RAILWAYS IN INDIA.

THEIR ECONOMICAL CONSTRUCTION AND WORKING.

BY

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INTRODUCTION.

The author in the following pages has pointed out what he thinks is not fully understood by many unacquainted with India; that the cost of railway construction and working lines is very different to what it is in England. The land is usually made over free to the company, there are no charges for parliamentary proceedings, the cost of material obtained locally is very much less than what the same costs in England, the cost of labour is one quarter of the English rates, many of the expenses necessary on an English railway to satisfy the public are not required in India, tunnels are seldom necessary, high speed is not required, and therefore serious accidents most rare, and claims for compensation arising therefrom are seldom heard of.

The most fertile parts of India are generally the parts offering no special difficulty in the construction of railways, and these parts are also naturally the most thickly populated, and where railways are mostly required and likely to be constructed in the early future.

The most important points necessary to insure economical construction and maintenance have been described. Until a recent date it has been customary

for capitalists to look to the Government of India for financial assistance in the shape of a guarantee; these days it is to be trusted in the interests of both India and England are passed. For the future, all new railway undertakings should be allowed to depend on their own merits and skill in execution for success. If this policy is allowed to develope and all applications for financial assistance from the Secretary of State for India be met in the direct negative, it is to be hoped that before long, railway construction will be carried out in India with almost the same facility as is the case in England, and that India will soon be covered with the railways the country so much requires for its full development.

The progress of railways in India constructed by joint stock companies from their first inception until the present time has been traced. Although undoubtedly in the early days of railway construction a money guarantee was necessary to facilitate the raising of the necessary capital required to construct the splendid existing system of trunk lines, and which were at that time required, as much for the safety of the country as for commercial enterprise; the same cannot be said of some of the railways constructed within the last decade, and which have obtained a sterling guarantee at the expense of the Indian tax-payer and without the country receiving sufficient compensating advantage for the many lacs of rupees taken annually from its revenue to meet those charges

The author believes that with ordinary attention to economy, and by supplying only such facilities for travelling as are required by the natives of India, many lines of railway could be laid out and worked, which would be certain to yield a favourable net return to investors.

All such railways must, however, be constructed without many of the luxuries customary on English lines, and which the natives of India do not require. It must be remembered that the passenger receipts will be derived almost entirely from third class passengers, who will pay from one-fifth to one-seventh of a penny per mile as compared to one penny in England, and that for those charges the natives of India do not expect nor require accommodation such as is usual on English railways.

The native of India if he can get a good tree to shelter himself and family from the rays of the scorching sun whilst waiting for his train and in the neighbourhood of a good drinking well, will be quite satisfied with this accommodation, and many of the small stations might be laid out with this point borne in view.

In the Chapter on rolling stock attention has been drawn to the possibility of designing a class of coach that would be suitable for carrying the native passenger or merchandise, whichever happened to be available, and thus avoid in a greater degree the empty running of rolling stock, which adds so much to the cost of working railways generally, and which

with the low fares necessary in India, makes the percentage of working expenses, much higher than would otherwise be the case.

Other important points in economical construction have been described, and which were in many cases overlooked in the construction of the earlier lines of railways in India.

If a few of the millions of British capital that have been fruitlessly wasted the last few years in unsound concerns in England, land and mining properties in Africa or foreign government loans, could have been diverted'to India, the advantage to that country would have been incalculable, and manufacturers and others in Great Britain would also have reaped a great benefit in these depressed times by the large expenditure on railway material that such enterprise would have necessitated. Investors in this case would have had with ordinary care a property increasing year by year in value, and yielding a fair and certain return on the capital embarked.

The author has added some tables at the end of the volume which are referred to in the text.

The author hopes this book may prove of assistance to those who take an interest in pushing forward railway enterprise in India. He looks back with regret at the comparative little that has been done in recent years by joint stock companies to assist railway construction in that country. He hopes the time is approaching when more will be attempted in this direction, and that the country with which he

has long been associated will in the future receive greater financial assistance than hitherto in the construction of railways which India so much requires, and thus help her to advance in the true path of civilisation.

CHAPTER I.

A SHORT RECORD OF RAILWAY CONSTRUCTION BY JOINT-STOCK COMPANIES DURING THE LAST 40 YEARS.

In the year 1853 the first lines of railway in India were commenced—the first two in the field being the East Indian and Great Indian Peninsula railways. Both were undertaken by joint-stock companies formed in London, to whom the Secretary of State for India gave a guarantee of 5 per cent. interest per annum on the necessary capital expenditure. Any profits above the 5 per cent. were to be divided equally between the shareholders and the Government of India.

The East Indian railway has its terminus at Howrah, on the banks of the Hooghly, opposite Calcutta, and at Delhi, in the Punjab, a length of 954 miles. Its progress was much delayed by the Indian Mutiny, which occurred in 1857. The main line follows generally the right bank of the Ganges, and passes through rich and fertile tracts of land in Bengal and the North-West Provinces. Amongst the principal towns passed through between its termini, may be mentioned Burdwan, the Zillah town of that part of Bengal; Raneegunge and Asansol, the centres of the Bengal coal-mining industry; Patna, a large and important native city; Allahabad, the capital of the North-West Provinces; Cawnpore and Allyghur,

large and important marts in the same provinces. In addition to the main line there is a loop line of 251 miles. This leaves the main line at the 75th mile from Calcutta, and rejoins it at mile 262. There are also important branches to Agra, Burakar, and Benares. An extension of the railway from Allahabad to Jubbulpore (228 miles), was constructed about the year 1868, and the total length of the East Indian railway at present is 1610 miles; this includes a few short lines constructed as State railways, and which have now been taken over by this company. This railway cost up to the end of 1892 Rs. 222,401 per mile. The railway is double line for the first 469 miles from Howrah. Notwithstanding its very heavy cost per mile, it has been from its commencement one of the most successful lines in obtaining traffic, and the gross traffic at present is on the average of Rs. 580 per mile per week (see table VI.) This is owing to the large and important part of India the line traverses. In the year 1880 this company's property was transferred to the Secretary of State for India, under arrangements which left the old company a continued interest in the working of the line for a term of years. This arrangement expires the end of 1899. For the five years to the end of 1892 the average net earnings amounted to 9.12 per cent. per annum.

The Great Indian Peninsula railway, whose construction was commenced at the same time as the East Indian, connects Bombay with Jubbulpore in

the Central Provinces, a distance of 616 miles. It also connects with the Madras railway, and there is a branch from Bhosawul to Nagpore. The total length is 1287 miles. It traverses equally important districts as the East Indian, and its capital expenditure and gross receipts per mile are very much the same as its great Bengal competitor. Its working expenses are, however, higher, owing to the heavier grades, and the greater distance the coal has to be brought for fuel. The net return for the five years to the end of 1892 averaged 7.60 per cent. per annum.

The Madras railway was commenced in 1856, and the Bombay, Baroda and Central India in 1860. These lines obtained the same financial assistance from the Secretary of State for India. The first, although its cost of construction is very much less than the others, has not succeeded in earning the amount necessary to meet the interest guaranteed by the Secretary of State. Its net earnings for the five years to end of 1892 averaged 3.46 per cent. per annum, and the deficiency of interest is taken from the general revenues of India.

The Bombay, Baroda and Central India railway cost nearly as much per mile as the East Indian or the Great Indian Peninsula railways, and the net earnings for the five years to 1892 averaged 8,38 per cent. per annum.

All the foregoing enterprises although not actually dependent upon economy in construction and working for a good dividend to their shareholders, have with

the exception of the Madras line done remarkably well, and it would be impossible to point out any large railway in England that shows equally good results. They were all constructed on the 5ft. 6in. gauge, and their gross receipts vary from Rs. 580 to Rs. 221 per mile per week. The aggregate length of the last two is 1301 miles.

Between 1861 and 1875 the Eastern Bengal, Scinde, Punjab and Delhi, Oude, and Rohilkund and South Indian railways aggregating 1558 miles were constructed, the three first on the 5ft. 6in. gauge and the last on the mêtre gauge. These lines have now under the terms of their contracts been bought up by the Indian government—they, like those already described received financial assistance in the shape of a guarantee.

Between 1886 and 1891 the Indian Midland, Bengal, Nagpore and Southern Mahratta systems were constructed, the two first on the 5ft. 6in. gauge and the last on the mêtre gauge; their aggregate length at present is 2,968 miles—they have contracts with the Secretary of State for India and are described as state lines worked by companies. The shareholders for the time of their contracts are guaranteed interest at the rate of 3½ to 4 per cent. per annum on the capital expended on their construction, and those contracts must go on until the year 1910 for the Indian Midland, 1913 for the Bengal Nagpore and 1907 for the Southern Mahratta. The two first lines open out new country, and form shorter connecting links

between upper India and Calcutta and Bombay, and are therefore to some extent competitors for the same traffic with the older trunk lines.—Their construction has conferred little benefit upon the country generally and including the Southern Mahratta their net receipts fall short by 43 lacs of rupees per annum of the sum required to meet their sterling guarantees. This sum has to be taken from the revenues of India at the expense of the general tax-payer. The average net earnings for the five years to end of 1892 were 1·34, 2·08 and 1·43 per cent. per annum for the three lines respectively.

Between 1882 and 1890 the Bengal and North Western, Delhi-Umballa-Kalka, and Tarkessur railways were constructed and these may be classed for all practical purposes as the only lines of importance constructed in India to date entirely by private enterprise.—None of these lines received any financial assistance from the Indian government; the first is a mêtre gauge line of 756 miles including the Tirhoot section and the last two are 5ft. 6in. gauge lines of 162 and 22 miles respectively. The Bengal and North Western cost Rs. 63,903, the Delhi-Umballa-Kalka, £6,790 and the Tarkessur Rs. 77,938 per mile.

It is with those lines in considering the future prospects of railway construction by private enterprise and without financial assistance from the Indian government that comparisons must be principally made.

The Bengal and North Western, notwithstanding

the great disadvantage it has had to contend against in the depreciation of the gold value of the rupee, has been able to pay to its shareholders interest at the rate of 4.35 per cent. per annum, for the year to end of 1893, and similar dividends for previous years, its stock stands at a considerable premium on the London Stock Exchange. Its working expenses are shown in table V. as 41.12 per cent. of its gross receipts. Its gross receipts average Rs. 120 per milo per week (see Table VI). This line is more fully referred to in Chapter III. It has opened out fertile districts on the left bank of the Ganges, and given an outlet for the produce of those parts. The towns are not of such importance as those traversed by the earlier trunk lines. It has, nevertheless, succeeded in getting a very fair gross traffic for mêtre gauge line. Its percentage of working expenses are much lower than those of the Indian Midland, Bombay and Nagpore, or Southern Mahratta Railways, and the price of its stock on the London Stock Exchange is very similar to these lines, although it has no guarantee from the Government of India. This line and its prospects are, therefore, so far very encouraging, and can be utilised as some guide as to the possibilities of future lines constructed in the same manner.

The Delhi-Umballa-Kalka Railway also offers encouraging results of the same nature, and if the rate of exchange had remained the same as when the capital was subscribed, the average returns would have been shortly after opening for traffic nearly 4 per cent

per annum. This line is worked by the Secretary of State for India, through the East Indian Railway, under an arrangement by which the shareholders receive 52 per cent. of the gross receipts. Its gross receipts amount to Rs. 140 per mile per week.

The Tarkessur line, was constructed by capital raised in India although a short line, it pays its shareholders $7\frac{3}{4}$ per cent. per annum on its capital cost.

These three lines may be taken as regards gross traffic and working expenses, as fair samples of what other lines, if undertaken in many parts of India, would be at least likely to accomplish.

Regarding results as a whole, they may be stated as follows, of the 18,042 miles constructed in India, about 9,659 miles have been constructed by private companies, made up as follows: 4,196 miles constructed between 1832 and 1860, giving net earnings on the average for the five years to end of 1892 of 7.14 per cent. per annum; 1,552 miles bought up by government, and need not be further considered; 2,968 miles termed State lines worked by companies constructed between 1886 and 1891, and which have received a guarantee of $3\frac{1}{2}$ to 4 per cent. per annum from the Secretary of State, and cause a loss to the Indian taxpayers of 43 lacs per annum; and 940 miles constructed between 1882 and 1890, without any financial assistance from the Secretary of State, and which return to the shareholders on the average 4.15 per cent. per annum per mile of railway.

The purely commercial lines constructed by Joint Stock companies, excluding the 2,968 miles which are causing such a serious loss to the revenues of India, and which would not have been constructed if the guarantee had been withheld by the Secretary of State, amount, at present, to 5,136 miles, the average net earnings of which come to 6.76 per cent. per annum per mile of railway.

In the United States of America with an area of over 3½ million square miles, or rather more than double that of India and Burmah, and a population of only 60 millions as compared to 286 millions in our Eastern possessions, there is at present 176,500 miles of railways, or nearly 10 times the Indian mileage. There is, therefore room in India for many more railways, and with 5,136 miles at present yielding net earnings on the average of 6.76 per cent. per annum, it seems difficult to account for the laxity shewn by the British public in undertaking the construction of new lines of railways in British India, especially at a time when money is so cheap and over abundant, and the day to day rate on the London Stock Exchange *rules at* ¼ *per cent per annum.*

CHAPTER II.

PROBABLE FINANCIAL RESULTS OF NEW LINES OF RAILWAYS CONSTRUCTED IN INDIA.

The best methods of construction and maintenance of railways in India is of such great importance, in view of the number of lines that still remain to be constructed, and the certainty that such lines will have to depend in the future for successful results in the economical manner in which they are constructed and maintained, that an account of these methods, based on experience gained in constructing the older lines, will be of interest.

