

of Messrs. Pierce and Knowles, private owners, come into the siding (and sometimes leave the scotch open) as well as those of the Lancashire and Yorkshire Company.

I am glad to learn that orders have been given for the erection of signals to guard the sidings near this junction; and I would take the opportunity of strongly recommending that a raised stage should be con-

structed, with locking apparatus, and all those accessories to safety which are now provided at such posts.

I have, &c.

H. W. TYLER,
Capt. R.E.

W. D. Fane, Esq.
Board of Trade,
Whitehall.

LANCASHIRE AND YORKSHIRE RAILWAY.

Board of Trade
(Railway Department),

SIR, Whitehall, 26th January 1866.

I AM directed by the Lords of the Committee of Privy Council for Trade to transmit to you, to be laid before the Directors of the Lancashire and Yorkshire Railway Company, the enclosed copy of the report made by Captain Tyler, R.E., the officer appointed by my Lords to inquire into the circumstances connected with the falling of the viaduct at Mytholm Bridge on the Holmfirth branch of the Lancashire and Yorkshire Railway on the 3rd ultimo.

The Secretary of the
Lancashire and Yorkshire
Railway Company.

I have, &c.
W. D. FANE.

SIR, No. 1, Whitehall, 22d January 1866.

IN compliance with the instructions contained in your minute of the 23d ultimo, I have now the honour to report, for the information of the Lords of the Committee of Privy Council for Trade, the result of my inquiry into the circumstances which attended the fall of the viaduct at Mytholm Bridge on the Holmfirth branch of the Lancashire and Yorkshire Railway on the 3d ultimo.

The Holmfirth branch of the above railway, $1\frac{1}{2}$ miles long, was opened for traffic in June 1850. The viaduct in question, about a mile from Holmfirth, was originally constructed of timber, but on masonry foundations. It was divided into 26 bays, each having a span of 20 feet 6 inches, and was, including the abutments, about 200 yards long, with an extreme height of $85\frac{1}{2}$ feet to the level of the rails. In 1864, the company determined to renew it in masonry, and the contract was taken by Mr. Henry Wadsworth for the low sum of 7,100*l.* Mr. Wadsworth signed the specification, copy of which I enclose, on the 4th July 1864, and the plans on the 20th of the same month. The accompanying plans, with which Mr. Meek, the engineer of the company, has been so good as to furnish me, are tracings of the original plans signed by himself and the contractor. They show, as will be observed, the principal details of both the old and the new viaduct, and the manner in which the piers of the latter were to be constructed intermediately between those of the former.

The viaduct was on an irregular curve of about 20 chains radius. In order to obtain an equal span on each side of the arches, the ends of the piers on the outer side of the curve were $11\frac{1}{2}$ inches wider than those on the inner side of the curve. The new piers were to be 27 feet long at the top, 4 feet thick at the top at the narrow end, and 4 feet $11\frac{1}{2}$ inches thick at the top at the wide end, with a batter of $\frac{1}{4}$ of an inch to the foot on each side and at each end. They varied, therefore, at their base in length and breadth according to their height. The footings were to be in two courses of 12 inches each, projecting 6 inches on each side for each course. The piers were to be sneaked on the face, with a through-stone in every square yard of surface, and the viaduct was to be built of "good rubble stones," with "imposts, corbels, "string-course, and coping of tooled ashlar." There were 11 arches, each with a span of 37 feet 8 inches, and a rise of 18 feet 10 inches, and 2 smaller arches, each with a span of 29 feet, and these were all to be

2 feet thick, "of pierpoint masonry, with pitched ace voussoirs, and backed up with rubble masonry."

Mr. Kershaw, an inspector of 15 miles of railway, in whose district the viaduct lay, was employed to superintend the construction of the work without any increase to his salary of two guineas a week. He had first, according to Mr. Watts, been a staff holder in levelling, and was then employed in fixing the profiles of tunnels, where he was found very useful. He then learnt to level and take a section of ground. He had never been employed before in the construction of a bridge or a viaduct, but had been in charge of the permanent way and works on the line between Penistone and Huddersfield, and on the Holmfirth branch since July 1864, and had been "applying for an advance." Mr. Watts, the assistant engineer of the company, explains that "this work was given to him as a means of "getting him an advance, and if it had been successful, he *might* have got 30*l.* or 50*l.* a year more, "as a compensation for the superintendence of the "viaduct." He gave a month's notice after the viaduct fell, and at the expiration of that period left the company's service.

