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Review Paper

Adaptations in Technology: Building the Rail line of the BB and CI Railway 1852-1869

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Abstract

There were technological transfers into India through developmental projects during the colonial period. Railway was one such important technological breakthrough which was introduced into India by the industrialized British. This paper exemplifies the adaptation of western technology and practices to Indian conditions. Since the circumstances in India, both ecological and social, were dissimilar to Britain, alternative technologies developed through a series of experiments. The eventual perfection of techniques after an elaborate process of trials and errors is explained in this paper with actual examples from the Bombay Baroda and Central India Railway Company that was built between Bombay and Ahmedabad from 1852-1869. The construction of Rail line consisted of a complex process involving many operations like the preparation of the rail bed, the placing of the plates through various gradients and curves, the laying of sleepers and ballast. In all these operations there were technological transfers, which were modified in accordance to Indian situations. Certain such examples have been highlighted in this paper.

Keywords: Railways, Bombay, Baroda, Central India Railway Company, technological transfers, adaptations.

Introduction

"Railways like every improvement in art and science had been completely established by experiment after a series of trials and errors[1]."

A railway was an important technological innovation in the nineteenth century. It was introduced into India by the industrialized West during the colonial era. They were built by private Railway Companies who were guaranteed five percent interest by the Government of India. While laying the railway line, they developed alternative technologies in India which differed from those in Europe due to dissimilar conditions[2].

The major difference between India and Britain was in natural features, which made it necessary to use special methods to handle the situations. Pointing out the differences in topography Lt.Colonel C.W.Grant, in his work "*Bombay Cotton and Indian Railways*", observed: "India was a country of extremes with vast plains, high and precipitous mountain ranges, broad rivers, down which at certain seasons of the year vast volume of water flowed with great rapidity. In England the railway passed over the undulating country facing frequent small obstacles almost at every yard. However in India the railway would pass through a plain requiring not more than the mere superficial construction of the permanent way involving an insignificant expenditure. But then it would have to ascend a range of hills or cross a vast river, which would consume a vast capital[3]."

There were other difficulties which the Court of Directors of EIC anticipated as early as 1845, due to India's peculiar climate and circumstances[4]. Lord Dalhousie, the Governor General was however confident that the British engineers of the Railway Companies could overcome them through their skill and experience[5]. They eventually learnt the technique, but only after several trials.

Bombay Baroda Central India Railway Company (hence forth referred to as BBandCIRC) was one such Company that constructed a railway between Bombay and Ahmedabad from 1852 to 1869. The European engineers primarily planned and built the railway in India, through the techniques they learnt in Europe. However, they could adopt the western methods in India only with variations. As J.B. Hayes, the Traffic Manager of the BBandCIRC rightly stated, "Considerable modifications and alterations of English practice are necessary and while taking the results of the practical experience of Railways in England as a pattern it will be well to remember that the peculiar difficulties and variations in circumstances of this country (India) are the main questions for consideration[6]." This paper, which is completely based on primary sources, culled from the Maharashtra State Archives exemplifies the adaptation of the western technology and practices to the Indian conditions in laying the rail line by the BB and CIRC. It highlights the nature of technological transfer and its effect on Indian situations.

Laying the Rail line

There are various processes involved in the laying of the rail line. The operations include preparation of the rail bed, placing of the plates through various gradients and curves and laying of sleepers and ballast. The technological transfers and adaptations that took place in these stages in the BB and CIR line are highlighted in this paper.

Railbed and Earthworks: Earthwork was the first operation in the process of building railways. Uneven terrain was level led by excavations and embankments before laying the tracks[7]. There were two methods to remove spoils of the cuttings while carrying out the earthworks, namely, the barrow or the earth wagon method and the pick and basket method[8]. While in India the latter was popular, in Britain the former was usually practiced.