India, at present including Burmah, with an area of 1,584,000 square miles, and a population of 286 millions, has 18,042 miles of railways as compared with 10,028 miles in the United Kingdom of Great Britain and Ireland, with an area of 121,115 square miles, and a population of 37,740,284. In India this gives one mile of railway to 87 square miles and 15,851 people as compared with 6·36 square miles and 1,983 people in the United Kingdom. There is, therefore, still an immense opening for the employment of English capital in the construction of railways in India.

Until a recent date, as explained in the last chapter, the Secretary of State for India, with a view to encourage the construction of railways, gave a

guarantee of a certain interest per annum on the capital outlay, payable out of the revenues of India. Under these circumstances the necessary capital was raised without difficulty, as those that found the capital knew the interest promised would be forthcoming, whatever might be the actual profits from working the railway.

This practice has now been discontinued, and in the following pages it has been explained how railway construction can be carried on in India, and be financially successful, without such assistance from the government, provided the routes are carefully selected, and the work economically carried out.

So long as the government of India took no action to protect the currency it was unlikely that much capital would be invested in India in railway or other enterprises. Now that the Indian mints are closed against the free coinage of silver, and a new law passed by the Viceroy of India in Council in June, 1893, which, it is hoped, will eventually keep *the Rupee at about 16* pence in value, it seems* reasonable to suppose that the next few years will see a much greater enterprise in the construction of railways.

Table V. gives the capital cost of some of the lines of railway constructed in India per

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* The last few months, since writing the above, the Rupee has at times been under 13 pence. It does not, however, seem likely to *remain at this very low figure for long. The present time is, therefore,* particularly favourable for undertaking the construction of new railways in India.

mile. It will be seen from this how very different has been their cost, and when it is remembered that on the first cost of a railway depends in a great measure its success as a financial undertaking, too much stress cannot be put upon the importance of economical construction.

Although some of the earlier lines constructed in India earn as much as Rs. 500 to Rs. 600 per mile per week, this cannot be taken as a guide as to the probable earnings of future lines constructed. It must be remembered that the earlier lines passed through the most important towns, and were generally the trunk lines, and have now been in continual work, developing traffic for about thirty years. The new lines for the most part will have to pass through less important cities, and amongst a very poor population. Table VI. gives the gross earnings of some of the existing railways in India constructed by private companies; it will be seen from this that the earnings per mile per week on the newly constructed railways average Rs. 157, whereas those of the older lines are as high on the average as Rs. 494 per mile per week.

Indian railway investments yield at the present market price 3·52 per cent. per annum on the average as shown in table VI., but due allowance has to be made by investors for the probabilities of several of the lines being bought up by the government after a certain time, at the par value of the stock, or converted into an annuity giving a less amount of income as is the case with the East Indian.

It seems reasonable to suppose that with interest of 3½ per cent. per annum assured, and larger dividends probable as the traffic developes, that there would be no difficulty in any well supported joint stock company raising the necessary capital on these terms.

Table VI. shows the average gross receipts on the newer lines constructed in India to date as Rs. 157 per mile per week. It will be safer however to assume them on the first opening of a new line at not above Rs. 120—and judging by past results—there is every reason to suppose that many hundreds of miles of railway could be laid out and constructed in India where the gross receipts would be at least equal to this.

Table V. gives the percentage of working expenses on some of the railways constructed in India by private companies, and in Chapter X., Section I. reasons are given for assuming them at 50 per cent. of the gross receipts.

With net earnings of Rs. 60 per cent. per mile per week or Rs. 8,120 per annum, the capital cost of any newly projected railway should not exceed Rs. 89,142 per mile in order to earn a minimum dividend to its shareholders of 8½ per cent. per annum.

With a view of pointing out the details of all necessary expenditure in constructing an ordinary railway in India, the estimate shewn in Table VII. has been prepared. One item of expenditure must necessarily be omitted, that is, the cost of the bridges and culverts, as this must vary, and cannot be decided

until the necessary surveys have been made. This estimate supposes a railway projected of 300 miles of single line and 5ft. 6in. gauge. The bank formation is not usually an important item of expenditure on railways in India, as the rate for this is low, the earth is generally dug from side tanks to form the bank, and that from cuttings thrown to "spoil." An average length of bank or depth of cutting of 8ft. has been assumed the top width of bank or cutting, being 18ft. and slopes 2 to 1.

The permanent way material estimated for is described in "chapter IX. on construction," and an allowance has been made for conveying it from port of arrival in India, a distance of 750 miles by railway.

A first class or changing station is supposed at the termini, and at two intermediate points, or altogether four changing stations. Other stations are estimated for at intervals of $8\frac{1}{3}$ miles apart.

There are therefore 37 stations on the 300 miles of railway, 15 of them have been estimated as second class stations, with sidings for passing trains and accommodation for passengers, and at six of the 15, the necessary arrangements for watering engines have been allowed, as well as goods wharfs and sheds. The remaining 18 stations are flag stations, as described in "chapter IX." The allowance for rolling stock is only sufficient to meet the probable traffic during the first few years after opening for public traffic. (See Chapter X.)

The estimate assumes an expenditure for interest on the capital raised, for the two years during construction and completion of the railway. The Secretary of State for India has agreed to allow this, which will very much facilitate the raising of the necessary capital.

The total cost works out Rs. 20,943,782 for the 300 miles of railway, and leaves a balance in hand of Rs. 5,798,818 for bridges and culverts, or Rs. 19,329 per mile. For railways passing generally over easy ground, and where the waterway necessary on many miles of the line will be met by the construction of a few small culverts, as is often the case on existing lines, the sum available for larger bridges that would be sure to be necessary at some part of the line, would be sufficient. Where this is not the case, the survey may, however, show some other manner in which a saving on the estimate could be effected. If the proposed railway is of such a promising character as to permit the raising of the necessary capital without payment of interest during construction, the amount available for bridges would be increased to Rs, 7,670,800, or Rs. 25,569 per mile.

In some cases reliable information might show that the gross receipts would exceed Rs. 120 per mile per week, and this would compensate in some measure for any excess expenditure, or perhaps owing to the vicinity of coal mines or other reason, the working expenses would be less than 50 per cent. of the gross receipts.

This estimate is based on what would be really necessary expenditure on any ordinary broad gauge railway in the plains of India. It will be observed that there are no allowances for the purchase of land, and other charges connected with the obtaining of the land, as usual in England, for reasons stated in chapter VII.

The thickly populated parts are naturally the most fertile, and these parts are generally also the most even ground, and where few engineering difficulties are likely to be met with, and it is in such parts that railway construction will be generally undertaken in the future, as most likely to yield good returns to investors. The rivers must be treated as described in Chapter V. and if deep foundations are necessary, the brick cylinders sunk as described in that chapter, and without the purchase of expensive plant. All work should be done by petty contract, and no daily labourers allowed except where the men can be watched by a responsible European Inspector. —(for rates see tables II. IV).

All girders and other steel and iron work should be procured in India if possible, and manufactured under the close supervision of a responsible officer of the company. They should be constructed to carefully prepared specifications, and tested when possible, before deliver y is taken. It much simplifies and cheapens the construction of girders to have as few different patterns as possible, and in building the necessary culverts and bridges, this point should be borne in mind.

CHAPTER III.

THE GAUGE OF A RAILWAY AND ITS SELECTION.

It is a great pity that the gauge adopted for Indian railways in the first instance was not 4ft. 8½in. or the same as in England, there can be no doubt that if this gauge is sufficient for English traffic, any wider gauge is unnecessary for India.

If this gauge had been followed in India, there would have been less inducement to depart from it and construct some railways on the mêtre gauge. At present the older lines have the 5ft. 6in. gauge, and the newer in some cases the mêtre gauge.

Experience is, however, showing that where the traffic is largely developing, the mêtre gauge lines are unable to deal with it, and the question of converting such lines to broad guage is being constantly discussed, and will, undoubtedly in some cases, have to be carried out. For hill railways, or lines going over rough country, where the traffic is sure to be light, and particularly where such lines will be only feeders to existing broad gauge lines, it may in some cases be sufficient to construct such lines of the mêtre, or even narrower gauge. There may also be other special reasons, such as existed in the case of the Bengal and North Western, for making the lines mêtre gauge. In this case entirely new country was being opened out on the left bank of the Ganges; there were no broad

gauge railways on that side of the river with which it would have through connection. The East Indian railway, over which the bulk of its traffic would have to go for Calcutta or export, was separated from it by a river more than a mile broad in the rainy season. The only way of connecting the two lines would have been by constructing very expensive bridges over the Ganges. There could, therefore, in this case have been nothing gained by constructing the Bengal and North Western on the 5½ft. guage. In fact, instead of the line being the financial success it is at the present time, and only a few years after opening for traffic, there is every reason to suppose that if it had been constructed on the broad gauge, the line could have never yielded to the shareholders such a satisfactory return on their investment. In this case there are no bridges over the Ganges for connecting with the East Indian railway, but at Deegha and Mokameh Ghâts, two points on the Ganges, ferry steamers are used for conveying the passengers across the river, and the Bengal and North Western goods waggons are conveyed across on flats, and run up to the tramship platforms of the East Indian railway, where the contents are taken out and transferred to the East Indian railway rolling stock. There is, therefore, in this case, the advantage of having comparatively portable rolling stock, for carrying across the river, and light permanent way material for quick taking up and relaying near the Ghât stations. This last is necessary owing to the position of the deep channels varying

each rainy season, and consequently the landing places from the steamers and flats have to be varied according to circumstances. Where, however, the lines *proposed to be constructed pass over easy ground, and* through populous districts, and the traffic carried will pass over broad gauge lines, with which they will be *connected, and where no special reason exists, such as* existed in the case of the Bengal and North Western, it will be generally found best to adhere to the $5\frac{1}{2}$ft. gauge. Each case must, however, be well considered and judged on its own merits. Experience seems to show, that although there is some saving in the first cost of construction of a mêtre gauge line as compared to broad gauge, the working expenses of the mêtre gauge lines are generally higher than those of a broad gauge line of similar grades and gross traffic.

CHAPTER IV.

THE SURVEY AND LOCATION OF NEW LINES.

In the earlier days of railway construction in India, it was customary to send out the whole engineering staff required for the construction of a railway, before the centre line had been set out, or any plans prepared, or even the general direction of the line determined. This led to a most wasteful expenditure of money, as usually a much larger staff than could be usefully employed was available, and when the survey was complete and the plans submitted, there was nothing further for the staff to do until sanction for construction of the line was received. For months the staff drew large salaries with nothing to do, awaiting the decision of the Government of India, and the handing over of the land. In all cases a most careful survey and estimate of cost is necessary, and if the plans and estimates are not available at a moderate cost from the India office, or the authorities in India, a small staff of engineers acquainted with the country must be sent out to obtain the requisite information. This staff should be sent out in September, if not available in India, one engineer being selected for about each 60 miles of ordinary railway, to be staked out and estimated for. The whole of the out-door work would then be completed by the end of the cold weather, and the small staff

engaged could then either prepare the plans and estimates in India, or return to England to do so.

For a line of 300 miles in length, the cost of the out-door work for a complete survey, including staking out centre-line in a permanent manner, and pegging out the side-widths, would be as given in Table VIII. To this would have to be added the cost of passages to India and back, if the staff were engaged in England; but in most cases the superintending engineer would *have no difficulty in obtaining the requisite number* of men in India, and they would probably be more efficient for survey work in India than men sent out from England.

The office work in India would occupy about four months. Preparing the necessary plans and estimates, would add approximately Rs. 25,236 to the cost of the out-door work, see Table IX.

This would make the total cost Rs. 90,248, or about Rs. 300 per mile of railway set out, with plans and estimates prepared in a complete form. If the whole of the engineers were sent from England, the saving in the salaries to be paid at the English scale, whilst preparing plan and estimates in England, would about pay the passage out and home of the five engineers, as there would in this case be no necessity *for the engineers to remain in India to prepare the* plans.

The estimates in Tables VIII. and IX. might be much reduced, if only a trial survey were necessary, but it is assumed in the foregoing, that the actual con-

struction of the railway had been determined, and the permanent setting out of the line with estimates in detail were required.

The engineers, whilst engaged in setting out the line, must be careful to obtain all information that may be required to prepare complete plans and estimates, they must take note what depth of foundation will be necessary for bridges, and in most cases trial pits dug at the sites will give them the necessary information. For important rivers small trial brick cylinder wells may be necessary, and these should be sunk by native petty contractors; boring-tackle will only be required in very exceptional cases.

The engineers should also examine all stone quarries in the vicinity of the projected railways, so as to be able to form an idea what stone will be suitable for masonry work or ballast. They should also ascertain the most convenient sites for brickfields, and by experiment decide upon the best lime that might be manufactured from limestone in the vicinity.

To obtain correct information regarding the waterway necessary for each bridge the railway will have to cross, is a matter of the highest importance. On some of the older lines in India much money has been wasted in reconstructing new bridges where the first have been carried away owing to the waterway not having been sufficient, or the foundations sufficiently deep. Carefully prepared maps have now been issued by the Government of India, at scales of one

inch and four inches to a mile, which will be of great assistance to the engineers in calculating the area drained. Levels should, however, also be taken up and down stream at each important crossing, so that the fall per mile can be ascertained, and the velocity and discharge calculated. The highest known flood levels must also be recorded in all cases, and this should be ascertained from the villagers, and checked by actual observations in the rainy season.

It is very important that in locating the line, the easiest grades possible should be obtained. It must be remembered that the usual charges for both passengers and goods are very much lower than in England, and that to work the traffic economically, as heavy a load as possible should be carried, and that the heaviest load to be carried by each train will depend upon the ruling, or steepest grade, and the full load of the train will have to be arranged accordingly. The curves should be set out as flat as possible, curves of two miles radius will often be found possible, and nothing less than a quarter mile radius should be given if it can be avoided. Much attention should also be given to taking the line as close to villages of importance as possible, most of the roads in India, where future lines of railway are likely to be constructed, are of the worst description, and very often simply cattle tracks. If the goods to be taken to a station have to traverse a long distance, it will be often cheaper to take them to their destination by bullock cart or bullocks, in place of making use of the railway.

