ON THE INTRODUCTION OF STEEL SUPPORTS FOR THE MAINTENANCE OF MAIN ROADS IN THE MINES OF CLEVELAND.

By A. L. STEAVENSON.

The paper which was read at the meeting in April on Iron Supports has led the writer to contribute his share to the common fund of information on the subject.

In February, 1885, he was asked to consider and give his views upon the suitability of steel for mining purposes, and having visited the steel works at Darlington, and selected such sections as seemed suitable, he reported in favour of a trial, but suggested—" timber will bend and give notice before breaking; will steel do the same ?"

The result was, 3 tons of girders, 69 lbs. per yard, and 2 tons for packing, known as channel, 16 lbs. per yard, of various lengths, to be used as cross pieces or packing, were obtained. See Plate L.

Most of the members probably know timber is a heavy item in the cost of ironstone at some mines; very large balks are required, viz., from 12 to 16 feet long, and 7 to 8¾ inches in diameter at the small end, weighing from 1 to 3 cwts., and, owing to the damp atmosphere, their average life is not much over two years.

Larch is preferably used peeled, and Riga and Norway, and yet good as it always is in quality, the resident manager reports—" We have some timber crossings that have been put in three times during the last four years;" this, of course, implies a large amount of labour as well as material.

The annual timber bill at the mines of Messrs. Bell Bros., Ltd., in Cleveland, now, does not fall far short of £10,000, although trade is slack and short time is worked.

The variation in cost of timber at different mines, is very striking, viz., from 0·10d. up to 5d. per ton, according to the conditions of roof, and the proportion of whole and broken mine being worked.

The roof is, of course, the Upper Lias or alum shale, 200 feet in thickness, but in some places there is a few inches, occasionally amounting to 2 feet, of dogger ironstone, which helps to make a roof, so that in such mines no timber is used in the whole mine; but in the frequent absence of sufficient dogger, or when removing the pillars additional weight is incurred, much of this 200 feet has to be borne by the timber.

In a large majority of mines, after the whole mine is worked and before removal of pillars, this shale gradually falls and fills up the "broken" ground.

Before deciding finally to adopt steel for the main roads, it seemed very desirable that an actual test of the strength of the full-sized girder should be made, rather than trust to any mere calculation, based upon the reputed tensile strength of steel, especially with a view to proving, in case of any future contingencies, that the change had not been made without full consideration of such questions, and in view of the somewhat conflicting data given by the authorities as to the relative strength of good wrought iron and steel.

Molesworth gives the latter a greater tenacity of 39 per cent. Mr. Adamson, in his address to the Iron and Steel Institute, says about 30 per cent. A committee of the Institution of Civil Engineers puts the tensile breaking weight in tons per square inch of Yorkshire iron, 23·70; Bessemer steel, 31·92; or *30 per cent.* in favour of the steel; whilst De Bèrgne & Co., of Manchester, in some special tests of Bessemer steel, prove it be 40 to 50 per cent. stronger than iron for structural purposes.

These tests the writer proceeded to carry out upon a few steel girders and full-sized timber balks, and he also, as a part of the investigation, made a number of experiments on a small scale upon timber.

For girders and large balks a suitable place was selected in the mines, near where water pipes for other purposes had been provided.

Recesses were cut in which to place the girders near the roof, as in ordinary use, and by means of a lever, made from a 75 lb. rail (L), an empty iron tub (T), Plate L., was suspended, capable of being slowly filled with water, until it brought down the specimen under examination—the weight of water required, tub, and leverage being easily got.

The large balks of timber were in the same way put to an actual test, just as they are used, except that the load was at the centre instead of distributed.

In all questions of strength of timber, Barlow may be said to be "the authority" in this country. His first essay on the subject appeared in 1817, and a sixth edition in 1867. He recites experiments by Buffon on pieces 4 to 8 inches square, and he adds—"These are, it is presumed, all that are historically deserving of any particular notice in this place."

He also mentions experiments by Colonel Beaufoy in the dockyard at Deptford, on specimens 5 feet long and 2 inches square; also by Messrs. Peake and Barrallier, 2 inches square; and by Mr. Conch, on triangular prisms, the sides being 3 inches.

Barlow's tests were all on small sections of from 1 to 2 inches square.

The objection to testing such small pieces is recognised by Gregory in his chapter on the "Strength of Materials," when he says—"If the material is of cast metal it is found that the exterior hard crust is different to that of the interior . . . . and in the case of fibrous material or timber . . . . . in cutting the bar to the required dimensions many of the exterior fibres will be cut transversely, and will not, therefore, be capable of so great a proportionate strength as the similar fibres within the more central portion of the bar."

Another writer on the same subject, in a paper read to the Society of Engineers, says:—"It may be remarked, however, that the greater part of these (experiments on timber) also are open to the objection before referred to of having been made upon exceedingly small pieces."

Numerous and very careful researches have also been made into the qualities of Colonial timbers; but without attempting any serious investigation of the subject, the writer has made what may be called a few "every-day" tests sufficient to satisfy himself in a practical way as to what the mines timber will actually carry, how far the steel girders may with safety be used instead, together with a little insight into the question of relative cost. Of course, timber in mines has its load distributed, whereas in results now got the weight was suspended from the centre.

The beams were also to some extent fixed, increasing to one and a half times the breaking weight when freely supported; but as in daily use they are fixed, it was the best arrangement, and, in fact, necessary, to prevent the girder canting under its load.