The Chief Engineer of BB and CIR, A.W. Forde intended to use earthwork wagons. However this raised a controversy between the government officials and the railway engineers, who had varied viewpoints. J.H.G. Crawford, the Government Consulting Engineer disapproved of the plan as the basket method was proved to be more economical in India than in Britain due to availability of cheap labour. The basket method also enabled the entire family to be employed, facilitating the availability and retention of labour[9]. Due to Crawford's insistence, the Bombay Government (henceforth referred to as BG) initially refused to sanction earth wagons for earthworks[10]. Forde however, in his efforts in convincing the government, reiterated that from a scientific point of view, the basket method involved immense loss of power. For instance to remove one cubic yard of earth, a distance of 100 yards, a man had to walk seven miles. He therefore insisted that it was desirable to introduce a system which facilitated speed and economy. He expected initial resistance from the workers due to its novelty, but was confident that in the long run one could reap the benefits. In fact he estimated a saving of half penny per cubic yard in the work between Surat and Ahmedabad by the use of wagons[11]. The Court of Directors of the East India Company (EIC), although not convinced with the arguments put forth by Forde, reluctantly gave its approval to the use of wagons as they believed that new methods must be experimented if they produced economy in time and labour[12].

When the earthworks on the line actually commenced, the Engineers of the B Band CIRC were given a choice of adopting either the basket or the wagons in their respective areas of work, called as districts[13]. A.A.Jacob, successfully used wagons in his district (from Vadodara to Anand beyond the Mahi). Seeing his success, J.Burns, another Engineer too adopted the system, after experimenting in the beginning with the Indian mode[14]. It was observed by Forde that in the districts between 8 to 12, where wagons were principally used, the works were done much cheaper and faster[15]. However most of the engineers discarded the use of barrows and wagons, to save them from the expense and trouble of superintendence over the labour[16]. Therefore, although the earth wagons were economical, they were generally socially unacceptable in India.

Permanent Way and Plate laying: Forde proposed to build the permanent way by a system known as "Adams Suspended Girder Rail" requiring less wooden sleepers and ballast, which were not easily available in India. In addition, it being made in a continuous line, it was expected to be free from expansion and contraction, removing all risk of bad joints and maintaining a plane road. It also economized on steam power and removed concussion[17].

The Court of Directors of the EIC however had doubts about its practical advantages as it had not been tried, tested and recognized in Britain. Therefore, to be on the safer side, they insisted that the usual permanent way should be provided[18]. Captain Humpkins, the Government Acting Superintending Engineer however insisted on reconsideration of its prohibition due to high prices and scarcity of sleepers in India[19]. Its need was stressed more between Wasind and Ahmedabad as there was not a log of teak available there[20]. Under these circumstances, the Court of Directors reluctantly gave permission to have the Adams rail to be experimented on 20 miles of the BB and CI Railway[21].

However the Adam's rails proved to be unsuccessful as both Adam No. 1 and 2 railway were found to be inferior to the ordinary permanent rail in lateral stiffness, cost of laying and keeping in repair[22]. The following table makes a comparison of the cost of laying and maintaining the ordinary double headed rail and the Adam's rail revealing the limitations of the latter.

The Adam Patent's No.1 was also found to be more suitable in areas with damp climate with regular rainfall throughout the year than in India, where there was periodical rainfall[23]. Adam No.2 appeared to be stiffer and easier kept in repair than No.1. But the process of providing sleepers for it was difficult, expensive and tedious[24]. The Adam Rails were also found to be unsafe and more prone to accidents to the public than ordinary rails. The BG therefore prohibited its further use in India and also suggested that those which existed must be removed[25]. This was an example of a technology which did not suit the Indian conditions.

Table-1
Comparison of cost of ordinary and Adam's permanent way

Name of rail	Cost of laying	Maintenance Per mile Ballast-Sand	Maintenance Per mile Ballast-Gravel
Ordinary Permanent Way	Rs.660 per mile	8 men, 1 mukadam Rs.700 per year	6 men, 1 mukadam Rs.552 per year
Adam's No.1	Rs.1100 per mile	12 men, 2 mukadam Rs.1100 per year	10 men, 1 mukadam Rs.840 per year
Adam's No.2	Rs.880 per mile	10 men,1 mukadam Rs.840 per year	8 men, 1 mukadam Rs.--- per year

Keys for permanent way: The wooden keys used in the permanent ways of the railways in India were made of compressed wood instead of ordinary wood. The ordinary wood, although cheap was found to be ill adapted to stand the changes of heat and moisture to which the permanent way of railways of India was exposed[26].