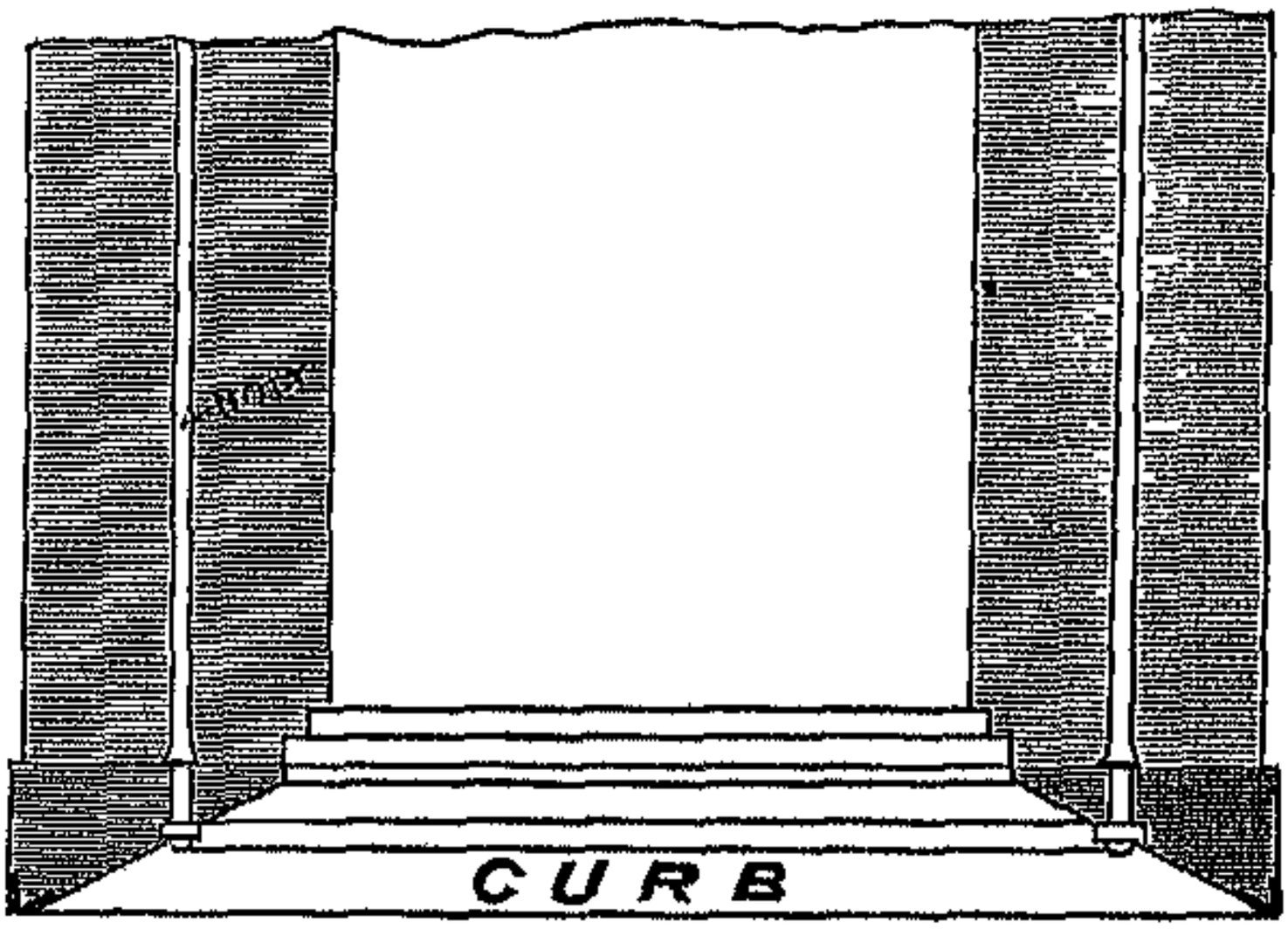
CHAPTER V.

RIVERS IN INDIA, THEIR PECULIARITIES, AND THE BEST AND CHEAPEST METHOD OF CONSTRUCTING DEEP FOUNDATIONS FOR BRIDGES.

The rivers in the plains of India have generally little water in them during the dry season, and this much facilitates the construction of bridges, and makes, as a rule, expensive plant not necessary. In the rains on the contrary, as they often have no defined banks, they spread over a large area of ground, and are also apt sometimes to forsake in part the channel of previous years, and take to an entirely new, or perhaps an old bed of the river. In selecting the crossing for a railway it is therefore important to get both banks well defined, or, if this is not possible, one bank well defined. When this cannot be done, training works may be necessary on the up side of the bridge, so as to keep the river from wandering out of its course, and endangering the railway bank after the bridge has been constructed. In selecting the crossing, the bed of the river must be examined, and if possible rock foundations obtained for the piers. Where this is not possible it may happen, owing to the sandy nature of the strata, that to secure a safe foundation, a depth of 100ft. has to be excavated, and in parts of Upper India 30ft. to 50ft. are very common depths to which it is considered

advisable to take the foundations, even in small rivers. The usual plan is to build the piers and abutments on circular cylinders of brickwork of sufficient diameter. Iron or wooden curbs (see fig. 1) are used to support the brick wells, to which they are fixed by strong bolts. The curb is placed in the bed of the river, accurately in position, and brickwork is built on the curb for a sufficient height, and the curb and brick well is then sunk below the river bed by excavating inside the well. When the top of the brickwork has been taken down to the river bed, or water level, another length of brickwork is built, and the well again sunk in the same manner. The alternate building and sinking of the well is continued until the well is sunk to a firm bed, or below all danger of scour.

FIG I
SECTION OF BRICK WELL.

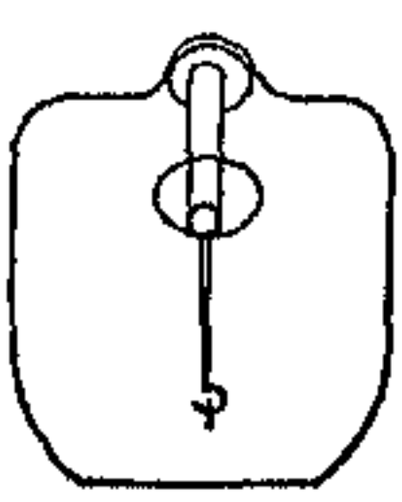


SCALE $\frac{1}{4}$" = 1 FOOT.

It will be noticed by referring to fig. 1 that the diameter of the outside of the well is made slightly less than the diameter of the curb; this is done to facilitate the sinking of the well. The brick well occasionally hangs and refuses to follow the excavation made for it, owing to the side pressure of the earth against the brickwork. By constructing the curb a little larger than the well, the earth pressure is somewhat lessened and the sinking of the well made less difficult. Heavy loads of rails are usually found necessary to weight the wells.

The excavation inside the well is usually carried on by dredgers or divers and sometimes the country jham is used (see fig. 2). This last is very effective for small depths. The jham is either driven into the soil by a long pole from the top of the well or native divers go down and force it in with the hands. It is then pulled up by a windlass and the stuff brought up cleared away. When some hard substance is met with it must be cut away by a diver, in helmet and dress.

SCALE 2" = 1 FOOT



COUNTRY JHAM

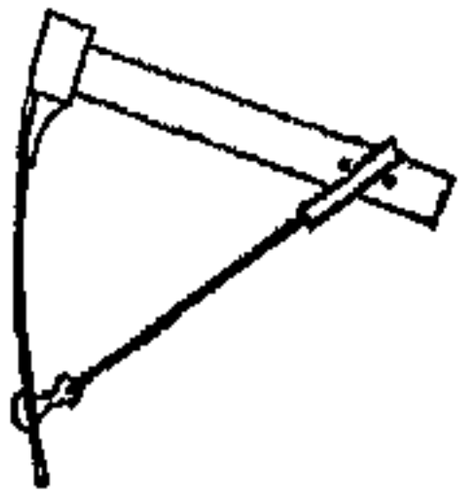


FIG. 2.

Emptying the well of water partially is also found sometimes very effective. This is done with leather bags and manual labor. The pressure of water outside the well being greater than inside, owing to the water *inside having been partly removed*, the water rushes in under the curb and carries away any impediments that may have prevented the well sinking. These methods of well sinking to obtain good foundations at great depths, although they may appear rather primitive and behind the age, are still the best *for India, as good natives who thoroughly understand* this system, can be easily obtained, and the plan is very economical as native labour is cheap and expensive plant is usually rendered thereby unnecessary. Great care is of course necessary that the brick cylinders are kept quite plumb whilst sinking, as any *departure from the plumb very much increases the* difficulty in sinking, but with good European supervision and trained native workmen no difficulty on this head need be anticipated.

CHAPTER VI.

THE SELECTION OF A TRAINED AND CAPABLE STAFF OF ENGINEERS.

It is absolutely necessary for any joint stock company prepared to undertake the survey or construction of railways in India, to see that its engineering staff are only composed of men acquainted with the country, and who can be relied on to execute sound work cheaply. The principle of railway construction is very different to what it is in England. In England most of the railway work is carried out by skilled contractors, who are themselves men of considerable experience in railway construction and who often have their own engineers to supervise the work. If the engineer requires bricks, lime, iron, wood, or any other material, large firms exist who can supply quickly all he requires. Through the system of calling for tenders for any particular work to be done, the engineer is at once able to decide regarding rates to be paid, and his knowledge of various men that submit the tenders, will tell him at once the particular man who can be best entrusted to execute a particular work to his satisfaction. In India as a rule the engineer will have no skilled or trustworthy contractor to carry out the work. He will himself have to arrange with native petty contractors for all the work required to be done. He will have to enter in the minutest detail of the work with ignorant men who have often

never carried out work of a similar kind previously. The engineer will have to settle what rates are to be paid with often unprincipled natives, who have no scruples in asking two or three times the proper rates if they see any prospect of getting them. He will have to be most careful regarding all measurements of work submitted to him for payment, and place little trust in certificates signed by the apparently most trustworthy native inspectors. It is almost invariably found on all large construction works in India that there is more or less false measurements submitted to the engineer by these men, who receive some kind of encouragement or reward from the native contractors for doing so. The best natives he may select for doing the work will require the most constant supervision of the engineer, or the work will be badly executed. Bad lime will be used unless it is manufactured under his close supervision. Bad bricks will be put in the work unless the bricks to be used are selected by him, and any inferior removed off the ground before the work is started. Little or no reliance can be placed on the promises or statements made by the native contractor, and even if the engineer leaves a native in his own employ to see that his orders are carried out, it will be generally found that still unsatisfactory work is done unless he is constantly on the spot to supervise the work in every detail.

It is, therefore, most essential that each engineer engaged on railway construction in India should not

only be a scientific but also a thoroughly practical man, able and willing to go into the minutest details of construction. He should be acquainted with the language and have done similar work before. He must be a good administrator, as the engineer will have a large number of European, East Indian and native employés under him, and if through want of tact disputes and changes are frequent, economical construction will be an impossibility. The engineer should be thoroughly acquainted with the manufacture of bricks, lime, tiles, etc. All he requires will probably have to be manufactured under his own supervision. He should be acquainted with the different classes of Indian timber, so that he can select the best available for any particular work. A great deal of the small ironwork he will require will have to be manufactured by his native workmen under careful directions given by himself. What he is able to purchase will generally be timber in the log, bar or plate iron, and from these he will have to manufacture what he requires for wood or iron work.

The same care as is required from the engineer on the work, will also be required in his office. It is usual to fix a schedule of rates which is to be paid for all work executed. He must see that these rates are not departed from without special reason. The native contractor is often unable to write even his name; the engineer must therefore himself witness all payments made to contractors. It is only by doing this that he can be perfectly certain the payments have

been made, as the statements made by the natives by whom he is surrounded are seldom reliable. Large European contractors are sometimes available to carry out work, but their rates are generally much higher than it would be necessary to pay to a petty native contractor, and they should not be employed except for special reasons, as although it facilitates the engineer's work, it makes economical construction more difficult.

CHAPTER VII.

GOVERNMENT ASSISTANCE AND OBTAINING THE LAND NECESSARY FOR CONSTRUCTION OF A RAILWAY.

All railways in India as in other countries have to be approved by the government before they can be constructed. Even permission to make the necessary surveys must be recorded in the Government of India Gazette before the surveys are undertaken. It would much facilitate English enterprise in Indian railways if there was some central authority in India, who could be directly communicated with as regards railway construction. India is a country of such large area, and has so many different local governments of different views that some central authority is required, through whom capitalists in England could communicate and submit inquiries. This authority should be publicly advertised and made known as the central authority to deal with the construction of all lines of railway. This Board of Control should have full power subject to the Viceroy's approval of making what terms they think best with those desirous and able to undertake railway construction. The same authority should also deal with the handing over of the land for railway construction. Now there is often much delay in handing over the land and putting the necessary machinery in motion. The correspondence has to pass through so many offices, and if there is delay in one office much time is lost, and it often

follows that the best time for construction has passed before the land is handed over. Little can be done in India by word of mouth regarding this and similar matters; the details of what is required has to be written out and passes through a series of offices, many of which are held by natives of India. These men are naturally dilatory, and questions referred to them regarding the land are pigeon-holed until it suits their convenience to go into the matter and reply to them. In the meantime the company prepared to construct the railway will probably have already raised some part of the capital necessary. Interest charges as well as other fixed charges are being incurred, and consequently such delay in dealing with the land question adds to the cost of construction.