The girders finally adopted, and which have given every satisfaction, are 50 lbs. per yard.

One of these, it will be seen, carried 9·36 tons, when it overcame the supports and canted to one side, after carrying at least double the breaking load of timber as shown in Table C; the next, a 66 lb. girder, sunk under a load of 12·62 tons without fracture, and was afterwards straightened and put into use. These were considered sufficient to show the capacity, so long as the quality was maintained; and it is satisfactory to be able to add, that out of nearly 200 tons now in operation, there has been only one girder a failure, *i.e.*, broken short.

The writer does not propose to use these results as evidence sufficient to base any general assumption of tensile or transverse strength. They are too few, and show too great a difference to permit of it; in fact, the figures obtained and given by Barlow, hardly warrant any general conclusion to be drawn.

Take, for instance, his larch results: with similar specimens, 6 feet by 2 inches square, he gets a breaking weight in lbs. of 300 in one case, and 552 in another, and his resistance of a rod an inch square, where

$$S = \frac{l \times W}{4ad^2},$$

varies from 853 up to 1,149, the only safe manner in which to treat the question, is to deal as with a chain, where it is said that its strength is that of its weakest link.

On this point Box, in his work upon the strength of materials, says:—"Experiments have shown that there is great variableness in the strength of all materials, even when apparently of the same strength and quality. The mean strength, as found by numerous experiments, is usually taken, and it becomes a matter of considerable practical importance that the engineer should know within what limits the strength may probably vary, and particularly that the probable minimum should be known." He also shows that larch, our hitherto favourite mines timber, is very variable.

An excellent article on this point appeared in *The Engineer*, 22nd February, 1861. The writer quotes a Table of Experiments sent to the Iron Commission by Mr. Robert Stephenson, made to determine the best iron for the construction of the High Level Bridge, in which 1 inch bars on 3 feet supports gave results varying from 518 to 1,072 lbs.

But we have by the few tests made on a large scale demonstrated with sufficient clearness that the timber, as daily used, is much inferior to the steel girders in point of strength, of much importance where the roof is heavy. Fewer pieces are required, and a much better and neater arrangement is produced; it also reduces the number of props, and makes a clearer road for men and horses.

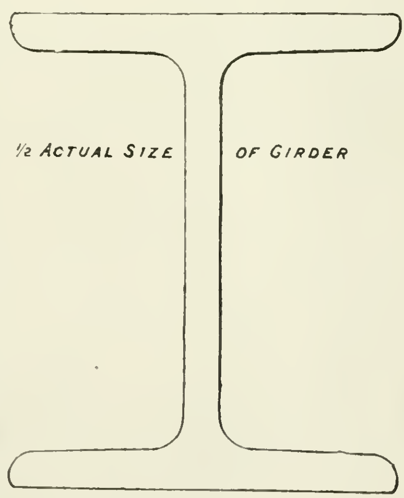
Other testimony may be found to the same effect in the *Transactions of the Midland Institute*, Vol. X. We have an account, by Mr. Smith, of the importance of additional strength in goaf roads. He says:—"These steel girders have given much greater satisfaction than the usual timbering, with which it was very difficult to maintain a road at all. So far, out of some thousands in use, only nine have broken."

Of the reduction of obstruction in the roads by the use of steel instead of timber, we find in the *Bulletin de la Société de l'Industrie Minérale*, Vol. XV.:—

	Cross Section of Roadway.		Proportion.
	Gross square feet.	Clear square feet.	Per cent.
Iron frames	33·8	27·4	81
Timbering	78·6	40·9	52
Brick arching	84·5	31·2	37

which is a satisfactory confirmation. For every day use in the working places the question of length of life does not arise, since timber in such cases is not worn out by age, but by fixing, and removing frequently from place to place.

The economy to be effected is not, of course, in first cost. In fact, as the following figures show, it is considerably more; but whilst the timber often averages a life of not more than eighteen months, the steel, so far as we see, with three and a half years' experience, appears to be a permanent job.



The cost of what in mining language we call "board end crossings" seems to offer the best opportunity for comparison of steel with timber, and details are given in Tables A and B, also sketches. These do not show the packing, which in bad roofs is an important item; but it will be readily seen what a much lighter and neater arrangement is the result.

The headways 12 feet and the board ends 14 feet in width, taking six of each kind as a sample, we find that, including the packing material and all labour, the average cost of steel is £5 4s. 1d., against timber £3 16s. 6d., or an increase of *36 per cent.* as the cost of permanency and greater efficiency.

TABLE A.—STEEL.

Cost of Six Steel Board End Crossings.

