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ON THE MODERN TENDENCY OF RAILWAY PRACTICE.

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In the following paper the author proposes to consider briefly the modern tendency of railway practice as exemplified by the great companies in England and America, so far as the matter comes within the province of the engineer, and it is hoped that these questions may be of some little interest to the members of this Association, seeing that in the absence of water-way the future development of these lands must to a large extent depend upon the extension of our railway system, and the economical working of the same. The subject may be divided into two sections, namely, the Road and Rolling Stock.

The Road.

In a paper like the present, it would be impossible to go into all the details of modern railway construction, so it is proposed to consider but one or two points, and then to deal somewhat fully with the various forms of permanent way. A matter that has been too often overlooked by English engineers, when constructing lines with sharp curves, is the question of easing-off the junction of the straight and curved portion of railways and the junction of reversed curves by a gradual increase of curvature. In America and the Continent engineers are fully alive to the advantage of easing-off curves, and the custom of introducing transition curves is fast becoming universal on all main lines in America. The disagreeable lurch and "thud" which is felt on entering short curves is only too well known to every one who travels on lines like those in this colony, where sharp curves are common, and the lurch would be much worse than it is if the instant change from the straight to the curve was not to some extent eased off by the fettlers after the line is constructed. The lurch is principally caused by the fact that it is necessary to work up the super-elevation of the outer rail on the straight portion of the road before the curve is reached; consequently the wheels slide down to the low side, and the flanges rub hard on the low rail immediately before entering the curve, and in taking the curve the flange of the low side leading wheel suddenly leaves the low rail, and the flange on the high side strikes the high rail, causing the vehicle to lurch. Now, with a properly laid out "transition curve" the radius is infinity at the point of inflection, and decreases until at the point where it joins the circle, the radius of the transition curve is equal to that of the circle; therefore the super-elevation can be gradually worked up from the point of inflection, and there will be no tendency for the flanges of the leading wheels to take the low rail, as in the case when the super-elevation is worked up on the straight, and consequently there is no sudden lurch.

The mathematical investigation of the best form of transition curve is rather tedious, and for those who care to look into it, the author would refer them to his paper read before the Royal Society in June, 1888, but the practical application is extremely simple, and an example may be sufficient to explain the matter. Let there be two reverse curves of eight chains radius, with two chains of straight between them, then to construct a transition curve, all that is necessary is to lay off parallel tangents at a distance of 1-3rd the offset at one chain, that is $\frac{49{\cdot}5}{3}$in. $= 16{\cdot}5$in., and from the parallel tangent set out the 8-chain curves in the ordinary way then the transition curve will meet the circle at a point one chain from the tangent point, will pass midway between the original and new tangent points and the origin of the curve will be one chain back from the tangent points. (Plate III.).

In the above case it will be seen the only extra work involved is to set out the curve 16·5 in. inside the ordinary curve where the transition curve is introduced.

The question of easing changes of grade by vertical curves is also one that has not received the attention it deserves, and is a matter of importance, as where the changes of grade are not properly eased-off the risk of breaking couplings is very great. This is especially the case where there is an abrupt change from a falling to a rising grade.*

To go fully into various questions of construction would take up a large amount of time, and as it is proposed to consider mechanical details rather than the more general questions in this paper, the author will confine his remarks to this part of the subject.

Permanent Way.

In the early days of railways, rails of very light section were used, but as traffic increased and the weight of engine and rolling stock increased, the weight of rails has of necessity increased. The original rails used on the Manchester and Liverpool line were only 35 lbs. to the yard, and the chairs were 10 lbs. each. At the present day the rails on the first-class English lines weigh from 80 to 90 lbs., and the chairs from 30 to 50 lbs. each, and in some cases rails of 100 lbs. to the yard have been used. In the days of iron rails it was usual to roll double-headed rails capable of being turned and used on both heads, and rails of this pattern made of steel are still used on many lines, but it is now almost universally admitted by engineers that there is no advantage in making steel rails reversible, as it is found that before one face is worn down the chairs have cut into the under face to such an extent that when turned the rail is so rough that trains cannot pass over them without an uncomfortable jar, which is not only unpleasant to the passengers but injurious to the rolling stock. It is, therefore, evident that unless double-headed steel rails are periodically turned and re-turned before the chairs have cut into them to a serious extent the excess of material in the rail, over and above what is actually required for strength, cannot be used to its full advantage in increasing the life of a rail. On account of this,

* The effect of abrupt changes of grade and the best way of easing them off is fully dealt with in "Wellington's Railway Location," chapter IX.

the tendency of engineers is to roll the whole of the working material into one face, making the bottom flange only of sufficient strength to resist the strains brought on to it as a beam, and allowing a sufficient margin for the wear between the rail and the chair, hence we see what is called the bull-headed rail fast coming into universal use on all chair roads. The permanent way used on the Midland may be selected as a fair example of modern English practice :—The rails are of steel, "bull-headed," 30 feet long, $5\frac{5}{8}$ inches deep, width of top $2\frac{5}{8}$ inches, weighing 85 lbs. to the yard, having a sectional area of 8 square inches, and are laid with an inclination of 1 in 20 towards the inside, or 4-foot way. The chairs are of cast-iron, each weighing 50 lbs., and are fastened to the sleepers by two iron spikes and two oak tree-nails. The sleepers are rectangular, 9 feet long, 10 inches wide, 5 inches thick, weighing 134 lbs. each, and placed at a distance of 2 feet $9\frac{3}{8}$ inches apart between centres, except at the joints, where they are only 2 feet 2 inches apart. The fish-plates are of the clip pattern—that is, they clip the rail by nearly meeting under it, they weigh 40 lbs. per pair, and the four bolts 1.68 lbs. each. The following is the average weight per yard of this permanent way :—

	lbs.
Steel	170
Wrought-iron	14.9
Cast-iron	110
Wood	151.9
Total	446.8

Although almost universally used in England, the chair road finds but little favour in other parts of the world; thus in America the T or Vignole rail is universally used, but we see the same tendency to increase the weight of rails in all cases where the traffic and speed increases; in English practice it is usual to provide from 1,760 to 2,000 sleepers per mile, but in America 2,640 is about the average number used, although in some cases this number is even increased; the heaviest rails used in America are