It is sometimes thought in India and even in England that the Government of India is not particularly anxious to encourage private enterprise. That it has its own staff of engineers and others, and that these men have to be kept employed, and that therefore, it is more anxious to see lines constructed as state railways than as private undertakings. The chairman of the Rohilkund and Kumaon railway seems to be of this opinion as he tells his shareholders in December last, quoting his own words "Well to make a railway extension in India requires the sanction of the Government of India, and the Secretary of State. Both of these authorities have on paper expressed their great desire that works should

be carried out by private enterprise; but experience now extending over ten or twelve years shows us that these are mere words, and that there is no real desire on the part of the Government of India to carry out any work. What they desire if they can accomplish it is to get your cash and expend it themselves on lines which they can control." General Strachey, the chairman of the East Indian railway has also frequently referred at recent meetings of the "deferred annuitants" at the difficulty of obtaining funds from the government to construct extensions which were required to fully develop that undertaking, and which funds were really available from the large surplus earnings of that railway, but which the government diverted to other purposes. The chairman of the Delhi Umballa Kalka-railway at a meeting of shareholders in December, 1893, also complains of difficulties put in their way by the Government of India, quoting his own words he says, "In January last of this year we addressed the Secretary of State fully with regard to the failure of the States railway administration in India, to give effect to the understanding that traffic was to be carried over this line at equal mileage rates with those charged on the North Western railway, and we have been in communication with him since. We have not had any final or formal reply to those communications, and although I cannot anticipate what answer we will get from him, I may say that I have not lost hope, that faith—I do not use the term offensively—will be kept

with us, that the spirit of our prospectus will be carried out, and that, if not justice, at least generous treatment will be accorded to us in this matter. It has been very disappointing to us to see traffic that ought to have gone legitimately over our line diverted to the state line, which runs a longer distance, and passengers to a certain extent coerced into going over that line instead of ours. I can only say that if the settlement is not satisfactory to us, it will be our duty to put the whole matter before our legal advisers, and if necessary we will call you together again to consult you as to the action we should take." At a recent meeting of the shareholders of the Assam Bengal railway, the chairman makes a complaint regarding the delay in handing over the land for this railway in these words. "Another circumstance to which it was necessary to allude was the continued delay on the part of the government handing over the land. According to the latest advice, there was still upwards of 95 miles to be made over to the company in the southern section alone, where it was of the greatest importance to push on as fast as possible. From the first the board had done its utmost to urge upon the government the necessity of promptitude in that respect, and it felt that more might have been done to expedite matters."

Capitalists in England are not likely to take up energetically the construction of railways in India, as long as the Government of India act in this manner, and the sooner a Board of Control is established for

initiating railway, and even tramway construction in India the better it will be for all interested in the extension of railways in that country. The same authority should also collect information regarding the existing traffic over cart roads between towns and villages, and publish the same with any remarks the Board of Control may think necessary. The approximate mileage should be given as well as the quantity and description of the principal commodities passing along roads in either direction. The approximate number of pedestrians using the road might also be given—so that the daily number likely to use the railway if constructed might be known. Such information should be at the disposal of all interested in railway construction in India. English capitalists and others desirous of taking in hand the construction of railways in India, would then have some reliable information as to the financial prospects of any particular project, in which they may be interested.

For all railways constructed in India to date, the land has been given free of cost to the railway company, and in any projected line which meets with the approval of the Indian Government, the land will most probably be handed over to the company in the same manner.

This item, which in England forms such a heavy charge on the first cost of a railway, need not therefore as a rule, be considered in forming estimates of cost for railways in India, and at once explains why the mileage cost of a railway in India should be very different to a similar line in England.

CHAPTER VIII.

THE MANAGEMENT OF THE NATIVES OF INDIA.

The proper management of the natives which the engineer occupied in the construction of a railway will have more or less under his control, forms by no means an unimportant factor in the economical construction of an Indian railway. This refers particularly to the most uncivilized parts of India, and where in the future railways are most likely to be constructed. The native of India employed as a petty contractor will be found by the engineer of the greatest use and assistance to him. But it depends a great deal upon the manner he is treated by the engineer as to the extent to which the employment of this native facilitates his work. These men are almost invariably civil and anxious to please the engineer; they are however, as a rule, perfectly uneducated and unscrupulous in their methods of carrying out work entrusted to them. The statements made by them are unreliable, and therefore the less conversation that is held with these men the better. It can only cause annoyance for the engineer to expect a certain work performed in a certain manner, and in a certain time, and afterwards to find that none of the promises made have been carried out in the faintest degree, in fact at the time the promises were made, most probably the native never had the

slightest intention of performing them. The engineer should give his directions carefully, and in as few words as possible to the native contractor in the native language, and as near as possible in the native manner of addressing a subordinate. He should be careful to fix the rate before-hand, or if as will be probably the case he has arranged a fixed schedule of rates for all work, he should simply inform the native contractor that he will be paid in accordance with this schedule. Bargaining or discussing the rates to be paid should be avoided as much as possible. The native is always only too anxious to do so if he is allowed, as amongst themselves the matter of a few pice one way or the other forms sometimes an argument of considerable duration. It would be however, impossible for the engineer to get through his duties if he were to waste his time in discussing rates for each small job he wished carried out. The engineer having let out the work, he must see by constant daily supervision that the work is being done as it should be. Bad work should be pulled down in his presence and without discussion, badly moulded bricks should be walked over and destroyed, badly thrown up earthwork should be levelled or thrown back into the side-tanks. If the work is not progressing as fast as it should, it should be measured up and another contractor employed to complete it. If the engineer whilst going his rounds adopts this practice the native contractors will soon learn, that it is best and cheapest in the end to do the work as the engineer requires it,

and not endeavour to do bad work during the absence of the engineer. As a rule petty contractors can be obtained in any numbers, and if one does his work badly another can be found to complete the work. They are generally forthcoming to undertake any job the engineer may wish executed, and are often only too anxious to carry out his behests for fear of another getting the job before him. The engineer if *he treats his men fairly, and sees that they are paid* regularly will have no difficulty in getting what labour he requires to execute his work cheaply, expeditiously and well.

CHAPTER IX.

CONSTRUCTION.

1. *Earthwork, the cheapest way to throw up the railway bank.*—The earthwork, which in India is thrown up by large numbers of men, women, and children, each carrying a basket full of earth on their heads, is usually done in a most careless manner. This work is generally done in the dry season, when the earth is very hard, and the side tanks free from flood-water. It is thrown up irregularly in large clods or lumps without any attempt at breaking them up or ramming the earth. It consequently follows that for many years after a line is opened for traffic the banks still continue to settle, causing an enormous waste of ballast, and much adds to the cost of railway construction.

This system of throwing up railway banks is also extremely dangerous, and many serious railway accidents have occurred owing to the sudden settling of the banks during the rainy season, shortly after opening a railway for public traffic. The engineer should insist that all earth thrown up to form a railway bank is laid in level layers, not exceeding 1ft. in thickness, and the lumps thoroughly broken up before another layer of earth is put on the top of the first. The cost of earthwork in India is sometimes as low as Rs.1-8 per 1000 cubic feet, and is seldom more than Rs.4.

It would be better to pay for this liberally, and assure the banks being properly executed. But no extra payment will insure this unless the engineer is constantly on the alert, and sees that his orders are being carried out.

2. *Masonry work and the manufacture of bricks and lime.*—Good building stone is available in many parts of India, and where this is the case good bridge-work can be executed for Rs.30 to Rs.40 per 100 cubic feet, and small rubble masonry for stations and similar buildings at Rs.20 per 100 cubic feet. Where building stone is not available good brick clay can always be found at no great distance from the projected railway. First-class brickwork can be executed for Rs.25 to Rs.30 per 100 cubic feet. Good bricks can generally be manufactured at Rs.10 per 1000 bricks. The moulding of the bricks is generally done by hand, costing about Rs.1-4 per 1,000 bricks. *Wood, coal, or Kundee (cow's dung) is always* to be purchased for burning the bricks, and the description of the kiln to be used must be determined by the kind of fuel available. For economical construction it is important that a large supply of bricks are ready immediately they are required.

It often happens that much delay in the construction *of bridges and culverts is incurred* owing to bricks not being available as soon as they are wanted. It would be a good plan for a company, immediately the location and construction of a line is determined, and before sending out its staff of engineers, or engaging

them in India, to arrange with some responsible firm in India for the manufacture of a sufficient number of bricks, so as to insure no delay in the execution of the work when the staff are engaged. It must be remembered that the fixed charges when work is actually in full swing are very heavy, and it is most important therefore that these charges, which includes engineers, inspectors, and a large number of natives salaries, should be continued for as short a time as possible. The description of mortar to be used must depend upon the limestone available in the vicinity of the projected railway. In most parts good lime can be manufactured, costing from Rs. 10 to Rs. 15 per 100 cubic feet. Where gravel is not available for mixing with the lime soorkee (pounded brick) must be used, and this can generally be made for Rs. 10 per 100 cubic feet. The proportion of lime or soorkee to be used must be carefully determined by experiment. The mortar should not be used until thoroughly mixed up in a mortar-mill, driven by bullocks, or for large works by steam-power. The engineer must see that his native contractors bond the work properly, and keep it moist until set. In a hot climate like India, and during the hot season, the last is not so easy. It is absolutely necessary, for the execution of sound work, that there should be a good supply of water available at all sites where masonry work has to be executed.

8. *Second and third-class railway stations, and the requirements of native passengers.*—Much money has

been wasted on some lines in India over the construction of railway stations. On many broad guage lines the platform for passengers have been made 3ft. to 3½ft. high where 1ft. or 1½ft. would have been sufficient. Station-houses and other accommodations have been built much in excess of actual requirements, and in some cases elaborate stations laid out where subsequent experience has shown little traffic has come to them.

On all future lines constructed in India the expenditure on stations in the first instance should be kept at a minimum. It is always easy to add to the accommodation subsequently, if found necessary. At all small villages a flag-station will be found, in many cases sufficient, and the platforms should be simply of earth to level the rail, with a little ashes spread over them. A small hut of one or two rooms will be sufficient for a porter to live in to exhibit a flag or light on the approach of a train, a station of this description would cost Rs. 500, and in many cases be sufficient for the traffic for many years after the opening of the line. No siding accommodation should be given until the absolute necessity for this has been proved.

Where larger stations are necessary they should be built in the most inexpensive, but solid manner. It must be remembered that nearly all the passengers that travel are natives, whose home is a mud hut, with a rough leaky thatched roof and a mud floor; and that the rate they will be required to pay for

travelling on the railway will be only two to two and a-half pies per mile or about one-fifth to one-seventh of a penny.

For such low fares it is impossible to give accommodation such as exists generally at stations in England, where the lowest rate is one penny a mile, or five to seven times the charge made on Indian railways. Nor do the natives who will use the railway require such accommodation. The sites for railway stations might in many cases, as already stated, be fixed where there is a nice large tree that will give shelter from the rays of the scorching sun, and a good well to supply drinking water to the tired and thirsty passenger waiting for his train. This is what the natives of India appreciate much more than a raised platform and other facilities which it has been customary to give to them.

The length of the platforms will depend upon the grades. If the grades are easy, and long trains possible, a platform 800ft. long will be necessary, for second-class stations one passenger platform will suffice. A permanent building of two rooms and a verandah will give all the accommodation necessary for the station staff. One or two godowns (store-rooms) will however be necessary attached to the main building for oil and other stores. Good roofs should be constructed, the trusses or beams of old rails or T iron. Slates or tiles form the best covering, as any other kind of roof gives great trouble by leakages in the rainy season. The walls should be built of rubble

masonry or first-class bricks set in mortar, and sites selected as far as possible where there is little or no railway bank, so that the cost of the building, in material, can be kept at a minimum. The platform, should be well consolidated, and not covered with any kind of metal until this is the case. A good drinking well must be provided at all stations. A waiting shed attached to the station building is much appreciated by the native passengers, and this should be constructed of old rail supports and galvanized corrugated iron sheeting, No. 18 gauge for the roof and sides. This last should be open except for 4ft. or 5ft. above the floor, and a brick on edge floor should be given. Latrines, if given, should be made of iron supports and galvanized iron corrugated iron sheeting for roof and sides, they are, however, seldom used, and at most stations will not be found necessary.

4. *The road high speed not necessary.*—The principal expenditure on a railway in India is in connection with the road. The description of permanent way material and ballast to be used is therefore a matter requiring the greatest consideration. Owing to the heavy floods at one time of the year, and the extreme heat and dryness at another, and also owing to the great difference in temperature which varies during the year from 32° to 150°, the satisfactory up keep of the road is by no means an easy matter. On the other hand, the low speed at which it is usually necessary to run the trains, makes lighter material

and fastenings necessary than would be required on lines travelling with speed, customary on some railways in England. No trains, except for special purposes, require to run more than 20 miles an hour. The native passengers, as long as they get to their destination at this rate of speed, are perfectly satisfied, time is of little object to them. The timing of trains is as well advertised in India as in England; still it is quite a common thing to see the native passengers arriving hours, and even sometimes a day or night before a train is timed to leave. For a 5ft. 6in. gauge railway, steel rails, 70 to 75 lbs. per yard, will be heavy enough for the light traffic to be expected for many years on the most promising new lines. The rails should be double headed, so as to allow of being turned end for end, and on their beds as the different faces wear out. Cast iron Denham Olphert plates of the heavier patterns where the rails are suspended on the jaws, and consequently receive no damage on their faces from bedding on cast-iron chairs, make excellent sleepers. The fish-plates should be long and deep, and kept in place by four bolts; the top edge of the fish-plate should be such as to fit well into the shoulder of the rail, and give support. Good hard stone ballast should be used, if possible; broken to pass through a 2½in. ring. No attempt should be made to lay the road, until at least one rainy season has passed, and the banks have become fairly consolidated. The ballasting of the road should be done partially as the linking-in of rails proceeds; to run

the trains over the road without any ballast, especially on new banks, is most destructive to the material, and should not be done if it can be possibly avoided. Much care should be used in linking-in the rails, the joints kept square with each other; the sleepers properly distanced, and the spaces for expansion and contraction of the rails carefully left. Not more ballast than sufficient to pack the sleepers should be put on to the banks in the first instance, and until the banks have fairly consolidated. The bottom of the Denham Olphert sleepers should have at least 4in. of ballast under them, the remaining ballast required to completely ballast the road, should be kept in stacks on the bank cesses until required for use. The permanent way should be laid on the telescopic principle. A rough cart-road is generally made along the space between toe of bank slopes, and the side-tanks, along which bullock-carts can go to deliver material required for construction. In some cases it may be possible to lead the permanent way material out by bullock-cart from the point where the material is stored; if this is not possible, it must be led out by material train, and linking-in proceeded with as the material is delivered. Ballast should be as much as possible arranged for immediately construction commences, and led out by bullock-cart or donkey along the cart road and stacked, to be ready for use when required. This way of delivering ballast being cheaper than leading it long distances by trains as soon as the rails are laid. Wood sleepers should not be used

except for special purposes. Although their first cost is less than iron, the life of the best (sál) is not often above 10 years; whereas the iron plates laid in good ballast should last, at least, four times as long It is hoped that before long C.I. plate sleepers will be obtainable in India in sufficient quantities without having to import them from England. They are now manufactured in large quantities in the East Indian locomotive shops at Jumalpore, for the use of that railway, and they are also made at the Burrakar ironworks.