No. of Balks.	Length of Balks.	No. of Pieces of Packing.	Weight of Balks and Packing. S.B. 16·66 lbs. ⅌ ft. S.P. 7¼ lbs. ,,	Rates.	No. of Men to put in each Crossing.	Cost.	Total Cost of each Crossing.	
	Ft. In.		Cwts. Qrs. Lbs.	£ s. d.		£ s. d.	£ s. d.	
2	14 9	...	4 1 25	5 5 0	...	1 3 4		
2	13 6	...	4 0 2	,,	...	1 1 2		
4	13 0	...	7 2 26	,,	...	2 0 6		A.
		66	4 1 2	,,	...	1 2 5		
					3	0 13 0		
							6 0 5	
3	15 9	...	7 0 3	,,	...	1 16 11		
2	14 9	...	4 1 25	,,	...	1 3 4		B.
		42	2 2 25	,,	...	0 14 3		
					3	0 13 0		
							4 7 6	
6	14 0	...	12 1 27	,,	...	3 5 7		
		29	......	2½d. each.	3	0 7 0		C.
						0 13 0		
							4 5 7	
4	14 0	...	8 1 9	£ s. d. 5 5 0	...	2 3 8		
2	13 0	...	3 3 13	,,	...	1 0 4		D.
		54	3 2 0	,,	...	0 18 4		
					3	0 13 0		
							4 15 4	
4	16 3	...	9 1 20	,,	...	2 10 7		
1	14 6	...	2 0 17	,,	...	0 11 7		
1	13 6	...	2 0 1	,,	...	0 10 6		E.
		126	8 0 17	,,	...	2 4 1		
						0 17 4		
							6 14 1	
6	14 0	...	12 1 27	,,	...	3 5 7		
		68½	4 1 20	,,	...	1 3 0		F.
					3	0 13 0		
							5 1 7	

Average cost of materials and labour, £5 4s. 1d.

TABLE B.—WOOD.

STATEMENT SHOWING COST OF WOOD BOARD END CROSSINGS.

No. of Balks.	Length of Balks.	No. of Pieces of Packing.	Weight of Balks and Packing.	Rates.	No. of Men to put in each Crossing.	Cost.	Total Cost of each Crossing.	
	Ft. In.			Each. s. d.		£ s. d.	£ s. d.	
5	16 0	...	......	7 0	...	1 15 0		
1	14 0	...	......	5 4½	...	0 5 4		
4	12 0	...	......	3 6¼	...	0 14 1		G.
		Pieces. 38	......	0 2½	...	0 7 11		
					3	0 13 0		
							3 15 4	
6	16 0	...	......	7 0	...	2 2 0		
...	14 0	...	......	5 4½	...	.....		
5	12 0	...	......	3 6¼	...	0 17 8		H.
		43	......	0 2½	...	0 9 0		
					3	0 13 0		
							4 1 8	
6	16 0	...	.....	7 0	...	2 2 0		
2	14 0	...	......	5 4½	...	0 10 9		
2	12 0	...	.....	3 6¼	...	0 7 0		I.
		10	....	0 2½	3	0 2 1		
						0 13 0		
							3 11 10	
4	16 0	...	......	7 0	...	1 8 0		
2	14 0	...	......	5 4½	...	0 10 9		
1	10 0	...	......	2 6	..	0 2 6		J.
		25	......	0 2½	3	0 5 2		
						0 13 0		
							2 19 5	
7	16 0	...	......	7 0	...	2 9 0		
1	14 0	...	......	5 4½	...	0 5 4		
8	10 0	...	......	2 6	..	1 0 0		
		Props, Pieces. 35	......	0 2½	...	0 7 3		K.
				For propping.	1	0 4 4	0 4 4	
						0 13 0		
							1 14 7	
3	16 0	...	......	7 0	..	1 1 0		
3	14 0	...	......	5 4½	...	0 16 1		
6	10 0	...	......	2 6	...	0 15 0		L.
		Props. 35	......	0 2½	...	0 7 11		
						0 13 0		
							3 13 0	

Average cost of six timber crossings, £3 16s. 6d.

TABLE C.

Tests made by Lever upon Steel Girders and Timber Balks.

STEEL GIRDERS.

Section of Girder.	Weight per Yard.	Length.	Length between Supports.	Weight Supported.	Deflection in Inches.		Weight.
	Lbs.	Feet.	Feet. In.	Tons.			C. Qrs. Lbs.
	50	12	11 0	9·36	7·75	Girder canted.	1 3 4
5″ ½″ ←4″→	66·15	12	11 0	12·62	7⅜	No fracture.	2 1 12
5″ ⅜″ ←4″→	50	7	6 0	17·10	1·50*	Shackle broken.†	1 1 17

* Not got when broke, but 1·50 at previous observation. † Shackle was ⅞th Low Moor iron, 7 in. links.

TIMBER BALKS.

Riga.

	Dimensions.						
Round ...	25·5″ circ.	12	11 5½	4·60	5·75	Broken.	...
	24″ "	12	11 0	4·70	7·75	Broken.	1 1 6

Larch.

Round ...	25″ circ.	12	11 5½	5·81	8·50	Broken.	...
Do. ...	22·5″ "	12	11 0	4·16	8·25	Cracked badly.	...
Do. ...	28·5″ "	12	11 0	6·06	4·0	Broken.	2 1 12

Norway.

	B. D.						
1	7½ × 6¾	12	11 0	2·50	1·5	Broke.	...
2	7 × 7½	12	11 0	4·58	2·5	Broke.	...

APPENDIX.

TESTS OF SMALL SAMPLES OF VARIOUS SIZES OF NORWAY, LARCH, AND RIGA TIMBER.

The arrangement or apparatus for experimenting consisted of a pair of uprights, upon which, 8 feet from the ground, the specimen to be tested could be rested, and by chains suitably attached a platform was suspended, weighing 24 lbs., upon which 28 lbs. weights were quietly deposited, the deflection caused being registered.