I had not an opportunity of examining Mr. Kershaw on the spot, but I learnt from Mr. Watts that a letter was forwarded to him on the 13th instant, informing him that I should make my inquiry on the 16th; and I requested Mr. Watts further to inform him that I should be happy to receive anything in writing which he might feel inclined to send me. I have since received a letter from him dated the 20th instant, which I herewith enclose. He was required to report to Mr. Meek every fortnight on the state of the permanent way and works in his district, and Mr. Watts states that his reports have been, as regards the viaduct, of one uniform character, that the work was progressing satisfactorily up to within a few days of its fall. That this was the case will be seen from the enclosed extracts from his reports, the last of which is dated 30th November 1865, four days before the viaduct fell. He therein reports "the "filling and ballasting done for one line," and that he is "laying the new road." In addition to Mr. Kershaw's superintendence, it appears that Mr. Meek visited the work three times, and Mr. Watts every month or six weeks, or "about half a score" of times between July 1864 and December 1865.

After the plans had been signed, Mr. Meek acceded, at Mr. Wadsworth's request, to the substitution of Yorkshire lime for Halkin Mountain lime provided in the specification, and a saving of something like 56 per cent.* is stated to have been thus made by the contractor in that important item.

In making my inquiry, I first inspected the site in company with the gentlemen of the Chamber of Commerce at Holmfirth, who have memorialized their Lordships, and others interested, as well as with Mr. Watts, Mr. Wadsworth the contractor, and his brother who had assisted him. I afterwards examined all who afforded me opportunity at the Huddersfield Railway Station.

The site presented a scene of complete ruin. The mortar had evidently been of bad quality, and there

* Mr. Meek has since explained that though there was no agreement on the subject, it was not his intention that the contractor should ultimately benefit by this alteration.

was an entire absence of cohesion between the parts of the fallen masonry. The timbers of the original viaduct protruded in various positions, but mostly falling towards near the centre, from a long line of rubbish across the valley.

The work was commenced in July 1864, almost immediately after the plans had been signed. As regards the foundations, Mr. Kershaw states simply that "they were all taken to the depth as shown upon the plan, and 5 of them below, to such a depth as I and the contractor thought sufficient." The evidence of Mr. Wadsworth as to the manner in which they were put in is, as will be seen, highly important.

Mr. Wadsworth states that the foundations of No. 7 pier (from Huddersfield, about 80 feet below the level of the rails) were about 5 feet below the surface, half on rock and half on gravel, longitudinally. "There was rather more rock than gravel at the thick end, and rather more gravel than rock—very little rock—at the thin end of the pier. No one but Mr. Kershaw knew of this, and Mr. Watts and Mr. Meek never saw it. I thought, perhaps, that might be sufficient at the time. It was pretty hard gravel, but I believe the water was under it. It was not for me to say exactly what depth I should go. I went to the depth required by the plan and specification. Nos. 6, 5, 4, piers were also half on rock and half on gravel, but in a different way, the thick end having been all rock, and the thin end having been all gravel. The south ends of the piers were all thicker than the north ends, on account of the curve in the viaduct, of which the radius was about 20 chains. It therefore happened that the thicker end of the piers had the stronger foundation, and the thinner end of the piers had the weaker foundation," or, in other words, the footings on the weaker were considerably less in area than the footings on the stronger foundation. Mr. Wadsworth adds, "I did not remonstrate against this state of things. I merely carried out the work according to my plans and specification, or, when I departed from them, by going deeper with the foundations, under the direction of Mr. Kershaw." And he states, with regard to the other piers, that Nos. 1, 2, and 3 were on mixed shale and clay, No. 8 was on gravel, No. 9 was on shale, and the deepest they went down was with No. 10 pier, which was 12 feet below the surface.

Mr. Wadsworth first began to observe symptoms of failure in No. 7 pier after he had got the centres set, ready for turning the arches. "It began to draw towards No. 8 under its own weight. We thought it would not go far, and allowed it to remain as it was for a long time, until the arches were turned. We noticed it continuing to go, and Mr. Kershaw thought it advisable to put up some buttresses, and ordered me to do so. I put up the buttresses under his directions, and Mr. Watts came down before they were quite finished. I was not there, and did not see Mr. Watts. There was a little settling at the narrow ends, also, of Nos. 8, 5, 4, and 3 (piers) after the arches were built."

Mr. Watts noticed certain cracks in No. 7, 8, and 9 piers when they had been built up to the springing course, but says "they were small and did not give me any alarm." He learnt, however, from Mr. Greenup, the sub-contractor for the timber-work, about the 31st October, that buttresses were being constructed against No. 7 pier, and he went out to visit the work without notice. He found that this was the case, and "the cracks were a little worse." "They had been pointed up, and were to some extent concealed from his view." He did not think there was any danger, but he "ordered Mr. Kershaw to watch the pier very minutely, and to let him know in case he saw any further movement." It will be observed that Mr. Kershaw states in his letter with regard to this visit, "Mr. Watts coming at the time said, 'I don't see that you could have done anything better.'"