5. *The cheapest fencing in the end.*—The cheapest fencing for Indian railways is stone or iron posts, with galvanized iron or steel wire. Stone posts, where procurable, are generally the cheapest, and should be used. Where not available, wrought iron or steel posts with cast iron bases, are the best. The fencing should be fixed on the boundary of the land taken up so as to define for all time the land belonging to the undertaking. A mud bound fencing often used on railways in India, should not be constructed, as every rainy season it requires extensive repairs, and is in other ways unsatisfactory. It will be found in the end best to construct a wire fence, costing about Rs. 1000 per mile, against Rs. 300, the cost of a mile of mud fence.

6. *Plant. Great expense in plant not to be incurred.* —As a rule, the purchase of expensive plant should be avoided. Except in a case of very heavy and special work, costly plant in India is unnecessary. Excellent

men can be had at four or five annas a day, capable with ordinary ropes and blocks, to drag and lift the heaviest pieces of metal likely to be required into position. The mortar required, except for very large works, should be ground on site by bullocks. Soorkee if used, should be pounded by native labour.

7. *Workshops—small shops only necessary at the commencement.*—A large expenditure on workshops should not be incurred by any newly constructed railway. Some machinery and tools will of course be necessary for the repairs of rolling stock; but with the few locomotives that will probably be required to work the light traffic of the first few years, great care should be taken to keep this expenditure at a minimum. All repairs that can be done well without machinery should be done by native labour; excellent skilled labour can usually be had at very cheap rates, good rivetters and fitters at Rs. 15 to Rs. 20 a month, carpenters at Rs.15, blacksmiths at Rs.12; many of these men with careful European supervision can turn out excellent work with the cheapest of tools.

8. *Changing stations—their selection and position.*—Much consideration should be given as to the best position for the changing stations. In fixing these, the distances apart should, unless special reasons exist, be about equal; it is, however, also equally important to fix them at healthy sites, as many of the staff, both European and native, will require to live there, and considerable expenditure will have to be incurred to provide the necessary staff quarters, which

would have to be abandoned, and consequently become useless if it were subsequently found for some reason that the position was not suitable for a changing station. There should be a good supply of water available both for the engines and drinking purposes. The sanitary arrangements should be of the best, and the facilities for draining of all neighbouring low ground, and tanks should be considered. Malaria is a very prevalent illness in most parts of India, especially amongst the natives, and it often arises from the houses occupied by the staff being badly situated, or the floors not being sufficiently raised. The engine shed should be built to accommodate the usual number of engines likely to be at a changing station at one time. They should be built of stone or brick, with good roofs, and plenty of ventilation; the flooring should be of the hardest material available; the ashpits made with stone beds to take the chairs and rails. There must be a plentiful supply of water laid on in connection with the overhead tank. Overhead tanks of a larger capacity than those at the intermediate watering stations will be necessary, and a small steam-pump and boiler will generally be best for filling them.

9. *Girders for bridges.*—Except for very small culverts, it will be best not to construct arches. The native workmen are not particularly apt at this class of work, and the engineer cannot be always present to watch the progress of the work. For spans 10ft. to 60ft., plate girders, with the road on the top, will be

found generally the cheapest and best for India; no cross girders should be used, but the pairs of girders firmly braced together, and placed for a broad gauge line (5½ft.) about 8ft. apart centre to centre.

The road should be supported on transverse sleepers of teak 9in. thick and placed 2½ft. apart centre to centre, the sleepers fastened to the top flange of plate girder by bolts—no packing pieces should be used, but the camber of the girders and any other irregularity taken out by cutting what is necessary from the underpart of the sleeper where they rest on the flange of girders. For small openings the girders should where possible, be constructed with flooring plates, so that the ordinary road and ballast can be continued over the bridge. All girders up to 20ft. span should be designed, for a 5½ft. gauge line, to take a moving load of two and a-half tons per lineal foot of bridge, for 30 and 60ft. spans two tons and for larger spans one and a-half tons will generally be sufficient for a single line. The girders of small dimensions can now generally be obtained from firms in India, but specially designed girders for large bridges must be ordered from England in time to be in India soon after the staff commences the work of construction.*

10. *Sidings—the cheapest method of constructing them.*—Sidings should not be put in at stations, unless it is quite certain they will be required for the traffic; they should be constructed in the most

* For calculations regarding girder see "Pocket-book of calculations in stresses," by the same author.

economical manner; only the damaged or crooked rails being used, a less number of sleepers per pair of rails, than used on the running road, will suffice, and any sleepers slightly damaged, should be kept back for this work. Only ashes should be used for ballast, and if not available, the sleepers can be packed temporarily in earth.

11. *Goods sheds and wharfs—not to be constructed until they have been proved necessary.*—Goods sheds and wharfs should not be built until the necessity for them has been proved. Only at large and important stations should they in the first instance be constructed. Where goods-sheds are found necessary, it will be cheapest to construct them of old rails, which are usually available in India from existing lines, and galvanised corrugated iron sheeting. The platforms should be as short as possible, and placed as near the station building as circumstances will allow.

12. *Water supply, an important factor in the economical maintenance of a railway.*—The supply of good water for the locomotives is of the greatest importance to assist economical working. As a rule, well water contains various impurities which act injuriously on the boilers. River or tank water should be used where possible, and the stations for the supply of water to engines fixed where such supply can be obtained in the most economical manner. Good ground tanks where river water is not available, can generally be constructed at small cost, but careful calculation should first be made to prove that during the rainy

season these tanks will fill so as to keep up the necessary supply during the dry season. Levels should be taken to prove that the catchment area with the smallest possible rainfall, will be sufficient to fill the ground tanks, if constructed. Overhead tanks should be constructed of cast or wrought iron, of the capacity required and supported on old rails or masonry. If the bottom of tank is placed 18ft. above rail, this will be sufficient for all usual purposes. Two water columns are necessary at each watering station, one each end of the platform, so that passengers can alight whilst engines are taking water. The water columns should be placed so that engines stand fairly over the ashpit whilst taking water.

18. *Staff quarters for the European and native staff.*—Before the construction of a railway, and whilst survey operations were in progress, it has been customary to build cheap bungalows for the European staff to live in during construction. This expense should be avoided unless the quarters built will be of some use after the construction of the railway is completed, and can be utilised for the accommodation of the permanent staff required for the maintenance and working of the line. Where this is not the case, the staff occupied in construction should be placed under canvas. All construction work should be commenced in October, so that by the succeeding rains which break in June all earthwork, minor culverts and bridges, station buildings and staff quarters required

for the permanent staff are nearly completed. This being the case the staff occupied in construction can occupy some of the permanent quarters.

The staff quarters necessary for the European staff should be built in a substantial manner of rubble stone if available, otherwise of first-class bricks. Old rails should be utilised for the roof supports, and good tiles should be manufactured in time to be ready for the roofs. Concrete with a covering of Portland cement make the best floors.

The accommodation for the native employés should be built in the cheapest possible manner, bearing in mind, that their own homes generally consist of a mud hut with a mud floor, and a leaky thatched roof. At the same time good healthy accommodation must be supplied for the native staff, much illness amongst the native staff will cause great inconvenience in the maintenance and working of an open line, and perhaps make a larger staff necessary than would otherwise be the case. Their peculiarities and prejudices must be considered, and the accommodation built must be made suitable to native requirements. For the native clerks somewhat better accommodation should be given than for native menials, and for both more spacious quarters should be given for the married than for the single men. Fig. 3 gives a plan of a building suitable for the better class of natives, such as stationmasters and telegraph clerks, and fig. 4 a plan of quarters suitable for menials, such as station porters, pointsmen, and others; the

clerks quarters shewn will be sufficient for three men

SCALE 24 FEET = 1 INCH.

FIG. 3.

CLERKS QUARTERS,

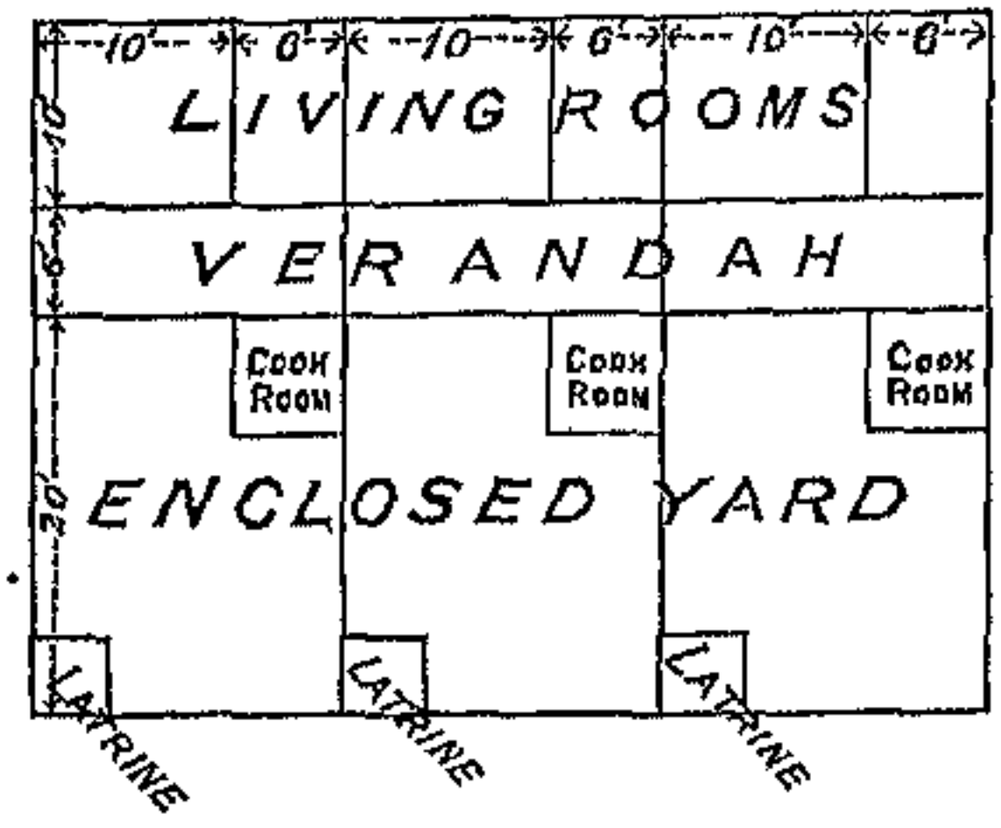
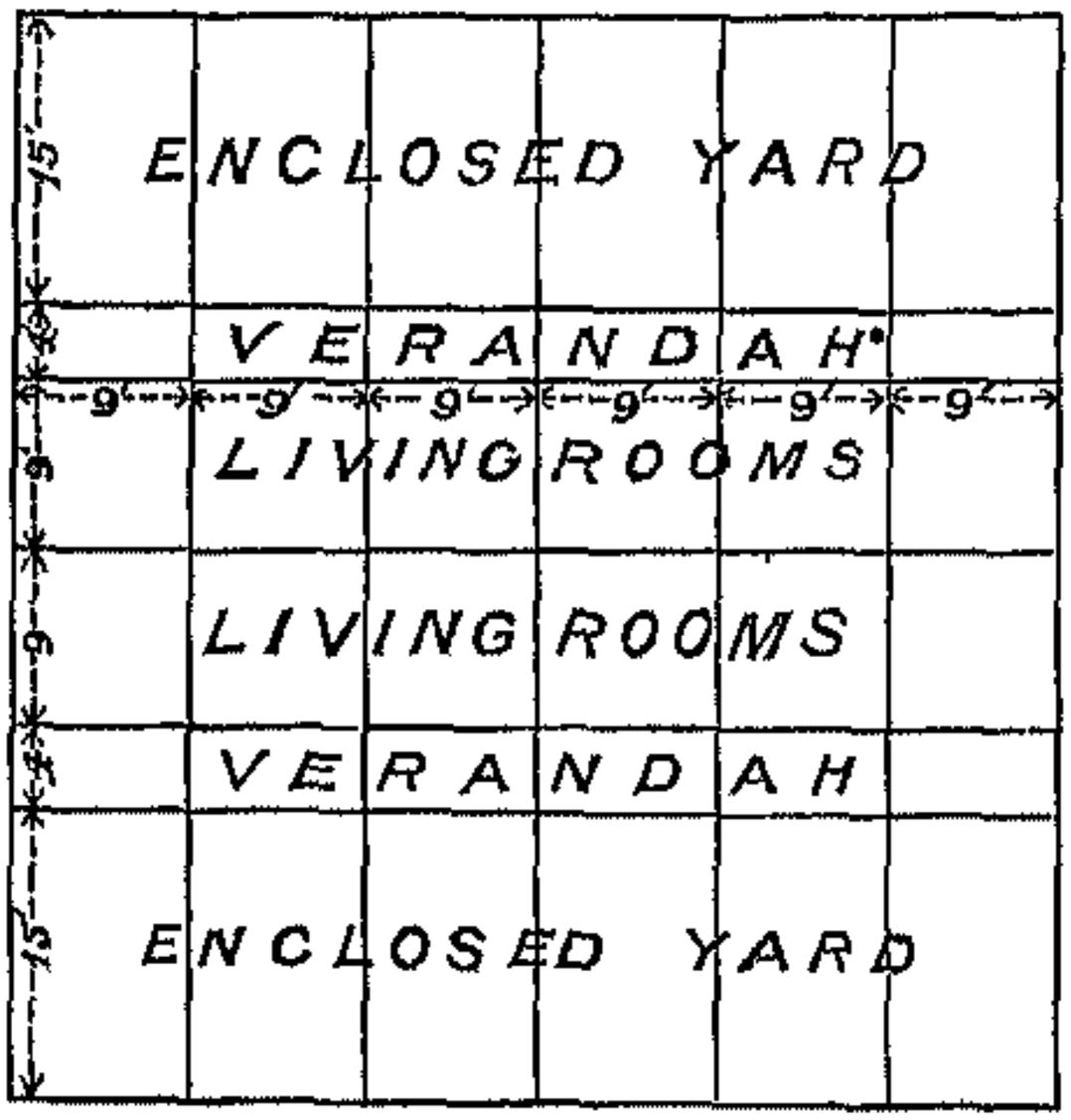


FIG. 4.