The whole of the observations were very carefully made by the writer, at intervals of spare time extending over several months, the net results being that the value of M_T or transverse strength or central breaking weight of a beam 1 inch square and 1 foot long between end bearings was—

Riga	M_T	=	475
Norway	„	=	460
Larch	„	=	395

ABSTRACT ACCORDING TO SIZES.

$$M_T = \frac{W \times L}{B \times D^2}$$

Size.	Riga.		Norway.		Larch.		
	Breaking Weight.	M_T	Breaking Weight.	M_T	Breaking Weight.	M_T	
	Lbs.		Lbs.		Lbs.		
1″ × 1″	150		120·5		103		Width between supports 4 feet.
1 × 1	136		120·5		...		
1 × 1	134		120·5		...		
Average ..	140	560	120·5	482	103	309	
1·97 × 1·97	845		1,063		...		
2 × 2	868		1,054		857		
2 × 2	836		949		...		
2 × 2	630		609		...		
Average...	778	391	871	435	857	440	
$2\frac{1}{8}\ \overset{2}{\square}$	...		...		787		
$2\frac{1}{16}\ \overset{2}{\square}$	...		...		584		
$2\frac{1}{8}\ \overset{2\frac{1}{8}}{\square}$	...		...		718		
					696		
1·95 diameter	845		...		...		
2·15 ,,	...		901		...		
2·20 ,,	...		907		...		
2·25 ,,	686		758		752		
2·25 ,,	886		752		724		
2·25 ,,	876		839		788		
2·25 ,,	1,368		951		1,088		
2·25 ,,	783		...		808		
2·25 ,,	920		...		...		
2·25 ,,	920		...		...		
Average...	913	475	825	463	832	437	
2·37 diameter	...		...		955		
		475		460		395	

DETAILS OF TESTS OF SMALL SAMPLES.

Tests of Norway Timber. Aug. 20th, 1885.

Size.	Deflection.	Total Weight.	Remarks.
	Inches.	Actual Weights.	
1″ × 1″	0·33	24	4 feet between supports.
	0·73	52	
	1·10	80	Slowly sunk to 5 inches, then broke; gave much signs of compression.
	1·90	108	
	...	120·5	
	...	Broke.	
1″ × 1″	·37	24	
	1·33	80	Good sample.
	2·33	108	
	...	120·5	Broke.
	4·00	Bent and broke very slowly.	
1″ × 1″	·40	24	
	1·25	80	
	2·00	108	
	...	120·5	
	3·50	Slowly bent and broke.	
2″ × 2″	...	24	
	·00	80	
	0·10	136	
	0·15	192	
	0·20	248	
	0·25	304	
	0·30	360	
	0·44	416	
	0·47	472	
	0·50	528	
	0·55	584	
	0·62	640	
	0·70	696	
	0·74	752	Good specimen.
	0·77	808	
	0·85	836	No knots.
	0·88	850	
	0·98	882	
	1·00	907	
	1·08	932	
	1·25	957	
	1·40	989	
	1·50	1,022	
	...	1,054	
	2·5	Slowly sunk and broke at.	

DETAILS OF TESTS OF SMALL SAMPLES.—Continued.

Tests of Norway Timber. Aug. 20th, 1885.

Size.	Deflection.	Total Weight.	Remarks.
	Inches.	Actual Weights.	
2″ × 2″	0·10	112	
	0·23	168	
	0·25	224	
	0·27	280	
	0·33	336	
	0·43	448	
	0·52	504	
	0·58	560	
	0·62	616	
	0·73	672	
	0·76	728	
	0·85	784	
	1·00	814	
	1·05	846	
	1·10	878	
	1·30	910	
	1·50	910	
	1·57	924	
	1·75	936½	Sunk to 2¼, and snapped rather short.
	2·25	949	
	...	Broke.	
2″ × 2″	...	24	
	0·23	80	
	0·27	136	
	0·45	192	
	0·52	248	Very sappy.
	0·61	304	
	0·75	360	
	0·85	416	
	1·05	472	
	1·30	528	
	...	584	
	2·00	596½	
	...	609	*Sunk and broke* rather suddenly; one corner showed sap, opened at fibre.

PARK PIT.

TESTS OF NORWAY TIMBER, 2·25″ DIAMETER. OCTOBER 15TH, 1885.

	Size.	Deflection.	Total Lbs.	Remarks.
		Inches.		
Turned Round in Lathe.	2·25″ dia.	...	24	
		0·10	80	
		0·20	136	
		0·25	192	
		0·36	248	Bearings, ⅜ inch under 4 feet.
		0·48	304	
		0·52	360	
		0·63	416	
		0·75	472	
		0·80	528	
		0·98	584	
		1·20	640	
		1·40	696	Cracks.
		1·60	727	
		1·90	758	Opens below.
		2·25	758	*Slowly sunk and broke.*
Not Turned Round.	2·15″ dia.	...	24	Bearings, 4 feet.
		0·05	80	
		0·18	136	
		0·25	192	
		0·30	248	
		0·40	304	
		0·50	360	
		0·60	416	
		0·70	472	
		0·76	528	
		0·90	584	
		1·00	640	
		1·18	696	
		1·25	752	
		1·60	808	
		1·75	839	
		1·85	870	
		...	901	Went to 2 inches, and *broke short.*
Square.	1·97″ × 1·97″	...	24	
		0·10	80	
		0·18	136	
		0·22	192	
		0·25	248	
		0·30	304	
		0·40	360	
		0·50	416	
		0·55	472	
		0·63	528	*Gradually broke.*
		0·70	584	
		0·75	640	Good sample.
		0·83	696	
		0·95	752	
		1·00	808	
		1·18	864	
		1·27	920	
		1·47	976	
		1·60	1,032	
		2·00	1,063	
		2·50	...	
		2·76	...	

