) ***Lewis*** (2004): The book [70] represents the findings of the 2002 paper: 'Although wind loads contributed to the disaster, the bridge was already severely defective owing to failure of its most important stabilising elements (wind bracing ties)'. He also writes: 'Nevertheless, there was no hurricane that fateful night in Dundee and while the wind was strong, it was not so strong to blow down the structure unassisted'. In addition, Lewis claims: 'The many defects in the structure have been quietly forgotten, and Bouch, after all these years, is posthumously vindicated'.

(x) ***Burt*** (2004): Dr Peter Burt is a Biometeorologist whose article[71] re-examines the storm affecting Scotland, and particularly the wind conditions experienced by the Tay Bridge on the night of the disaster. Reviewing the meteorological data available at the time he shows that the bridge experience a force 10-11 on the Beaufort scale. He favours the theory that the bridge was under designed for wind loading conditions at Dundee on the night of the disaster.

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[66] R.W. Duck and W.M. Dow, 'Side-Scan Sonar Reveals Submerged Remains of the First Tay Railway Bridge' 1993), *Geoarchaeology: An International Journal*.

[67] D.R H. Jones, 'The Tay bridge disaster – Faulty materials or faulty design?' *Engineering Failure Analysis,* (1994) vol.1 (3), pp. 245-253.

[68] **T.** Martin & I. A. MacLeod The Tay rail bridge disaster – A reappraisal based on modern analysis methods *Proc. Instn Civ Engrs 1995, 108, 77-83*.

[69] P. R. Lewis & K. Reynolds Forensic Engineering: A Reappraisal of the Tay Bridge Disaster, reinvestigating the Tay Bridge disaster of 1879 (2002), *Interdisciplinary Science Reviews, vol 27, no 4*.

[70] P.R. Lewis, *Beautiful railway bridge of the silvery Tay. Reinvestigating the Tay Bridge disaster of 1879* (Tempus Publishing; 2004).

[71] P. J. Burt, The Great Storm and the fall of the first Tay Rail Bridge, R. MetS., Dec 2004, Vol 59, No. 12

(xi) ***Martin and McLeod*** (2004) – rebuttal of Lewis. In response to Lewis's paper and book, a follow up paper [72] concluded that the evidence for fatigue being the main cause of the collapse is weak compared with the evidence for failure due to wind loading. The paper acknowledged that fatigue was present, but it was not the primary cause of the collapse.

(xii) ***Björn Åkesson*** (2008) – The author devotes chapter 5 of his book[73] to the Tay Bridge disaster. He references **Jones** (1994) **Martin and Macleod** (1995) and **Lewis** (2002) papers as well as the **Martin** website. He accepts that wind loading was the primary cause of the disaster, and the probable collapse scenario is the one proposed by **Martin and MacLeod**. He also thinks the bridge was prone to wind induced oscillations.

(xiii) ***Gagg and Lewis*** (2011): This paper [74] challenges some of the findings of the 2004 paper by **Martin and MacLeod**. The authors state: 'Nevertheless, there was no hurricane that fateful night in Dundee and while the wind was strong, it was not so strong to blow down the structure'. Lewis does not recognise that a force 10 on the Beaufort scale is considered exceptional for this country. The gust velocity, for a force 10 at the height of the high girders is **104 M/Hr** while the mean velocity would be **66 M/Hr**. When designing a structure, it is the **gust velocity** that must be used to compute the wind loading.

Lewis agrees with Baker's evidence (the latter thought the wind pressure was **15 psf**. while the actual wind pressure was **65psf**!) that the windows of the signal boxes at either end of the bridge would have been blown out. In addition, Lewis contends that 'if the bridge was brought down by the storm-force winds, why did it not also bring down the high chimneys seen in the background?' Nevertheless, it is a fundamental fact that the wind loading on a structure depends on its unique structural properties and the fact that the wind flow around objects with different shapes and located in different terrains leads to different wind loads. For each structure a combination of structural engineering and aerodynamics must be used to calculate the wind load. The Fatigue page on the **Martin's** website deals with all the issues raised in this paper.

(xiv) ***Petroski*** (2012): This book[75], one of many by Petroski, deals with various historical structural failures. In the case of the Tay Bridge disaster, he accepts the new theory proposed by **Lewis** (2002) that fatigue of the cast iron lugs was the primary cause of the collapse and not the wind loading. He does not seem to be aware of the **Martin and MacLeod** (2004) study showing the evidence for fatigue failure is weak.