MENIALS QUARTERS,



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and their families, and the menials' quarters for twelve men (single) or six men married, the married men being allowed two rooms, and the single one room.

Care should be taken to put the floors well above the level of ground so as to keep them dry, the walls may be 2nd class bricks laid in mud and lime plastered or pointed, windows with plain wooden shutters should be given to the clerks' quarters, and for the menials no windows are necessary, as if given they are generally blocked up by the occupants. Good ventilators should be fixed on the roof, and the enclosure walls built of such height as to insure privacy For both quarters common country doors strongly made with padlocks are necessary, good roofs must be given as an inferior roof is a constant source of trouble and expense in the rainy season ; mud floors for the menials quarters will be best, and for the clerks' quarters concrete floors with a layer of Portland cement. Having constructed well-arranged quarters for the native staff, they should be inspected periodically by officers of the company, and the quarters not occupied kept locked. Unless this is done, there will be constant sickness amongst the staff, as the native has little knowledge of what conduces to his health. The filth instead of being carried to some distance will be deposited in heaps just outside his enclosure wall, cows and goats will be brought inside his quarters at night, and the dung and sweepings allowed to accumulate for days in

heaps inside his quarters, and then finally converted into fuel for cooking purposes. It is, therefore, important that some officer with full powers should be constantly on the alert, to prevent the native occupants keeping their quarters in an unhealthy condition.

14. *Turntables, weighbridges, traversors, and other station machinery; also signals.*—For 5½ft. gauge railways, a 50ft. turntable for engines should be fixed at each changing station, carriage turntables will only be necessary at the termini of a line unless some special reason exists, weighbridges for weighing the contents of goods wagons will be necessary at most large stations, traversors for quickly moving a vehicle from one line to another are sometimes useful and economical Two or three-throw hand-pumps are the best for lifting the water from a well or ground tank at small stations where engines require to be supplied, and forcing it into the overhead tank. Water columns and the necessary piping must be fixed according to requirements. The points at all large stations should be grouped and worked from several convenient sites where moveable pointsmen's huts should be fixed. The grouping of the points which enables one pointsman to work many different sets of points is a very economical arrangement, and should be introduced on new lines wherever possible. Intricate interlocking arrangements such as exist on English lines need not be considered on newly constructed lines for many years to come, or until

the traffic is such as to make them necessary. For single lines working a main signal and two distant signals will be all that is necessary at most stations. These signals should be constructed entirely of iron except the arms, and cost from Rs. 200 to Rs. 300 each according to the length necessary so as to be clearly visible. The three signals should be worked from one position, close to the stationmaster's office.

15. *Level crossings—their necessity and economical construction.*—Overhead road bridges will, as a rule, not be found necessary on railways in India, level crossings take their place, and are generally found necessary on the average of one to a mile of railway. Strong 8ft. iron gates or chains, will be generally found sufficient protection against carts and cattle. The cost of the gatekeeper's hut should not be allowed to exceed Rs. 250, and gates and approaches Rs. 150.

In some cases where there is sufficient headway, it will be best to construct a 8ft. opening in the railway bank, and thus avoid the necessity for a level crossing, and the expense of a gatekeeper costing Rs. 60 per annum.

CHAPTER X.

MAINTENANCE AND WORKING.

1. *The working expenses and how to keep them down.*—The next in importance to economical construction of a railway, is the economical maintenance and working of the same. Table V. gives the working expenses per cent. on the gross receipts of some of the Indian railways worked by private companies, and Table X. gives the probable working expenses per train mile in detail for each class of expenditure for a 5ft. 6in. gauge line with easy grades, such as is usual in India, and is likely to be constructed in the early future.

The lowest possible traffic has been assumed in the above table as two mixed trains daily each way, or 28 miles per week for each mile of railway. The lead of coal has been taken at 750 miles, and the cost of carriage at four pies per ton per mile; this being the rate at which Bengal coal can be carried. This works out Rs. 18.10 per ton of coal. Table XI. gives the prices paid by some of the railways at the present time in India per train mile for coal.

The cost assumed is, therefore, much higher per train mile, than paid by railways at the present time in India. It is necessary, however, that this should be so, as future lines will probably have to carry their coal further than existing lines. The other details of expenditure in Table X., are higher than those of the

best lines in India. Refering again to Table V. it will be found that the average working expenses of the 10 lines of railways, comes to 49·37 of the gross receipts, and this is the result, although on seven of the railways enumerated in Table V. the Government of India guarantee interest of 3½ to 5 per cent. per annum under all circumstances on the capital outlay. It is reasonable to suppose that railways constructed entirely by private enterprise, and depending entirely upon the way they are worked as to the financial results to the shareholders, will be worked more economically, and show a lower rate of working expenses as compared to gross receipts.

On the only three important railways constructed in India to date, upon which the management have to rely entirely on their own recourses as to financial results, viz., the Bengal and North-Western, Delhi-Umballa and Kalka, and Tarkessur lines, the average working expenses equal 45·18 per cent. of the gross receipts. In Table X. the working expenses amount to 47·84 of the gross receipts. The older lines, East Indian, Great Indian Peninsula, Bombay, Baroda and C.I., and Madras, are worked on the average of 44·98 per cent. of their gross receipts. From whatever point of view this important question is therefore considered, it seems safe to assume 50 per cent. of the gross receipts as a figure on which to base the cost of working future lines in India with economical management, and without any special difficulty in their working.

The item of expenditure entered in Table X. under "general charges," includes chief administrators, auditors, medical, police and telegraph establishments, and offices, as well as directors' fees, and English office. "Miscellaneous" includes rates and taxes, law charges, compensation, and similar charges.

Where an office and Board in England is necessary, these charges should not be allowed to exceed one halfpenny per train mile.

In some cases in India existing railways are worked by a neighbouring railway at a fixed charge on the gross receipts. Where this is possible it is an excellent arrangement, as it enables the shareholders of the new line to calculate exactly what their probable dividends will be, and there is then no risk to them of their working expenses being too high, and their dividends too low. The actual construction expenditure being known, and the gross receipts, a shareholder can at once determine what dividend he will receive. He has no risk of fluctuating dividends, but his dividends will come to him almost as certain as his interest on consols. There is also this further advantage, that the newly constructed railway will have no provision to make for rolling stock and workshops.

The shareholders can look upon their property as a railway with many of the usual risks eliminated, and there can be no doubt that such an arrangement much facilitates the raising of the necessary capital.

Where, however, a newly constructed railway has

been completed, and such an arrangement is not feasible, the company must keep its own staff in India to work and maintain the railway. In this case every every effort should be made by the staff to keep the working expenses strictly in accordance with the train mileage. If the staff generally were paid small salaries, and the remaindor of their remuneration made to depend upon the working expenses per train mile, all concerned in the expenditure would have every possible inducement to work in the most economical manner.

A certain fixed scale for working expenses per train mile might be fixed for each department of the service, and any saving on this scale distributed half-yearly to the staff concerned in the saving. This would be working the railway on true co-operative principles, and make all who have any hand in the expenditure anxious to keep the working cost as low as possible.

A provident fund for the higher paid European and native employés should also be established on somowhat similar lines, payment by the company to the fund depending in a great measure on the results of the working. A fixed percentage of the net half-yearly earnings after paying say 3½ per cent. per annum to the shareholders, should be paid into this fund, and the amount placed to the credit of each employé, in proportion to the sum standing in their respective names. Each employé, on entering the service, who is likely to be in any way responsible for

the working expenses of the line should be compelled to join the fund, and pay a percentage of his salary monthly into this fund. Permission to withdraw money from the fund would only be accorded to those leaving the service, or in case of death the amount at the credit of the employé would be paid to his heirs.

The fund would therefore in time become a provision for old age on retirement, and would also effectively assist in the economical working of the railway, as the amount paid into the fund half-yearly by the company would depend upon the net earnings of the undertaking.

2. *The general administration of a railway after opening for public traffic.*—The capital for the construction of a railway in India will usually be raised in England. A board of directors to represent the shareholders, with an office in London, will therefore generally be required. The general management of the railway in India must, however, be in the hands of an officer resident in that country.

Too great care cannot be taken by the board in England in selecting an officer for this appointment. The officer appointed will, as a rule, have to act entirely on his own responsibility. Owing to the distance only matters of great importance, on which an immediate decision is not required, can be referred to the board in England. All matters of detail, as well as important matters that require immediate decision must be settled by the officer representing the company in India.

The officer appointed should have considerable experience in the working of Indian railways, he must be a man of acknowledged ability and of the highest intogrity. The board having decided upon the officer to represent them in India, should entrust to him full powers in all ways. He should not be hampered by instructions, which might prevent him acting in the best way for the interests of the company he is representing. His principle instructions from the board should be to work the line in such a manner as to insure the necessary funds being forthcoming half-yearly to pay to the shareholders the dividends they have been led to expect, and to do all he can to quickly develope the traffic.

The chief representative of the company in India should be allowed to select his own heads of departments, subject to the board's approval, and he should generally in India have full powers of appointment and dismissal. He should regulate the powers of his own establishment in accordance with the train mileage, and compel his heads of departments to do the same. No new works, improvements, or additions, should be undertaken by the engineering department without his concurrence, and this permission should be withheld, except in a case of emergency, until special funds for this purpose have been allotted.

All stores required by heads of departments should be procured in India if possible. Only a very small quantity of permanent way material should be kept in stock, as the renewals will be very light for the first few years.

The chief representative must see that proper checks are adopted to insure no tampering with the proper fares, or the money actually realised. He will have to watch carefully the gross receipts being earned, and the weekly expenses, and see that they are such as will allow at the proper time the necessary funds being available for remitting to England to pay the interest on the capital. And when such is not the case immediate steps should be taken to endeavour to reduce the working expenses. He should do all he can to assist the construction of feeder roads to stations, so that every facility for bringing the traffic to the station is afforded. He should have his head-quarters at the principal town through which the railway passes, and be prepared to take up instantly any complaints from merchants and others regarding detention of waggons, or difficulties put in their way regarding the forwarding or the receipt of goods. He must forward to the board in England weekly returns of the traffic, and also approximate returns of the weekly expenses, and keep the board generally informed of all matters of importance. He should give the board early notice of any exceptional expenditure that may seem probable for rolling stock, etc., so that they can give the matter their consideration, and decide the best way of raising the necessary funds.

The heads of departments should, if possible, reside in the same town as the chief representative of the company, so that consultations can take place at any time between the chief officials of the company, and

all possible be done, through frequent inter-change of opinions, to advance the interests of the undertaking.

8. *The requirements to meet probable traffic.*—The traffic requirements of a future 5ft. 6in. gauge railway in India, will be generally met for the first few years by running two mixed trains each way daily. Any extra goods trains necessary, should be met by running special trains as required. All trains should be made up to the full load, and if the grades are easy 800 ton goods trains can sometimes be run economically. With four mixed trains daily, two in each direction, the gross earnings require to be on the average Rs. 4·28 per train mile, so as to earn Rs. 120 per mile per week.

The usual rate for third class passengers, which is the only class of passengers that need enter into the calculation, as there are very few passengers of other classes, is usually two and a-half pies per mile, or about one-fifth of a penny. One hundred and fifty-three passengers in each train will therefore yield Rs. 2 per train mile, and if Rs. 2·28 per train mile is earned by the goods carried, the earnings will suffice to yield the money required to pay $3\frac{1}{2}$ per cent. per annum on the capital expenditure, provided the working expenses, Indian and English, do not exceed 50 per cent. of the gross receipts, or 34·24 annas per train mile, and the total capital expenditure on the railway has not exceeded Rs. 89,142 per mile of railway.

These train mile rates are mentioned to show what little traffic is necessary over a railway to earn the

shareholders a fair return on their investment, provided the railway is economically constructed and worked. The *average earnings per train mile on* some of the best lines in India, are for goods over Rs. 5-8, for passengers over Rs. 3-8 and for all traffic over Rs. 5 per train mile.