PARK PIT.

TESTS OF NORWAY TIMBER. FEBRUARY 11TH, 1886.

	No.	Size.	Deflection.	Total Weight.	Remarks.
			Inches.	Lbs.	
No. 5.	...	2·25″ dia.	...	24	Scales.
	1		...	80	
	2		0·25	136	Bad sample; very dry.
	3		0·27	192	
	4		0·40	248	
	5		0·52	304	
	6		0·63	360	
	7		0·70	416	
	8		0·90	472	
	9		0·90	528	
	10		1·00	584	
	11		1·10	640	
	12		1·27	696	
	13		...	752	Broke.
No. 6.	1	2·25″ dia.	0·05	80	
	2		0·20	136	
	3		0·25	192	
	4		0·30	248	
	5		0·40	304	
	6		0 50	360	
	7		0·60	416	
	8		0·70	472	
	9		0·75	528	
	10		0·80	584	
	11		1·00	640	
	12		1·15	696	
	13		1·27	752	
	14		1·50	828	Cracked. slightly.
	...		...	839	Broke.
No. 9.	...	2·25″ dia.	...	24	Scales.
	1		0·12	80	
	2		0·20	136	
	3		0·27	192	Been cut and dried three months.
	4		0·30	248	
	5		0·44	304	
	6		0·50	360	
	7		0·54	416	
	8		0·60	472	
	9		0·74	528	
	10		0·76	584	
	11		0·80	640	
	12		0·90 / 0·95	696	
	13		1·10	752	
	14		1·20	808	
	15		1·30	864	
	16		1·70 / 1·90	920	
	17		2·10	951	Broke.

PARK PIT.

Tests of Pieces of Larch Cut from a Balk. August 20th, 1885.

Total length, 4′ 6″; between supports, 4′ 0″.

	No.	Size.	Deflection.	Total Weight.	Remarks.
			Inches.	Lbs.	
No. 1, Square.	1	$2\frac{1}{8}'' \times 2''$	0·125	56	
	2		0·187	112	
	3		0·25	168	
	4		0·37	224	
	5		0·43	280	
	6		0·50	336	
	7		0·62	392	
	8		0·75	448	
	9		0·81	494	
	10		0·93	560	
	11		1·12	616	
	12		1·37	672	
	13		1·50	702	
	14		1·62	728	
	15		1·87	753	
	16		2·00	763	
	17		2·62	787	Broken.
No. 2, Square.	1	$2\frac{1}{16}'' \times 2''$	0·375	168	
	2		0·50	224	
	3		...	248	This piece had a knot
	4		0 62	260	
	5		1·00	448	in middle.
	6		1·25	494	
	7		1·50	560	
	8		...	584	Broken.
No. 3, Square.	1	$2\frac{1}{8}'' \times 2\frac{1}{8}''$	0·125	80	
	2		0·25	136	
	3		0·37	192	
	4		0·50	248	
	5		0·56	304	
	6		...	360	
	7		0·75	416	
	8		0·75	472	
	9		0·87	528	
	10		1·00	584	
	11		1·37	640	
	12		2·00	668	
	13		2·12	682	
	14		2·50	694	
	15		...	718	Broken.
No. 4, Round.	1	$2\frac{1}{4}''$ dia.	0·125	80	
	2		0·25	136	
	3		0·37	192	
	4		0·50	248	
	5		0·62	304	

PARK PIT.

TESTS OF PIECES OF LARCH CUT FROM A BALK. AUGUST 20TH, 1885.—*Continued.*

Total length, 4′ 6″; between supports, 4′ 0″.

	No.	Size.	Deflection.	Total Weight.	Remarks.
			Inches.	Lbs.	
No. 4; Round.—*Continued.*	6	$2\frac{1}{4}''$ dia.	0·68	360	
	7		0·75	416	
	8		0·93	472	
	9		1·06	528	
	10		1·25	584	
	11		1·50 / 1·62	640	
	12		1·75	668	
	13		1·87	682	
	14		2·00	692	
	15		2·25	704	
	16		2·37	716	
	17		2·50	728	
	18		2·75	740	
	19		...	752	Broken with this weight.
No. 5, Round.	1	$2\frac{1}{4}''$ dia.	0·125	80	
	2		0·25	136	
	3		0·37	192	
	4		0·50	248	
	5		0·56	304	
	6		0·68	360	
	7		0·75	416	
	8		0·87	472	
	9		1·00	528	
	10		1·18	584	
	11		1·50	640	
	12		1·75 / 2·12	696	
	13		2·25	724	Broken with this weight.
No. 6, Square.	1	$1\frac{1}{32}''$	0·50	24	
	2		0·37	38	
	3		1·00	48	
	4		1·12	52	
	5		1·50	62	
	6		1·68 / 2·00	76	
	7		2·50	...	
	8		2·87	...	
	9		5·75	103	Broken.
No. 7, Square.	1	1″	0·50	24	
	2		1·00	52	
	3		1·37	66	
	4		1·75	76	
	5		2·00	91	
	6		3·00	103	Broken.

PARK PIT.

TESTS OF LARCH TIMBER TURNED IN LATHE, $2\frac{1}{4}''$ DIAMETER.