Except for **Petroski**, the commentators with a structural engineering or meteorological background think that wind loading was the primary cause of the disaster. Except for **Jones**, those with a forensic engineering background look to fatigue of the faulty cast iron lugs to explain the failure. Dow and Jones think the train was necessary for the collapse.

To decide conclusively the primary cause of the collapse a **comprehensive computer structural analysis** of the bridge is required. This approach has been carried out and reported in the two ICE papers by **Martin and MacLeod** along with the accompanying website dedicated to the study.

4. Context: legal and social

[72] T. Martin & I.A. MacLeod **'T**he Tay rail bridge disaster revisited' *Proc. Instn Civ. Engrs, 2004 ,**157**, 187-192*.
[73] B. Åkesson, *Understanding Bridge Collapses* (2008), Chap. 5, Taylor & Francis Group.
[74] C.R. Gagg & P.R. Lewis, The rise and fall of cast iron in Victorian structures – A case study *review, Engineering Failure Analysis* 18 (2011) pp.1963–1980
[75] H. Petroski, *To Forgive Design Understanding Failure* (The Belknap Press of Harvard University Press; 2012).

There is little doubt that the wider international and domestic context of the Tay Bridge has been neglected: these included, but were not restricted to, the world interest in the bridge and the collapse, the Tayside economy and the reason for the bridge, the raising the finance for the construction, the state of the construction site and any health and safety issues there, and the social consequences of the collapse and its rebuilding. While some histories have touched upon elements of these aspects of the history, there is a sense in which the detail has been neglected and consequently the full life of the bridges has not been produced.

While some of the general histories of the Tay Bridge recognise the enormous investment implied in building the world's longest bridge, little has been done to develop the economic theme in greater detail. The construction was preceded by extensive general railway legislation, and that specific to the Tay Bridge itself. Moreover, the existing *North British Railway Company* continued in railway business up to and beyond the Tay Bridge itself. (but excluding the bridge). The Tay Bridge itself was the property of a separate company formed for the specific purpose of crossing the river, and while some of the directors were appointees for both companies not all were in both companies. The construction of the old and the new Tay Bridges may be seen as an example of major project management.[76] The liability of the directors of the two companies seems never to have been considered or examined by historians, although the disaster and the rebuild occurred in an era of evolving general limited liability.[77]

The context of the disaster within the jurisdiction of Scotland raised a number of points about the law which also seem never to have been considered by others. These points may or may not have been relevant to the historians, but, at the very least, they explain how or why some things were done or not done.[78] In the absence of the office of coroner, and no coroner's court, the manner in which sudden suspicious and unexplained deaths were investigated in mid-Victorian appears to have been left unexamined by historians until comparatively recently.[79] With the collapse the question of compensation claims and support for the nearest relatives of some of the deceased became pressing issues. The liability of the *North British Railway Company* was not challenged and the only point of contention was probably that of amounts to be paid by the company.[80]

There was a local legal bar that was acquainted with railway companies locally and doubtless the associated legislation and they were engaged professionally and available to provide advice should it be required.[81] The police as a force, in the modern sense, were still very much at the stage of development. Their role was determined and limited to a degree by what was then comparatively modern legislation but even so there has been little or no explanations of what the police did do or might be able to do, both in keeping with their statutory duties and pragmatism.[82]

It would be too simple to assert merely that after the collapse a new bridge was built in its place. The hitherto unexplained political tensions (essentially those between local government in Perth and the

[76] Robert Shiels, 'Corporate governance, Financial risk and the Tay Bridge project' (2024) 92(2) *Scottish Law Gazette* 46-51.
[77] Ron Harris, 'A new understanding of the history of limited liability: an invitation for theoretical reframing ' *Journal of Institutional Economics* (2020), vol.16, pp.643–664, at p.655, [this paper is freely available online].
[78] Robert S. Shiels, 'Scots law and the Tay Bridge disaster of 1879' (2013) *Scots Law Times* (News) vol.40, pp.271-274.
[79] Robert S. Shiels, The investigation of sudden deaths in the Tay Bridge disaster of 1879' (2016) *Juridical Review* Issue 3, pp.213–226.
[80] Robert S. Shiels, The Tay Bridge disaster and the major personal claim' (2015) *Reparation* 122 (Feb.) 4-7.
[81] Robert Shiels, 'The Tay Bridge disaster of 1879 and Dundee solicitors' (2024) 92(4) *Scottish Law Gazette* pp.118-122.
[82] Robert S. Shiels, 'The Tay Bridge disaster of 1879 and the role of the police', *unpublished paper*.