The number of third class passengers in a train is also on the average over 200, and the weight of goods in a train over 200 tons; whereas in the foregoing, each mixed train has been assumed to contain only 153 passengers, yielding Rs. 2 per train mile, and Rs. 2·28 for goods, which represents 87 tons carried at the average rate of five pies per ton per mile. If each mixed train contained only 100 passengers and 114 tons of goods, the results would be the same as regards the gross earnings per train mile.

No allowance has also been made for earnings by any special goods train that would be certain to be necessary at the busy time of the year.

4. *Best description of rolling stock for economical working*—On most lines of railway in India there will always be a good and a loan half-year in traffic earnings. This is owing to the rainy season, which begins in June and finishes in October, when the almost continuous rain, and the bad feeder roads makes it difficult for much traffic of any kind to come to the railway. During the dry weather on the contrary, there is a great inducement to travel. Native marriages always take place in the spring; most of the native fairs are held during the dry weather. Then

again, the grain and other commodities are mostly brought in for transit by railway during the early part of the year. There are, consequently, some months when there is a large demand for rolling stock, and others where there is little comparative demand for it. This makes a larger outlay on rolling stock necessary than would be the case if the weekly returns of traffic were the same all the year round. This, consequently larger demands for rolling stock must, however, be met and arranged for. On the 5ft. 6in. gauge lines, covered goods waggons, to carry 12 to 14 tons, are those most in use in India, and these are the most serviceable waggons. They can be used for loading most descriptions of goods, and at times of fairs and pilgrim traffic, they are occasionly used for conveying the native passengers. In the author's opinion these waggons are, in some ways, more suitable for native third class passengers, than the ordinary third class vehicle divided into compartments with seats on the English pattern, as usually supplied by Indian railway companies. They are also often preferred by natives of India, as they can sit down on the floor in the manner they are accustomed to sit in their own houses, and not perched on uncomfortable and confined seats.

With a little alteration in design, this class of vehicle could be made to do as well for goods as native passengers. The dead weight hauled would then be very much less than is the case at present on the best Indian railways, as empty waggons could then often be

filled with native passengers, if goods were not available; or, if passengers were not forthcoming, they could be kept back for goods traffic. Hinged shelves, 4ft. wide, might be fixed inside these waggons, at the ends about 8½ft. above the floor, for the passengers to sit or lie on. This would make a two-storied carriage, and accommodate about 50 passengers. These shelves would be let down when the waggons were required for carrying goods.

Covered waggons are used much more in India than is the case on railways in England, as it prevents pilfering. All goods liable to theft on the road, and there are few descriptions of goods that are not thought worthy of attention in this respect by some class of native, require to be conveyed in covered and closed waggons, the doors of which are sealed to prevent, as far as possible, all tampering with their contents. A liberal supply of this or similar class of waggon should be supplied to meet the heaviest traffic. Some low sided open trucks, also timber trucks will be necessary as well as goods brake vans. Other description of goods waggons should not be supplied, until the necessity for them has been proved.

The coaching vehicles necessary for a newly constructed line, will be generally nearly all vehicles suitable for third class native passengers. A few composite first and second class carriages, also intermediate carriages will be required for the European and better class of native passengers. One of each of these to each train, will probably give more accommodation of

the kind than is actually necessary. A very few horse boxes and post office vans may be necessary; these, with the requisite number of passenger brake vans, are all the coaching vehicles that will be usually found requisite.

It has been previously stated, that if one kind of vehicle could be designed suitable for both native third class passengers and goods traffic, the result would be very advantageous to the railway concerned, as much empty running of rolling stock would be then avoided.

On the best lines in India for every 1,000 tons of goods carried over 1,000 tons of dead weight, including empty waggons, has to be hauled, In the coaching traffic the proportion is still greater, owing to the class of accommodation it is thought necessary to give the third class native passengers, and the empty stock it is at times necessary to run. In coaching traffic for every 1,000 tons of passengers carried about 12,000 tons of rolling stock is carried.

It is, therefore, most important that all possible should be done to raise the paying load on newly constructed railways.

Table XII. shows what would probably be the result if the paying load in coaching traffic could be made one in six, or 6,000 tons of rolling stock made to carry 1,000 tons of passengers.

It is assumed in the above table, for the sake of easy comparison, that the train mileage for goods and passengers is equal. By reducing the dead weight in passenger stock one-half, the total working expenses

become Rs.28-11-4, plus Rs.18-2-4, equal to Rs.46-13-8, as compared to Rs.57-6-8, shown in Table X., and this would, in this case, increase the returns from 3½ to 4¼ per cent. per annum,

This saving in expenditure would also be sufficient to allow the third class passenger fares to be reduced to nearly two pies per mile without causing any loss to the railway.

The reductions in fares would, however, in a very short time be certain to increase the number of passengers, so reducing the dead weight hauled would be as advantageous to the undertaking as to the general public.

If, therefore, for future railways in India a waggon was designed that could be utilized both for passengers as well as goods, it would lead to very great economy in the working, and an effort should be made to solve this problem in a satisfactory manner.

It has been sometimes thought that a larger class of waggon for conveying goods could be introduced with advantage. The tare of the covered waggon at present in general use is six to seven tons, and the quantity of goods it is supposed to carry, 12 to 14 tons. In practice, however, it is found that the maximum average load is seldom more than nine tons.

This is partly owing to the actual carrying capacity of the waggon not being sufficient to take the full paying load allowed.

Except for a few descriptions of goods, such as minerals, wheat, etc., it is often not possible, even

with close packing, to load the waggon to the full weight allowed.

On the other hand it also often happens that the goods at a small station for completely loading a waggon are not available, and the waggon is dispatched with something less than its full load.

It must also be remembered that if a much larger and heavier waggon was introduced it would not be so easily hand-shunted, as a very small staff of men is usually kept at road-side stations, and the native's power of propulsion is very much less than that of an European.

On the 5ft. 6in. gauge railways the rigid wheel base should be less than in England, with a 4ft. 8½in. gauge, but even if it were possible to lengthen the present class of waggons, so as to get a better paying load, it is probable that a newly constructed line introducing such stock would find that railways with which it was connected could not receive this stock owing to the turntables and weighbridges not being of sufficient length.

The great discrepancy between paying loads and dead weight on Indian railways is not so much in consequence of the average load in the waggon being less than its full allowance, but is principally owing to the large quantity of empty running of all classes of stock, and any plan which could effectually reduce this is deserving of consideration.

The average rate charged for goods in India for transit by railway is about five pies per mile per ton,

as compared to two and a half pies, the charge for a passenger—taking the average weight of a passenger as one and a quarter cwt., or one-sixteenth of a ton, the rate for passengers seems at first sight excessive—it should in fact on the basis of actual weight of each, be for passengers five-sixteenth of a pie, if five pies is a paying rate for goods.

It must, however, not be forgotten that the dead weight hauled in the case of passengers in order to give them comfortable accommodation, is about ten times as much as for the same weight of goods. Allowing for this, the passenger should therefore pay $\frac{5}{16} \times \frac{10}{1} = 3.12$ pies per mile. With the present allowance of empty stock running, the rate charged for passenger traffic is not at all too high, and it does not seem possible to reduce this until some better system of working the traffic is introduced.

One class of locomotive only should be supplied for the mixed and goods trains. For a 5ft. 6in. gauge line six-wheeled coupled engines, wheels 5ft. to 5½ft. diameter, weighing about 18 tons on each axle, or averaging this weight, and of sufficient power to take a load of 600 tons up grades of 1 in 200 at 15 miles an hour, will be generally found the most useful engine for an ordinary line of railway for the first few years after the opening of a line for public traffic.

As the traffic developes passenger engines can be supplied as subsequently found necessary.

TABLE I.

A few of the Railways required in India.

No.	Railways required in India	Gauge.	Approx. Mileage	Particulars
1	Mogulserai to Daltongunge coal fields.	5′ 6″	145	A fair weather railway should be constructed and a permanent bridge over the Sone subsequently added, if found necessary. Government of India report 8½ millions tons of coal in upper seam. The same Company should also arrange to work the mines.
2	Jherriah coal field to Mogulserai. Branches to Gya and Daltongunge.	5′ 6″ Do.	227 70	Besides the coal traffic, this line would also shorten the route from Calcutta to the North-west Provinces by 60 miles.
3	Agra to Delhi on right bank of "Jumna."	5′ 6″	120	This line would shorten the distance between Agra and Delhi by 20 miles.
4	Mirzapore to Maiher (*via* Rewah).	5′ 6″	120	This line would shorten the distance by E. I. Railway and G. I. P. Railway between Calcutta and Bombay by about 60 miles, or if this and No. 2 line were constructed together, the distance would be shortened by 120 miles.
5	Asansol to Nulhattee (*via* Sooree).	5′ 6″	90	This line would shorten the distance between Asansol and Nulhattee by 37 miles, and bring Bengal coal to the Ganges.
6	Ghazeabad to Chundowsee.	5′ 6″	80	At present there is no direct railway, and passengers from Delhi and neighbourhood have to travel *via* Allyghur.
7	Hurdwar to Rajpore.	5′ 6″	35	This line is much wanted for taking passengers and goods to the foot of the hill for Mussoorie and Landour.
8	Kurrachee to Delhi.	5′ 6″	750	The present route Kurrachee to Delhi is 1160 miles.
9	Calcutta to Cuttack (*via* Midnapore).	5′ 6″	300	No railway connexion at present.

TABLE II.

Rates for Contract Work.

Earthwork	Rs.1-8 to Rs.4, according to lead per thousand c. ft.
Brickwork (best)	25 Rs. to 30 Rs. per hundred c. ft.
Masonry, rubble	15 Rs to 20 Rs. „ „
Do., superior..	30 Rs. to 40 Rs. „ „
Pointing, best	Rs. 1-4 to Rs. 1-12 per hundred square ft.
Brickwork (labour only) ..	Rs. 3-8 to Rs. 4-8 per hundred c. ft.
Kunker lime (unslaked) ..	15 Rs. to 18 Rs. „ „
Gooting lime..	„ „ „ „
Stone lime	30 Rs. to 35 Rs. per hundred maunds.
Soorkee	Rs.9 to Rs.10 per hundred c. ft.
Laying C. I. piping (labour only)	An. 1-6 to An.2 per l. ft.
Best timber in log	Rs. 1-8 to Rs.2 per c. ft.
Sawing timber	Rs.2 per hundred square ft.
Moulding bricks	Rs. 1-4 per thousand.
Nicking out boundaries (12in. wide and 6in. deep)	An.1 per hundred l. ft.
Carting by bullock	8 An. per mile per hundred c. ft.
Digging kunker	Rs. 1-4 to Rs. 1-8 per hundred c. ft. or maunds.
Kunker metal, new (labour only)	1 Rs. per hundred c. ft.
Do., picking up and ramming again old	An.8 per hundred square feet.
Supplying stone ballast at quarry to 2½in. in size ..	Rs.2-8 to Rs. 3-8 per hundred c. ft.
Pulling down masonry or brickwork	1 Rs. to 2 Rs. per hundred c. ft.
Pounding Soorkee (labour only)	4 Rs. per hundred c. ft.
Best timber woodwork ..	3 Rs. to 4 Rs. per c. foot.
Best panelled or glazed doors and windows	8 to 12 An. per square foot.
Fencing (mud bund) ..	300 Rs. per mile.
Concrete in mortar	10 Rs. to 12 Rs. per hundred c. ft.

TABLE III.

Approximate English Prices for Rolling Stock, Girders, Machinery, etc.

Description of Material.	Cost.
Rolling Stock.	£
3rd class carriages, in five compartments, for 50 passengers, 6 wheels, 4ft. 8½in. gauge, 30ft. long. Weight, 11 tons	350*
1st class carriages, 4ft. 8½in. gauge, 6 wheels, 30ft. long	450*
Composite carriages, 4ft. 8½in. gauge, 30 ft. long, 6 wheels	400*
2-4 wheel bogie truck carriages, 3rd class, 45ft. long, 4ft. 8½in. gauge	550*
Mètre gauge, 3rd class carriages, for 32 passengers, 20ft. long	200
Do., 1st class carriage, in three compartments, 20ft. long	275
Actuating apparatus for continuous brake	35
Low-sided trucks, 4ft. 8½in. gauge. Weight, 4¼ tons	65*
Covered waggons, 4ft. 8½in. gauge. Weight, 6¼ tons	95*
Goods brake vans, 4ft. 8½in. gauge. Weight, 11 tons	160*
Timber trucks, 4ft. 8½in. gauge. Weight, 5¼ tons	75*
Passenger or goods engine with tender, 18in. cylinder, 26in. stroke, 4ft. 8in. gauge. Weight, 60 tons	2500*
Tank engines, 4ft. 8½in. gauge. Weight, 40 tons	2150*
2ft. gauge locomotives, 5in. cylinders. Weight, 2¼ tons	400
Mètre gauge locomotives. Weight, 15 tons	1300
Axle boxes, per set of four, for waggons, 4ft. 8½in. gauge	4
Do. do., passenger carriages, 4ft. 8½in. gauge	7
Permanent Way Materials.	
Steel rails for heavy sections. Per ton	5
Fish plates. Per ton	7
Fish bolts. Per ton	15
Spikes. Per ton	13
Cast iron chairs, ordinary, above rate for pig. Per ton	2
Wooden keys, oak. Per thousand	8
Greave-pot sleeper, above rate for pig. Per ton	3
Denham Olphert plates, above rate for pig. Per ton	3 to 4
Switches, steel, per set complete, with levers and boxes	25
Crossings, C.I. chilled or steel. Each	13
Bridge Materials.	
Cast iron screw piles. Per ton	9 to 12
Solid wrought iron or steel piles. Per ton	13 to 17
Steel girders, in addition to cost of steel plates and bar. Per ton ..	6 to 8
Pipes.	
Spigot and faucet C. I. pipes, above rate for pig, without turning or boring. Per ton	4
Flange Do. Do.	6
Branch, tees, bends. Per ton	9
Machinery.	
Horizontal engines, 8 to 20 h.-p. Per H.-P.	13
Do. Do. 50 h.-p. Per H.-P.	10

* Add 20 per cent. for 6ft. 6in. gauge, and deduct 30 per cent. for mètre gauge.