Gauge: The gauge[27] adopted by the BB and CIRC was 5 feet and 6 inches, which was uniformly adopted all over India before 1869. The experience at Britain had warned against the use of different or mixed gauges. J.B. Lane, the Managing Agent of BB and CIRC found it to be suitable to every requirement. It enabled powerful locomotives as well as commodious wagons, capable of running safely at high speed with a dead weight of ten or more tons[28]. Similarly F.Mathew, the Chief Resident Engineer of BB and CIRC appreciated the width of the gauge as it provided safe and economical journey for both passengers and goods[29].

Ballast: Ballast is spread on the bed of the railway line for the smooth running of the trains. A variety of ballast was used on the BB and CIR line. It was formed in accordance to the availability of the material in the localities. Between Amroli (Utran), on the north bank of Tapi, and the Kim River, a distance of about 12 miles the ballast material was brought mostly from the bed of the Tapi river. It consisted of coarse sand, substantially free from any admixture of earth and heavy enough to resist the action of winds. It was laid at a depth of two feet under the sleepers by gradually lifting the rails. This was considered to be one of the best materials used for ballasting[30]. The ballast between Amroli (Utran) and Ankleshwar composed of sand was obtained principally from the Tapi and Amra Rivers[31]. The line between Sachin and Jullalpur was ballasted with sand, gravel as well as a great deal of broken bricks and refuse of kilns[32]. In the section between Bharuch and Meagaum, the operation of the ballasting on that portion of the railway was the most difficult and tedious as there was no sand fit for ballast in the nearby areas, except on the south bank of the Narmada opposite Bharuch and on the north bank near the island of Sokulterat. Therefore boats were used for the carrying the ballast material across the river. A special railway, 7 miles in length was also made to connect it to the line[33]. Between Bharuch and Vadodara, no ballast was available all along the line. Therefore all the ballast was brought either from Dhadur or Narmada Rivers. For transporting the ballast, wagons with engines were used[34]. The ballast on the portion between Surat and Valsad was very good. An excellent quarry at Doongry furnished a large quantity of loose debris which when mixed with conchea and sand bonded well[35]. The ballast used between Grant Road and Valsad was either stone or sand. The stones laid down were large blocks which formed a smooth running of the road[36]. Thus ballasting illustrates the adaptation of the railway in India to the local conditions.

Understanding the importance of babool: The BB and CIR line being parallel to the coastline ran perpendicular to the outlet of the water of the region through which it passed. This made it more prone to floods, causing enormous loss to the company due to the damage it caused to the railway. For instance, the floods of 1858 wore away parts of the earthwork along the line. However, it was observed that the damage was not uniform throughout. It was realised that the parts of the embankment where there were babool trees were uninjured. Forde consequently concluded that babool provided protection to the embankments during inundations. He hence proposed to plant babool on the land adjoining the railway line to protect it from damages due to floods[37]. This was an instance of inference drawn through observation.

Inclines: J.P. Kennedy, the Consulting Engineer of the BB and CIRC insisted on the gradients of the line being 1 in 500[38]. This he believed would reduce the working cost of trains and thereby increase the profits of the company. This was also expected to reduce the fares, which was necessary to be kept low as the railway, being parallel to the sea had to compete with waterways[39].

In spite of a ruling gradient of 1 in 500, the expected low cost of haulage and the low charges on the BBandCIR was not realized. The cost of consumption of coal by the BBandCIR was greater than the other two railways of the Bombay Presidency while the charges per ton per mile for goods was not as low as the rates on the Sind Railway. The average charge for carriage of public goods per ton per mile in half-year ending 30th June 1868 for the Great Indian Peninsula Railway, BBCIR and Sind Railway was 19.9pies, 17.73 pies and 16.69 respectively. The paying load and the consumption of coal , on the three railways of the Bombay Presidency in the half year ending 30th June 1868, were as follows[40]:

Table-2
Consumption of coal by Railways of Bombay Presidency

Railways of the Bombay Presidency	Coal per train mile	
	Consumption	Cost
	Pounds	A. P
Great Indian Peninsula Railway	43.84	11 8
Bombay Baroda and Central India Railway	54.67	13 11 ¼
Sind Railway	45.2	10 0

This shows that the principle propounded by Kennedy that low gradients led to economy in the running of the Railway was groundless. Therefore gradient alone was not a factor affecting the cost of working the railways.