In visiting the viaduct a week after, Mr. Watts

saw no change. He had No. 7 pier plumbed by an assistant from the engineer's office, and found that it had bulged half way up to the extent of an inch and a quarter. He also noticed slight bulging in No. 8 pier. "He felt satisfied that there would be no further danger if there was no further movement," and trusted to Kershaw to give "him information." He "saw the viaduct about ten days before it fell, but without discovering any great changes in it, or any movements to lead him to apprehend danger."

Mr. Watts now believes that he was deceived by Mr. Kershaw's "plastering up cracks, and not reporting to him," and that there were cracks pointed up which he did not discover. And he states that when he visited the viaduct with Mr. Meek "in the frost of last winter," after receiving an anonymous letter, "they were dissatisfied with a portion of the work, and ordered 4 feet to be pulled down from 3 or 4 piers at the Huddersfield end," as well as "more through stones to be employed, and better mortar to be used," trusting to Mr. Kershaw to see these things done. It appears, however, from the statement of Mr. Wadsworth, that he heard nothing of the order as regards the piers, and that certainly they were not pulled down as so directed.

In regard to the condition of the works from time to time, I received the evidence of several other gentlemen.

Mr. Holmes, a woollen manufacturer, of Holmfirth, met Mr. Barrowclough, an architect of the same place, at the viaduct (where they were on other business) on the 28th October 1865. Mr. Holmes then observed that No. 7 pier was cracked up each end, and in several places along the face, and he noticed that No. 8 pier had bulged.

Mr. Barrowclough has "passed through the viaduct, and noticed the piers once or twice a week ever since the work commenced." He had frequently, before the 28th October, seen men with ladders pointing up Nos. 5, 6, 7, 8, and 9 piers. On that day he pointed out to Mr. Holmes that Nos. 7 and 8 piers had "given way very badly." He then saw stones, which had been pointed up before, fractured in fresh places, and No. 8 (the highest) pier was "bulged to the extent of 4 or 5 inches." About the 1st November he visited the viaduct with Mr. Moorhouse, and they saw a man with a ladder pointing up Nos. 5 and 6 piers. He had never seen any through-stones used in the piers. He had been "on the scaffolding 5 or 6 times on Sundays," and he "found one Sunday on examination" that the "stones in the interior of about No. 7 pier had been put in dry without mortar." He examined it specially, because he heard that such had been the case. He noticed also that the lime was of bad quality, such as he "would not use for any work." He saw the viaduct for the last time four days before it fell, and noticed that Nos. 7 and 8 piers, but particularly No. 7, were "getting worse," and the cracks opening afresh, though he did not see that the bulging of No. 8 had increased.

Mr. Lockwood, a farmer, who lives 200 yards from the site of the viaduct, has seen "the men making up" cracks in Nos. 5 and 6 piers week after week. He also saw them fill up a crack at the wide end of No. 7 pier with stones as well as mortar. He says, "About four o'clock on the Saturday afternoon before the viaduct fell (which it did on Sunday morning), I passed it on my way to the field and back again. I noticed that No. 7 pier was giving way on the Huddersfield side. I saw it bulging out in three places. One was near the top, and the others below it, but above the abutments (buttresses), and nearly the whole width of the face. I told the miller, William England, about half past 4 the same afternoon, that the pier seemed to be giving way, and that it would not stand long." It appears that Mr. Lockwood had sought employment from the contractor, and from his brother, and been refused it as being too old; but his statement as to what he told the miller, William England, on the

afternoon before the viaduct fell, is corroborated by the latter.

Mr. Wimpenny, of Stoney Bank Mills, 300 yards from the viaduct, had seen the piers several times a week from the commencement of the new viaduct. No. 7 was the worst. Nos. 8 and 9 were also cracked. He saw that "they had pointed them up from time to time."

Mr. Moorhouse, a gentleman residing nearly a mile from the viaduct, visited it with Mr. Barrowclough a fortnight or three weeks before it fell, and saw a man with a long ladder making up cracks in some of the piers. He has "frequently walked under the viaduct and seen the cracks being made up," and has "seen a crack as much as five inches wide in No. 7 pier." He "looked for through-stones, because it was a regular talk that there were no throughs, but he did not see any." He "saw them putting in tailed stones, or stones which went half way through the piers, but none which went quite through, excepting at the top of the piers under the springing-course." "The piers were filled up with rubble-stone," which was "put in, levelled down, and covered with mortar." He did not see any built dry. He "saw some of the foundations put in near Nos. 7, 8, and 9 piers, and the work appeared to be well done; it was a dry season."