Table III. (continued).

Approximate English Prices for Rolling Stock, Girders, Machinery, etc.

Description of Material.	Cost.
	£
8-horse portable engine	230
4-horse portable engine	170
6 Do. Do.	200
10 Do. Do.	270
12 Do. Do.	320
Turntables, 50ft. for locomotives	500
Do. for carriages. Per foot of diameter	9
Traversors for carriages	100
Water column, complete	35
Crane on truck for lifting 5 tons	400
Do. Do. 10 tons	600
Direct acting steam pumps to raise 10,000 gallons per hour 250 feet (without boiler)	120
Centrifugal pump, 6in. delivery, to lift 3,000 gallons per minute ..	120
Pulsometer, to raise 150 gallons per minute	50
6in. lathe, 6ft. bed plate, complete..	50
10in. lathe, 20ft. bed plate, complete	110
Drilling machine for holes up to 1½in.	60
Planing machine, 14ft. long and 5ft. wide	550
Do. 5ft. long and 2ft. wide	110
Slotting machine (small) or shaping machine	50
Punching and shearing machine, ½in. hole in ½in. plate	42
Steam hammers, single, ½cwt. hammer, including block	50
Do. Do. 10cwt. hammer	200
3 ton wharf crane	120
Steam winch for lifting 2 tons	80
Do. Do. 5 tons	130
Boring tools for testing ground to 30ft.	15
Do. Do. to 300ft.	100
Diamond rock drill, complete, with engine and boiler, including lining tubes for boring 200ft.	500
Pile drivers, with 15cwt. ram	55
Driving apparatus, with helmet, dress, and air pump	110
Do. for double equipment	150
Telegraph.	
Iron poles, 20ft. Each	1½
Wire galvanized No. 8, 100lbs. per 500 yds. Per 100lbs.	1
Telephone instrument, complete	10 to 15
Porcelain insulators with iron hoods. Each	2 shillings
Miscellaneous.	
Steam roller, 7½ft. roller by 5ft. diameter..	800
2in. canvas hose with connections. Per 100ft.	8
2in. leather Do. Do. Per 40ft.	8
Cast iron columns and similar castings in addition to cost of pig ..	10
Hydraulic rams to force 5,000 gallons per hour to a heighth ten times the fall	40
Steam injector for locomotives	12

TABLE IV.

Rates for Labour in India.

Description.	Rupees per Month.
Carpenters	7 to 20
Blacksmiths	8 to 12
Hammermen	4 to 6
Bellowmen	4 to 6
Fitters	14 to 30
Masons (stone)	15
Bricklayers	8 to 12
Men labourers (coolies)	4 to 8
Women labourers	3 to 4
Child labour	3 to 4
Rivetters	15 to 20
Platelayers	6 to 20
Iron turners	20 to 30
Timekeepers	10 to 15
Clerks	20 to 40
Stationmasters	30 to 40
Telegraph clerks	20 to 30
Porters	6 to 7
Pointsmen	6 to 8
Skilled supervisors (for works)	10 to 30
Peons (messengers)	5 to 7
Khalassers for pitching tents	5 to 6
Do., for lifting heavy weights and accustomed to tackle	6 to 8
Divers	12 to 30
Native drivers on railways	30 to 40
Native guards on railways	8 to 15
Accountants	80 to 150
Cashiers	50 to 100
Platelayer inspectors	30 to 40
Inspector of works (native)	50 to 100
Inspector of works (European)	100 to 400
Tailors and leather workers	7 to 10
Sweepers	4 to 6

TABLE V.

MILEAGE COSTS OF RAILWAYS IN INDIA, AND THEIR GAUGE AND WORKING EXPENSES.

Railway.	Gauge.	Mileage.	Capital Cost per mile.	Percentage of working expenses on gross receipts.	Remarks.
East Indian.	5′ 6″	1610	Rs. 222,401	28·73	
Great Indian Peninsula.	5′ 6″	1287	211,520	50·28	
B.B. & C India.	5′ 6″	461	201,713	42·92	
Madras.	5′ 6″	840	139,300	55·40	
Bengal Nagpore.	5′ 6″	831	108,573	50·55	
Indian Midland.	5′ 6″	734	123,601	61·63	
Tarkessur.	5′ 6″	22	77,938	46·42	Worked by the E.I. Railway.
Delhi-U.-Kalka.	5′ 6″	162	£6790	48·00	Do.
Bengal and North-Western.	Métre	756	Rs. 63,903	41·12	
Southern Mahratta.	Métre	1403	78,433	68·74	

TABLE VI.

GROSS EARNINGS OF RAILWAYS IN INDIA AND DIVIDENDS PAID.

Name of railway	Gross earnings per mile per week		Par value of share or stock.	London market price of share or stock.	Return to shareholders per cent. per annum on market price	Remarks.
	Old lines	New lines.				
	Rs.					
East Indian	580		100	137	3·77	Present contract liable to expire in 1900
Great Indian Peninsula	584		100	160	3·6	
Madras	221		100	147	3·40	
Bombay Baroda & C.I.	594		100	190	3·88	
Bengal Nagpore		141	100	117	3·41	Present contract expires in 1913.
Indian Midland		130	100	117	3·41	Present contract expires in 1910.
Tarkessur		254	100			Capital raised in India.
Delhi U. Kalka		140	100	95	2·71	
Bengal and N.W.		120	100	118	3·91	
Average.	494	157			3·52	

TABLE VII.

Estimate for 300 Miles of single line Railway, 5ft. 6in. gauge.

No.	Details of Quantities.	Description.	Amount.
			Rupees
1	300 miles at 300 Rupees per mile	Cost of survey (see chapter IV.)	90,000
2	300 miles at 7,180 Rupees per mile	Formation .. .. Average height of bank .. 8ft. Width .. 18ft. Slopes .. 2 to 1.	2,154,000
3	300 miles at 30,847 Rupees per mile.. .. The above includes per mile 352 double headed steel rails, 30ft. long of 70lbs. per yard. 1,760 Denham Olpherts plate sleepers, complete. The necessary fishplates and fishbolts.	Permanent Way ..	9,254,100
4	300 miles at 6,000 Rupees per mile .. .. (One lac of ballast per mile).	Stone ballast ..	1,800,000
5	4 Stations at 272,000 Rupees each .. .. The above includes—	1st class or changing stations.	1,088,000
		Rupees	
	European staff quarters	48,000	
	Native staff quarters..	7,000	
	Engine shed for six engines ..	20,000	
	Three miles sidings	90,000	
	Platforms	8,000	
	Station house and goods shed ..	21,000	
	Approach roads	4,000	
	20 sets points and crossings ..	10,000	
	Waiting shed and latrines	2,000	
	Turntable, traversor, and weigh-bridge	14,500	
	Ground tank and piping	8,000	
	Overhead tank	10,000	
	Steam pump and house	3,000	
	Ashpits and water columns.. ..	2,000	
	Native doctor's quarters	500	
	Signals and grouping points ..	3,000	
6	9 stations at 22,500 Rupees each .. .. The above includes—	2nd class station for passengers.	202,500
		Rupees	
	Station house	2,500	
	Staff quarters..	1,800	
	Platforms	2,400	
	Quarter mile siding	7,500	
	2 sets points	1,000	
	Waiting shed, well, and latrine ..	1,750	
	Signals..	1,000	
7	6 stations at 52,900 Rupees each .. .. The above includes in addition to above (item 6)—	2nd class stations for passengers, goods, and watering engines.	317,400
		Rupees	
	Ground tank and piping	7,000	
	Water columns and ashpits.. ..	2,000	
	Overhead tank	5,000	
	Hand pump, and pumpmen's quarters	1,100	
	Goods shed and wharf	6,800	
	Quarter-mile siding and two sets points	8,500	
8	18 flag stations at 500 Rupees each	See Chapter IX., Section 3.	9,000
	300 miles telegraph at 800 Rupees per mile..	Complete for single line working.	240,000
10	600 miles wire fence at 1,000 Rupees per mile	See Chapter IX., Section 5.	600,000
11	300 level crossings at 400 Rupees each ..	See Chapter IX., Section 15.	120,000
12	Head office building		10,000
13	Bridge plant and platelayer's tools		50,000
14	Locomotive workshops..		500,000
	ROLLING STOCK.		
15	This includes— 25 locomotives, 250 covered waggons, 100 low sided trucks, 20 timber trucks, 15 brake vans, 25 3rd class carriages, 5 composites, 5 intermediates, 3 horse boxes, 3 postal vans. 300 miles at 6,420 Rupees per mile	Rolling Stock (see Chapter X., Section 4.	1,926,000
16	General charges—2 years expenses during construction, at 323,000 Rupees per annum. The above includes—	All charges for supervision, Indian and English, also offices and stationery.	646,000
		Rupees	
	Engineer's salaries	216,000	
	Subordinate salaries	144,000	
	Offices	136,800	
	Travelling allowances	25,200	
	Passages	20,000	
	Administration { Indian	42,000	
	Administration { English	42,000	
	Stationery, etc.	20,000	
	Maintenance for one year after opening line for public traffic. This includes—	This extra expenditure is necessary, owing to the railway bank not having sufficiently consolidated. Especially will this be the case, if the allowance in item 3 and 16 have been expended.	
		Rupees	
	Engineers salaries	14,400	
	Extra P. W. inspectors	14,400	
	Extra labour maintaining road ..	36,000	64,800
18	Interest for 2 years on capital expenditure..	3½ p. ct. per annum on 300 × Rs. 8,9142 = Rs. 26,742,600.	1,871,982
		Total Rupees ..	20,943,782
	Balance available for bridges and	culverts. Rupees ..	5,798,818
	Assumed cost at 89,142 Rupees	per mile. Rupees ..	26,742,600

TABLE VIII.

Estimate for a complete survey for 300 miles of Railway in India (outdoor work).

Details.	Rate.	Amount.
		Rupees.
5 Engineers for six months	800 Rupees per month.	24,000
1 Superintending engineer	1,500 Rupees per month.	9,000
Tents and camp equipage	lump.	5,000
Pegs, etc., 300 miles	*50 Rupees per mile.*	15,000
Nicking out centre line and side width, 300 miles.	15 Rupees per mile.	4,500
Menials (36) for six months	7 Rupees per month.	1,512
Instruments	*lump.*	*6,000*
		Total Rs. 65,012

TABLE IX.

Estimate for a complete survey for 300 miles of Railway (office work).

Details	Rate	Amount.
		Rupees.
5 Engineers for 4 months	800 Rupees per month.	16,000
1 Superintending Engineer for four months.	1,500 Rupees per month.	6,000
12 Menials for four months	7 Rupees per month.	336
Office rent for four months	100 Rupees per month.	400
Office furniture	lump.	500
Passage out and home for Superintending Engineer.	lump.	2,000
		Total Rs. 25,236

TABLE X.

Working Expenses per Train Mile.

Weekly train mileage 28 train miles per mile of railway.

Class of Expenditure.	Coal per train mile.	Cost per week per mile.	Gross earnings per mile per week.	Net earnings per mile per week.	Percentage of working expenses on gross receipts
	Annas.	Rs. A. P.	Rs. A. P.	Rs. A. P.	
Ways and Works.	7·00	12 4 0			
Locomotive (excluding coal)	6 00	10 8 0			
Carr. and Waggon ..	2·50	4 6 0			
General Charges ..	3·50	6 2 0			
Traffic	5·50	9 10 0			
Miscellaneous	1·00	1 12 0			
Coal (55 lbs per train mile)	7·31	12 12 8			
Total.	32·81	57 6 8	120 0 0	62 9 4	47.84

Rupees 120 | Rs.62-9-4 | 47.84

TABLE XI.

Cost per train mile for fuel.

Name of Railway.	Cost per Train Mile.	Average Lead from Source of Supply.
	Annas.	Miles.
East Indian	·76	226.75
Bengal Nagpore	1·46	11 to 283
Indian Midland	4·60	149 to 485
Great Indian Peninsula	3·86	
Bombay, Baroda and C. I.	3·87	241
Madras	4·28	
North Western	4·94	
Oudh and Rohilkund	2·66	561
Bengal and North Western ..	1·57	151

TABLE XII.

Working cost per train mile by reducing dead load hauled.

Class of Expenditure.	Cost per mile as given in Table X.	Cost per week per mile for goods traffic.	Cost per week per mile for passenger traffic	Cost for running half the present weight of passenger rolling stock per week per mile.
	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Way and works	12 4 0	6 2 0	6 2 0	4 1 4
Locomotive (excluding coal)	10 8 0	5 4 0	5 4 0	2 10 0
Carriage and waggon ..	4 6 0	2 3 0	2 3 0	1 1 6
General charges	6 2 0	3 1 0	3 1 0	3 1 0
Traffic	9 10 0	4 13 0	4 13 0	3 3 4
Miscellaneous	1 12 0	0 14 0	0 14 0	0 14 0
Coal (55 lbs. per train mile)	12 12 8	6 6 4	6 6 4	3 3 2
Total	57 6 8	28 11 4	28 11 4	18 2 4

NOTE.—In this Table the cost of running half the number of passenger trains has been taken in the case of Way and Work, and Traffic at $\frac{8}{9}$ of the cost of running the full number, and for General charges and Miscellaneous the cost has been taken at the same as if the full number were running.