82 lbs. per yard on a portion of the New York Central, the weight of rails averaging from 60 to 70 lbs. on the principal trunk lines. The opinion amongst the best American engineers is decidedly set against light rails. In Belgium, rails of 100 lbs. per yard have been recently introduced with very satisfactory results, and there can be but little difference of opinion that from an economical point of view experience shows a decided advantage in the use of heavy rails.

It is now proposed to consider the relative merits of chair and T road, and the reason why in some countries the one possesses advantages over the other, and *vice versa*.

The question of chair versus T road is one that cannot be settled off-hand by a bare assertion that one is better than the other, as under certain conditions the chair road is undoubtedly the best, whilst under different conditions the T road has the advantage. The case is put rather forcibly by Wellington in his recent work on railway location, where he states:—"The difference of practice in England and America result, for the most part, from differences of conditions and not from mistakes of judgment on either side. When wood of any kind is dear, hardwood out of the question, and labour and rails cheap, the English and Continental plan of widely spaced ties (sleepers) and the rail carried in chairs is at least defensible, although it may be questioned if there is any real economy in spacing ties so widely. When good hardwood ties are cheap it would be folly to space ties further than 2 feet apart, or to use a rail requiring chairs. One effect of the English plan is that for equal stability and strength, very much heavier rails must be used than with the ties nearer together, which is the chief explanation of the fact that they are heavier."

From the above it would appear that the whole question is, that where good hardwood timber can be procured at a reasonable price the T road has the advantage, but when hardwood cannot be procured except at a very high price, and soft wood has to be used, the chair road becomes a necessity where heavy traffic has to be dealt with. Now in this colony we have one of the finest classes of timber in the world for sleepers, namely ironbark, and good squared sleepers of this material can be got for about the same price as pine sleepers cost in England. In England the average life of sleepers, even when creosoted and protected from the cutting action of the rails by heavy cast-iron chairs, is only about eight years, whereas the average life of good ironbark sleepers is at least twice as much, and there are sleepers in the road in this colony, which are perfectly sound after something like thirty years wear. With pine sleepers a T rail, even with an exceptionally large bottom flange, will rapidly cut the sleeper, but an ironbark sleeper will resist this cutting action to a great extent, even with a moderately wide flange, although with a narrow flange and exceptionally heavy traffic, as exemplified in the case of our tramways, even the best sleepers are rapidly cut. From the above considerations the author is of opinion that, with some modifications hereinafter to be described, our present T road is decidedly preferable to the chair road under our local circumstances. One of the great troubles with the permanent way in this climate is the creeping of the rails on the inclines on a chair road. The effect of this is to constantly work the keys out; thus in the early morning the ganger may drive all the keys in, and by mid-day, when the sun is at its height, the creeping of the rails will probably have caused a number of keys to be pushed out. This difficulty of creeping can to some extent be got over with a T road by notching the flange, and driving a spike into the sleeper through the notch, but this causes a much greater evil, namely, it enormously increases the risk of broken rails, and in point of fact in several places where the rails have been notched breakages have occurred. The difficulty of creeping rails can be got over by the use of angled fish-plates, and at the same time the strength of the joint is much increased.

When the traffic is very heavy it will probably be advisable to introduce a heavier rail of 90 lbs. or 100 lbs., with sleepers placed as shown in fig *b*, and with similar angled fish-plates.*

* Figs. *a* and *b* (Plate IV.) show the present form of T road in use on the lines in this colony, and the improved road suggested by the author.

The use of steel for sleepers is coming into use where there is a difficulty in getting good timber sleepers, but as long as good timber sleepers can be procured at their present price there is little or no chance of steel being largely introduced in this colony. One of the most successful steel sleepers is that of Mr. Webb, of the L. and N. W. R., but as this sleeper, with the lugs in chairs, weigh about $1\frac{1}{2}$ cwt., and would cost about £7 per ton, or 10s. 6d. each in Sydney, there would be very little justification in adopting it under our present circumstances. Four steel sleepers for T rails were submitted for test on our railway by Messrs. Cockerill and Co., of Belgium, some time back, and are still in the road. They are somewhat similar in section to Mr. Webb's, and about 160 lbs. each, the result of the test has been most satisfactory, but their cost must keep them out of our local market.

Interlocking.

To enter into the question of interlocking would take up far more space than is available in a paper like this, in fact several important papers could be written on this subject alone, but it is sufficient to say that the necessity for interlocking increases every day, as the traffic increases, and if it was not for the very extensive, and in fact almost universal use of this system, it would not be possible to work the crowded lines in England and the continent with any degree of safety, and on our suburban lines the introduction of interlocking and the block system have resulted in the satisfactory and safe working of our heavy traffic, which has so far been conducted with a remarkable freedom from accident.

Rolling Stock.

Having thus briefly considered the road, it is now proposed to deal with rolling stock, and to show what the tendency of modern practice points to. In the development of railways the design of rolling stock has gone through various stages, and in the early days a very wide latitude was given for experiment, more especially in America, where patents for every possible contrivance were taken out, and almost every conceivable thing was tried, but at the