No.	Deflection.	Total Lbs.	Remarks.
	Inches.		
1	0·05	...	
2	0·20	80	
3	0·40	136	
4	0·52	192	
5	0·74	248	
6	0·90	304	
7	1·10	360	
8	1·27	416	
9	1·50	472	
10	1·73	528	No fracture.
11	2·00 2·10	584	
12	2·20	596	
13	2·27	608	
14	2·40	620	Still bending.
15	2·60 2·85	632	
16	3·00	644	No fracture.
17	3·40	675	
18	3·60 3·75	706	
19	4·00	737	
20	4·25	749	
21	4·50	...	
22	4·75	...	
23	5·00	...	
24	5·25	788	Broken.

PARK PIT.

Tests of Larch Timber Not Turned, 2·20″ Diameter. October, 1885.

Size.	Deflection.	Total Lbs.	Remarks.
	Inches.		
2·20″ dia.	...	24	
	0·10	80	
	0·20	136	
	0·25	192	
	0·33	248	
	0·48	304	
	0·58	360	
	0·70	416	Out of last balk tested.
	0·75	472	
	0·85	528	
	1·00	584	
	1·18	640	
	1·30	696	
	1·50	752	
	1·70	783	
	1·83	814	
	2·00	845	
	2·20	876	
	...	907	Broke before it could be read.

PARK PIT.

Tests of Larch Timber, Square, 2″ × 2″.

Size.	Deflection.	Total Lbs.	Remarks.
	Inches.		
2″ × 2″	...	24	
	0·10	80	
	0·20	136	
	0·25	192	
	0·40	248	
	0·50	304	
	0·60	360	
	0·70	416	
	0·77	472	
	0·90	528	
	1·05	584	
	1·25	640	Breaks.
	1·40	671	
	1·50	702	
	1 60	733	
	1·75	764	
	2·10	795	
	2·40	826	
	2·60	857	Broke, good break.

TESTS OF LARCH. FEBRUARY 11TH, 1886.

	No.	Size.	Deflection.	Total Weight.	Remarks.
			Inches.	Lbs.	
No. 3.	...	2·25″ dia.	...	24	Scales.
	1		0·10	80	Good specimen, full of sap, green wood only been cut off balk two days.
	2		0·25	136	
	3		0·30	192	
	4		0·48	248	
	5		0·52	304	
	6		0·60	360	
	7		0·75	416	
	8		0·77	472	
	9		0·90	528	
	10		1·00	584	
	11		1·10	640	
	12		1·20	696	
	13		1·25	752	
	14		1·35	808	
	15		1·48	864	
	16		1·53	920	
	17		1·75	976	
	18		1·90	1,032	
	19		2·15	1,088	Broke.
No. 4.	...	$2\frac{1}{4}$″ dia.	...	24	Scales.
	1		0·05	80	This piece very wet, only been cut off balk two days.
	2		0·10	136	
	3		0·20	192	
	4		0·25	248	
	5		0·27	304	
	6		0·40	360	
	7		0·48	416	
	8		0·50	472	
	9		0·60	528	
	10		0·70	584	
	11		0·75	640	
	12		0·80	696	
	13		1·00	752	
	14		1·15	808	Broke.
No. 7.	...	$2\frac{3}{8}$″ dia.	...	24	
	1		0·20	80	Good sample.
	2		0·25	136	
	3		0·40	192	
	4		0·53	248	
	5		0·70	304	
	6		0·75	360	
	7		1·00	416	
	8		1·20	472	
	9		1·30	528	
	10		1·50	584	
	11		1·60 / 1·75	640	
	12		1·90 / 2·00	696	
	13		2·30	752	
	14		2·50 / 3·00	808	
	15		3·25	839	
	16		3·60	863	
	17		3·75	887	
	18		4·50	943	Cracked slightly.
	19		7·00	955	Broke.

PARK PIT.

Tests of Riga Wood. August 26th, 1885.

Size.	Deflection.	Total Lbs.	Remarks.
	Inches.		
1″ × 1″	$0\frac{1}{4}$	24	*4 feet between supports.*
	$0\frac{1}{2}$	52	
	$0\frac{3}{4}$	66	Opened from a knot 6 inches from centre.
	0·88	80	
	1·25	108	
	1·50	136	
	2·25	136	Suddenly broke in putting on.
	2·25	150	
1″ × 1″	0·25	24	
	0·90	80	Apparently a good sample.
	1·40	108	
	1·75	122	
	...	136	Gradually sunk and broke; no knot.
1″ × 1″	0·20	24	Fair sample.
	0·88	80	
	1·45	108	Broke from middle.
	1·80	122	No knot.
	...	134	Slowly sunk and broke.
2″ × 2″	0·10	...	
	0·12	80	
	0·16	136	
	0·20	192	
	0·24	248	
	0·26	304	Fairly good sample; broke rather suddenly.
	0·28	360	
	0·33	416	
	0·48	472	
	0·51	528	
	0·58	584	
	0·70	640	
	0·76	696	
	0·90	752	
	1·15	808	
	1·40	836	
	2·00	868	Broke.
2″ × 2″	0·10	80	
	0·23	136	
	0·26	192	
	0·30	248	
	0·40	304	
	0·49	360	
	0·51	416	
	0·55	472	
	0·62	528	
	0·70	584	
	0·75	640	
	0·83	696	
	1·00	752	
	1·15	808	
	1·50	836	Broke rather short.
2″ × 2″	0·05	...	
	0·15	80	
	0·26	136	
	0·43	192	
	0·50	248	Opened at bottom in the fibre; sappy; much owing to sap in the specimen.
	0·58	304	
	0·72	360	
	0·77	406	
	0·90	462	
	1·06	518	
	1·25	574	
	1·50	630	Broke.