I should observe here that the through-stones referred to in the specification were explained by Mr. Watts as meaning merely stones laid transversely from face to face of the piers in two or even three pieces. Mr. Watts states that some of the stones in the work would have answered the specification "perhaps one half of what they ought to have been."

The evidence which I have received can only lead to one conclusion. No. 7 pier was founded longitudinally on part rock and part gravel. When this foundation was subjected to a sufficient weight, the pier split longitudinally, the portions on the rock remaining firm, and the portions on the gravel settling down. The statements as to the cracks at the ends tend strongly to confirm the evidence of Mr. Wadsworth as to the character of the foundation of this pier. The buttresses which were applied to it had but little effect in checking this action, and as soon as the viaduct was loaded with ballast on one

side, in readiness for the permanent way, and while it was being prepared for traffic, this pier failed altogether, and the whole mass crumbled into ruin.

The inquiry cannot be considered to be by any means complete, without an examination of the foundations themselves, and of such parts of the work as may be visible when the debris has been cleared away. I should be glad to have an opportunity of visiting the spot at a future time when this has been done, and the foundations of No. 7 pier have been opened out. In the meantime, the point to which it is my duty particularly to direct their Lordships' attention is the very inefficient superintendence which the work received on the part of the Lancashire and Yorkshire Company. A viaduct of rubble-work requires especial care in construction, as regards the quality of the mortar, and, generally, in superintendence. These elements of security were all wanting. The lowest—a very low—tender was accepted for its construction. The foundations were put in entirely, and the work progressed, for the most part, under the inspection of an officer who was evidently, whatever may have been his good qualities, quite unfitted to the task, and without such a salary as could be expected to render him independent. The company, indeed, paid nothing specially for its superintendence, inasmuch as it was placed under the charge of the inspector of the district of 15 miles in which it happened to be. And this niggardly mode of carrying on the work must be assigned as the principal cause of failure, and of the awful risk which was occasioned to the public, who travelled regularly over the viaduct up to the time of its fall.

I think it only right to recommend, in conclusion, that as the inhabitants of Holmfirth are deprived by the fall of this viaduct of the advantages of the communication with Huddersfield and other places by railway, which they have now possessed for many years, and as they have no other railway to the town, a temporary viaduct should be erected with as little delay as possible, pending the completion of a permanent structure.

I have, &c.

H. W. TYLER,
Capt. R.E.

*The Secretary of the
Board of Trade,
(Railway Department),
Whitehall.*

LONDON AND NORTH-WESTERN RAILWAY.

*Board of Trade
(Railway Department),
29th July 1865.*

SIR,

I AM directed by the Lords of the Committee of Privy Council for Trade to transmit to you, to be laid before the Directors of the London and North-Western Railway Company for their consideration, the enclosed copy of the report made by Captain Tyler, R.E., the officer appointed by their Lordships to inquire into the circumstances connected with the accident on the 28th of June last in the tunnel on the north of New Street station, Birmingham.

I am, &c.,

*The Secretary to the
London and North-Western
Railway Company.*

W. D. FANE.

*Broadstairs,
26th July 1865.*

SIR,

IN compliance with the instructions contained in your minute of the 11th instant, I have the honour to report, for the information of the Lords of the Committee of Privy Council for Trade, the result of my inquiry into the circumstances which attended the accident that occurred on the 28th ultimo, in the tunnel on the north of the New Street station at Birmingham of the London and North-Western Railway.

This tunnel is about $\frac{3}{4}$ of a mile long, and on a gradient rising from the New Street station of 1 in 70. It is worked by telegraph, as I have before had occasion to report, and only one engine or train is permitted to be in it upon either line of rails, though any two engines or trains are permitted to be in it, one upon each line of rails, at the same time.

The tunnel has been under repair for three years. Defective portions of the brick arch with which it is lined, are taken down and rebuilt in lengths of four feet, the workmen being employed between 11 o'clock at night and 5 o'clock in the morning only, when the trains are not running. To rebuild the upper part of the arch, a timber platform is constructed on which the men work, rather more than 14 feet in the clear above the level of the rails; and the beams composing this platform are, as will be seen by the accompanying sketch, supported upon rails such as are used on the line, bent to the form, and wedged against the sides of the tunnel. The workmen who erect this scaffolding are provided with a gauge 9 feet wide, with notches to rest on the rails; and of a section to suit the maximum loading allowed on the line, as well as with a rod 14 feet long, by which to test the height of the horizontal beams; and they are expected to allow about four inches in every direction in addition to the dimensions shown on the gauges thus provided.

On the 28th ultimo the 10 a.m. goods train left the