railway company) reappeared in civil litigation. The collapse left a very substantial quantity of portions of the old bridge in the river and at such places as to affect the free movement of shipping up and down the river to Perth. Responsibility for that residue was complicated by the arrangements put in place to use again parts of the old bridge for the construction of the new one. Litigation that started in the Court of Session in Edinburgh, ended in the appellate committee of the House of Lords in London.[83]

Finally, the Court of Inquiry established after the collapse began with a hearing of witness evidence at an initial attendance at Dundee a very short time after the event. Indeed, as the first hearing was within a few days of the collapse it might be said to have been too quick. The history of inquiries has itself become a matter of some interest, the implication being that there is more to them than the outcome of deliberations.[84] A modern examination of the procedural aspects of the Court of Inquiry has concluded that the investigation and the conclusions were controlled by the same government department that took up suggestions for further research. Personnel who had advised to some degree during construction were engaged in the inquiry hearing itself and then the research. The inquiry was unfair in having more than merely the appearance of bias.[85]

5. Concluding remarks

it remains a general mystery why a full history of an important example of practical success and obvious failure, such as the two Tay Bridges, should have been neglected. That may be seen as a paradox given the detail of the findings of the Court of Inquiry and the available photographs, for example, of remarkable clarity of the engineering remains of the edifice. There were in 1879 on the River Tay great engineering triumphs and failures, with an apparent unwillingness by historians to confront engineering issues. Separately, there has been neglect of the political, social and economic conditions of mid-Victorian Scotland, in the wider context to attain a full history of the bridges. A few interim conclusions might be offered.

A. Engineering

It seems that everyone who writes a book, paper or article on the Tay Bridge disaster wants to have a new slant on what caused its demise. The Court of Inquiry heard a great deal of evidence which uncovered many defects in design and construction. Some of the evidence was so dramatic that the main issue was eclipsed: Even if the bridge had been perfectly constructed it would still have collapsed in storm force wind conditions as existed on the evening of the disaster. Most commentators who are not trained as structural engineers tend to home in on either the train or the materials to explain the disaster. In contrast those commentators with a structural engineering background are convinced that wind loading was the main cause of the collapse.

To attempt to resolve the competing collapse theories, Martin/MacLeod[67,70] carried out a comprehensive modern computer structural analysis of the bridge utilising the modern wind loading code. The analysis clearly shows the bridge could not withstand storm force wind loading which existed on the evening of the disaster. In addition, the study clearly shows the train was not necessary for the

[83] Robert Shiels, 'Civil litigation and the construction of the second Tay Bridge' (2024) 92(1) *Scottish Law Gazette* pp.17-23.
[84] McLean and Johnes, '"Regulation Run Mad": The Board of Trade and the Loss of the *Titanic*', ibid.
[85] Robert S. Shiels, 'A Conflict of Interest at the Tay Bridge Disaster Inquiry' (2022) 13(2) *Northern Scotland* pp.113-129.

bridge failure and that fatigue of the cast iron lugs was not the primary cause of the collapse. A independent endorsement for this study comes from Professor Roland Paxton's forward to Swinfen's[86] book:

> "This is an important book because Professor Swinfen, for the first time in a popular text, highlights the findings of Tom Martin and Professor Iain Macleod based on their comprehensive structural assessment published in the Proceedings of the Institution of Civil Engineers in 1995 and 2004. Most previous books on the subject have promoted the hypothesis that collapse occurred not primarily from the inherent weakness of the structure to extreme wind force, but from damage caused by the derailed train, or, uncharacteristically for cast iron, fatigue." It is worth noting that computer structural analysis only became possible from about 1960 and the modern British wind loading code (CP4) was only made available for British structural engineers in 1944. This may partly explain why it has taken so long to properly reinvestigate the findings of the Court of Inquiry report.