PARK PIT.

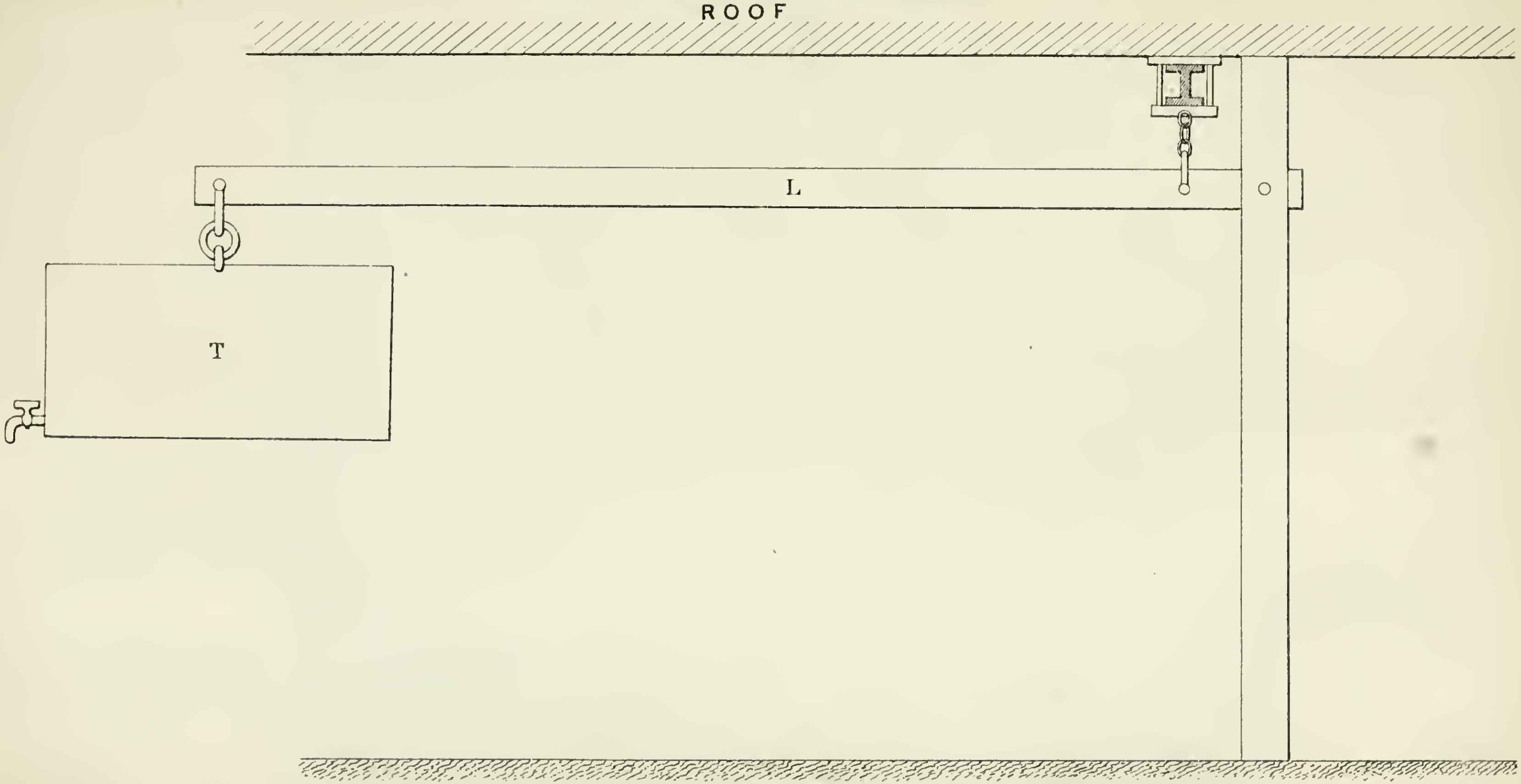
Tests of Riga Wood. August, 1885.
Round, not Turned.

Size.	Deflection.	Total Weight.	Remarks.
	Inches.	Lbs.	
2 25″ dia.	0·00	...	
	0·08	80	
	0·12	136	
	0·25	192	
	0·27	248	
	0·42	304	Broke straight, and rather short.
	0·49	360	
	0·51	406	
	0·60	462	
	0·75	518	
	0·80	574	
	1·00	630	
	1·25	686	
	2·25	...	Broke slowly, but snapped at last.
2·25″ dia.	0·06	80	
	0·15	136	
	0·23	192	
	0·25	248	
	0·27	304	
	0·33	360	
	0·48	416	
	0 51	472	
	0·60	528	
	0·66	584	
	0·75	640	
	0·80	696	Sunk slow at first, and then broke off at 1½.
	0·90	752	
	1 05	808	
	1·50	836	Broke.
2·25″ dia.	0·10	...	
	0·20	80	
	0·24	136	
	0·32	192	
	0·40	248	Broke at once; a less weight would have done it.
	0·48	304	
	0·51	360	
	0·58	416	
	0·68	472	
	0·75	528	
	0·85	584	Good sample.
	0·94	640	
	1·07	696	
	1·25	752	
	1·40	780	
	1·50	812	
	1·75	844	
	...	876	Broke short.