Sleepers: A process of experimental trial and error went on to determine the best sleepers suited to Indian conditions. Engineers had to grapple with problems of selection and treatment of wood sleepers, given India's climatic conditions and the ubiquitous white ants(termites)[41]. It was initially decided by the BB and CIRC that timber sleepers should be procured in India than in Britain to avoid the increase in the cost of the article due to its freight charges[42]. An assessment of the forests near Gujarat was made by the Conservator of forests, Ulm Elwin to establish the kind of wood suitable as sleepers[43]. Initially the Indian Contractors supplied some wooden sleepers[44]. But later it was difficult to obtain suitable and reliable number of sleepers from India. For instance, J.B.Lane, the Managing Director of the BBandCIRC inviting contractors for the supply of sleepers, advertised six times each in two English and two indigenous language papers. He put up 500 placards at Bombay, Ahmedabad and at different points along the BBandCI line. However the response was lukewarm. He received only one tender in proper form, with however very high prices quoted. In the other tenders the quantity or date of supply was unspecified. Consequently Lane decided to obtain sleepers for the line between Vadodara and Ahmedabad, from Britain[45].

Forde however, preferred the creosoted[46] English sleepers to the Indians as they were more easily placed in position and the chairs could be fixed over them with much less trouble and expense. Moreover the cost of both almost came up to be the same[47]. So, the rail line experimented with both Indian as well as British wooden sleepers.

Most of the Indian woods proved nondurable except teak and red eyne. Within three years babool wood decayed while beowood lasted less than a year. The Jahore sleepers were also found to be unsuitable as they had a tendency to split. In 1869, therefore 50 per cent of the sleepers had to be renewed at a large expense. Even a large number of creosoted English sleepers decayed. It was therefore realized through experience, that in India, any wooden sleepers whether imported or indigenous, whether seasoned or chemically prepared, became unserviceable after few years[48]. The inexperience of the engineers to the Indian conditions further accelerated the problems as they passed and admitted many such woods which were not always beowood but of duplicate and inferior quality[49].

Due to these circumstances, together with the difficulty and expense of obtaining wood in India, it was recommended by the Consulting Engineers of some of the railway companies to use iron sleepers, converted in the shape of an inverted cup, and called "Greaves Pot Sleeper"[50] The Directors of the BBandCIRC too supplied iron sleepers instead of wood as a trial. Since they were already successfully implemented on the GIP and Madras lines, they could be confidently adopted. Hence, 12,496 iron pots were laid in light sand on the northern division of the line. They were fitted with oak cushions to make a smooth and durable road. But they were found to be hard at places where there was stone ballast used. Therefore in the centre and southern divisions of the line, timber sleepers continued to be used.

Conclusion

The designing and technical aspects of the railways in India were done by the skilled European engineers with the realization that their experiences gained in Europe were insufficient in Indian conditions and had to thoroughly acclimatize their technology to Indian situations. The soil, climate, labour, social conditions, the flora and fauna were disparate. Experiments and practical experiences alone taught them more than theory. The period under review was a phase of trial and error, and the engineers had to break new ground and evolve novel devices. Although there were numerous disappointments due to failure of certain experiments, this period ought to be credited for many innovations, which formed the basis of future railways. Experience taught that Adams' Suspended Girder Railway was unsuitable for Indian conditions. Importance of babool in protecting the embankments during deluge was recognized.

Nevertheless, there were many innovations that were yet required to be made. However, a new technology emerged in India with the building of the railways which was an amalgamation of the European and Indian methods. One would like to succinctly conclude in Ian Derbyshire's apt words:

"Elements of modern western engineering practices were blended with more traditional Indian applications British techniques were not always to be transmitted in an unmediated form.the circumstances of the Indian labour market were to induce some dilution of the 'technology mix' vis-à-vis European and American constructional norms".

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