The collapse of the Tay bridge exposed a major weakness in British civil engineering. While engineers in America and France were using significant wind loadings few of their British counterparts even considered it. Although light truss bridges were new to Britain in the 1860s and 70s, it had been the accepted practice in America for 20 years. As a result, American engineers had experienced bridge failures due to wind loading and had made allowance for such loading. Shortly before the Tay Bridge opened Thomas Clarke[87] ,who was one of the one leading civil engineers in Canada and the United States in 1848 to 1901, gave a paper at the ICE on iron bridges of very long span. The approach he was accustomed to in relation to wind loading had reached a stage where he was more than surprised with the attitude of British engineers to wind loading and that this could be the limiting factor in the design of a bridge.

Unfortunately records of these failures did not seem to be readily available to British engineers. It was only in the mid-1870's that international communications were properly established. Many lessons were from learned from the disaster: research into wind effects on structures was stimulated; quality control during construction was highlighted as being of primary importance; and the use of steel, which superseded cast/wrought iron, as a structural material was sanctioned by the Board of Trade; keeping abreast of engineering developments in other countries; maintenance of records detailing incompletely explained accidents so that new problems may be ascertained before they caused a major collapse.

B. Legal context

A comprehensive history of the Tay Bridge disaster encompasses, or should do, the legal background of the venture and an attempt has been made in the modern legal articles cited. The legal history should also extend beyond the collapse itself to consider the consequences of any individual disaster under consideration. Two separate areas might be considered: first, the bespoke legal regulation of the Tay Bridge was extensive, and expensive as the company's Edinburgh solicitors would be required to instruct Westminster solicitors, Parliamentary Agents, to instruct counsel, specialist barristers in London, to draft the Bills. The Parliamentary Agents would manage the legislation through the

[86] Swinfen, *The Fall of the Tay Bridge,* ibid, (2nd ed., 2016), Foreword.
[87] T. C. Clarke, 'Iron bridges of very long span' Min. Proc. Inst Civ. Engrs 1881, 69, 145

Parliamentary procedure. There is, apparently, a substantial and hitherto unexamined set of legislation concerning the two Tay Bridges. As well as showing the statutory boundaries of a major industrial construction in the era of laissez faire, the local law shows some of the consequences of the disaster.

For example, the *North British Railway (Dundee and Arbroath Joint Line) Act 1879* (42 & 43 Vict, Ch. clv) received Royal Assent on 21 July 1879, with the provision in section 3, for 'a vesting period' so that the Act would come into force on 1 February 1880. The aim of the statute was to consolidate the existing rights of ownership and use of railways to the east of Dundee, and the management of them by a joint committee of the Caledonian Railway Company and the North British Railway Company, acting jointly and in equal proportion. As the bridge collapsed before that legislation came into effect, it would seem that the arrangements for the use of the relevant railways before the collapse had from 28 December 1879 to be reverted to on an *ad hoc* basis which may, or may not, have been regulated by contract. All this, and more of the statutory basis of the construction and environment, remains under-investigated.

Secondly, the history of the police, and the individual police forces have, in the modern era, been developed. The history of the police is a separate subject from that of the history of crime, but both are clearly linked.[88] Little has been done on the history of the police in the vicinity of the construction site of the two bridge, and then the bridges themselves. There is a distinct interest by historians in the railway police generally, and in that regard a history is available explaining some of the background to the Railway Police in Scotland.[89] There does not seem to be any study of the effect of the bridges, when each was viable, on the commission of crime: the movement of people and goods was greatly assisted by the benefits to transport by the bridge and presumably criminal activity of some sort developed.

C. General history

A wider narrative of events requires to consider the political tensions around the bridge and its construction. The edifice at Dundee was said to obstruct to a degree the plain sailing of ships up the Tay to Perth. Yet, the existence, before the construction of the bridge, of a railway from Perth along the north bank of the river was already an indication of the economic benefits of a railway.

The social and economic history, encompassing the politics, of the Tay Bridges remains to be assessed fully. The manner in which the two bridges were financed, and the legal background (through private legislation obtained at private expense) to construction and replacement, have both been neglected.

Finally, the existence of the first bridge, its collapse and its replacement were matters of intense social and engineering interest internationally, across the world and not just across the British empire. The speed of communication and the details of what was made public, especially after the report of the Court of Inquiry became known, provides an indication of the intense public concern about these matters 150 years ago.

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[88] Generally see: Jonathan Oates, *Great Train Crimes: Murder and Robbery on the Railways* (Barnsley: Wharncliffe Books; 2010).
[89] David Conner, 'The History of the Scottish Railway Police' *British Transport Police History Group* (1997): available at The History of the Scottish Railway Police – British Transport Police History Group