PARK PIT.

TESTS OF RIGA WOOD, $2\frac{1}{4}''$ DIAMETER. OCTOBER 15TH. 1885.
Turned up in Lathe.

Size.	Deflection.	Total Weight.	Remarks.
	Inches.	Lbs.	
2·25″ dia.	0·10	112	
	0·18	168	
	0·25	280	
	0·26	336	
	0·30	392	
	0·35	448	
	0·42	504	
	0·45	560	
	0·50	616	N.B.—Half a ton.
	0·52	672	
	0·60	728	
	0·68	784	
	0·73	840	
	0·75	896	
	0·80	952	
	0·90	1,008	
	0·95	1,039	
	1·00	1,070	
	1·10	1,101	
	1·13	1,132	
	1·20	1,163	
	1·25	1,219	
	1·38	1,250	
	1·50	1,306	Shows weakness; sunk slowly; broke straight.
	1·75	1,337	
	1·80	1,368	
	2·00	...	
	Total with scale and chain ...	1,392	
1·95″ × 1·95″	...	24	
	0·10	80	
	0·18	136	
	0·25	192	
	0·30	248	
	0·40	304	
	0·50	360	
	0·55	416	
	0·63	472	
	0·73	528	
	0·77	584	
	0·85	640	
	1·00	696	
	1·10	752	First crack.
	1·20	783	
	1·25	814	
	1·45	845	Cracks, and gradually broke.



ARRANGEMENT FOR TESTING STRENGTH OF BALKS.

Scale ½ inch to a Foot

To illustrate Mr. A. L. Steavenson's paper "On the Introduction of Steel Supports for the Maintenance of Main Roads in the Mines of Cleveland."

ANDREW REID. NEWCASTLE.

TESTS OF RIGA WOOD. TURNED. FEBRUARY 11TH, 1886.

	No.	Size.	Deflection.	Total Weight.	Remarks
			Inches.	Lbs.	
No. 1.	...	2·25″ dia.	...	24	Scales.
	1		0·20	248	
	2		0·25	304	
	3		0·27	360	
	4		0·30	416	
	5		0·35	472	
	6		0·50	528	
	7		0·53	584	
	8		0·60	640	
	9		0·75	696	
	10		0·75	752	Cracked slightly.
	11		1·25	783	Broken.
No. 2.	...	2·25″ dia.	...	24	Scales.
	1		0·12	80	Been turned up three months; very dry.
	2		0·20	136	
	3		0·27	192	
	4		0·30	248	
	5		0·50	304	
	6		0·55	360	
	7		0·68	416	
	8		0·75	472	
	9		0·80	528	
	10		0·90	584	
	11		1·00	640	
	12		1·12	696	
	13		1·25	752	
	14		1·50	808	
	15		1·75	864	
	16		2·10	920	
	...		2·25	920	Broken.
No. 8.	...	2·25″ dia.	...	24	Scales.
	1		0·10	80	Very dry; same as last.
	2		0·20	136	
	3		0·27	192	
	4		0·30	248	
	5		0·40	304	
	6		0·50	360	
	7		0·60	416	
	8		0 70	472	
	9		0·75	528	
	10		0·78	584	
	11		0·85	640	
	12		0·98	696	
	13		1·05	752	
	14		1·20	808	
	15		1·27	864	
	16		1·50	920	Broken.
	...		1·55	...	

Professor MERIVALE—As Mr. Steavenson is engaged in experiments, I would ask if he has made any with creosoted timber, and, if not, perhaps he may be able to add some experiments upon this form of mining timber?

Mr. STEAVENSON—No; he had not made any experiments with creosoted timber. They had used it at the collieries for main roads, and no doubt it was an improvement upon timber that was uncreosoted, but he preferred steel under their circumstances. They were using creosoted timber at the collieries. The objection to creosoted timber for mining purposes was that if they once cut it, or even put in a nail, they destroyed the effect of the creosoting. They must use the timber as it was sent out when creosoted.

Mr. GEO. B. FORSTER said, they must use steel in the same way. He had used a considerable amount of creosoted timber in his time, and he had some which had been in, he believed, twenty-four or twenty-five years, and there was no perceptible sign of decay. He himself did not think that the cutting of the timber absolutely injured it. The President suggested to him to refer to the case of railway sleepers, which were made of creosoted timber, and holes were bored into the sleepers to receive the plugs. He agreed with Mr. Steavenson as to the superiority of steel in the way of strength and handiness, but he thought it would be found that creosoted timber would last quite as long as steel. So far as durability went, creosoted timber would last a long time. It was all well enough in Cleveland to use steel, where they had particular widths of drifts, and where they knew exactly what they were going to do; but in coal mining they had a great variety of cross places and drifts, and sometimes a balk of timber was more handy to arrange and set up than steel.

Professor MERIVALE said, there were other things besides creosote used in preserving timber. Sulphate of copper was used. He would like Mr. Steavenson to extend his experiments, and give them some information as to the preservation of timber.

Mr. JAMES WILLIS—I apprehend Mr. Steavenson's paper is more as to the strength of steel as compared with timber.

Mr. STEAVENSON—In the case of creosoting timber you do not increase the strength at all. We can have something like double the strength with steel.

A vote of thanks was passed to Mr. Steavenson for his paper.

Professor P. PHILLIPS BEDSON, D.Sc., read the following paper on "A Contribution to our Knowledge of Coal-dust."