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Technologies of transportation: road, bridge and boat construction in colonial Punjab

Mandakini Thakur[1]

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Abstract
The road and river transport have laid the foundations of human settlements since ancient times. After annexing Punjab in 1849, the British brought western technologies in road and river transportation for better movement of people and material for consolidation of their rule. The measures included building of roads, bridges and navigation through steam vessels. This paper gives a brief description of the technologies employed by the British in Colonial Punjab for construction of metalled roads, permanent and temporary bridges, native boats and introduction of steam vessels for river transportation. The technologies for road and bridge construction were western and modified as per local requirements. The best example of road construction was in the form of Grand Trunk road which traversed the region from Delhi to Peshawar. Permanent bridges were made using iron and masonry arched techniques. Steam vessels were brought to the rivers of Punjab after being constructed elsewhere. But owing to lack of depth in the rivers, the steam vessels did not succeed and were discontinued. Due to western technologies, the road and river transportation became quick and efficient and also generated employment, thereby impacting the local population.

Keywords Colonial Punjab · Road transportation · River transportation · Technologies · Construction

1 Introduction

When the British East Indian Company established its political base in India after the Battle of Plassey (1757), modern science and technology was already in a phase of rapid development in Europe due to the Industrial Revolution. Therefore, the proliferation of western science in India during the Company's rule was destined to play a key role. Political and commercial gains were the foremost factors for the British and science and technology was to be used to achieve the desired objectives in India. Technology transfers took place in many spheres including agriculture, industry, construction, medicine, transport, communication and other fields.

Historians have propounded many theories to explain the concept of technology transfer. Out of these, the three-tier model for the study of 'colonial scientific development' in 1967 by George Basalla (1967) and a three-stage model for discussing the advent and development of modern science in India by Kochhar (1991) are well known. However, Roy Macleod, Daniel Headrick and Deepak Kumar have tried to re-examine the concepts of colonial science and technology transfer. According to Roy MacLeod, colonial science was the practice and application of science in the colonies through institutions and other structures, while scientific colonialism defined the processes through which colonial policies were implemented (MacLeod, 1982). Daniel Headrick argued that the transfer of technology from one society to another and from one civilization to another was of an altogether higher order of complexity and no theory had yet emerged to encompass it all (Headrick, 1988, p. 9). Roy MacLeod and Deepak Kumar reasoned that British political control over agricultural and engineering projects and education ensured that the transfer of technological knowledge and its dissemination into the local knowledge systems was almost impossible (MacLeod & Kumar, 1995, p. 27).

The road and river transport are linked to the economy and social fabric and are the major means of movement of people and freight. Civilizations have developed and evolved with improvement in means of transportation. It is thus imperative that technological transfers made by the

✉ Mandakini Thakur
thakurmini84@gmail.com

[1] Punjab State Council for Science & Technology, Chandigarh, India

British in modes and means of transport be studied and discussed to understand the development patterns in colonial period.

The province of Punjab in Indian sub-continent derived its name from a Persian term, '*Punj-aab*', meaning five rivers or waters which referred to the country surrounded, watered and intersected by rivers (Census of India, Punjab, 1931, pp. 15–20, 49–50). The province was the entry point to major trade routes connecting the Indian subcontinent to Central/West Asia.Therefore, due importance was given by the rulers, especially Mughal rulers to build and maintain decent roads for travel, trade and commerce using medieval technologies.

The political and administrative annexation of Punjab province was made by the British on 29th March, 1849 (Grewal, 2009, p. 39). A Board of Administration was constituted to set machinery of government in motion, (Khilnani, 1951, pp. 44, 106–107). From the beginning, the British colonial government in Punjab gave priority to transportation system due to the political, commercial and military importance of the province. The administrative personnel were concentrated in the divisional headquarters and the capital city of the province while several city centers housed cantonments. This centralized administration and military authority gave a distinct character to the growth of towns and cities. Under colonial context, government departments were formed and the control of roads and buildings was given to the Provincial Government (Khilnani, 1951, pp. 44, 106–107). Western technologies were introduced to improve the road network and construction of bridges and for river navigation, steam vessel fleet named Indus Flotilla was introduced.

This article examines the road, bridge and boat construction technologies in colonial Punjab as well as introduction of steam vessels for river transportation. The impact of improved road and river transportation facilities on the Punjabi society is also discussed.

2 Road and bridge construction technologies in colonial Punjab

Before we discuss the road and bridge construction technologies employed by the British in colonial Punjab, it would be pertinent to briefly discuss the existing technologies during the Mughal period in pre-British Punjab.

The importance of road as channels of inland transportation was recognized in medieval India by Sher Shah Suri (1540–45 CE) who had a road (Sarak-e-Azam) constructed from Sunargaon in Bengal to Punjab which became the precursor of the modern Grand Trunk Road. The roads in Mughal period were not metalled but were well maintained (Kumar, 1984, p. 23). The technological advancements were made in road construction during Akbar's rule (1556–1605 CE) that built and maintained several important roads including the Khyber Pass which was an important road built for wheeled traffic. A section of the Khyber Pass was made by cutting through solid rock. The imperial road crossing the Sindh-Sagar doab in Punjab was paved with great masses of a hard bluestone embedded well into the road surface (Habib, 2008, p. 60). At Rawalpindi, on the Lahore-Attock road, where the road crossed through Margala Pass, it was cut through rock. This six or seven yard broad road was strongly paved with bluish and grey lime-stone for three-quarter of a mile. There was a strong revetment of masonry which defended each side of the road (Anjum, 2010, p. 110). Great care was also taken to maintain the pre-existing roads including the Badshahi road. Thomas Roe, a European traveller, noted that the Agra to Lahore part of the road had palm trees planted on both sides (Sarkar, 1925, pp. 32–33). In spite of the care taken to build strong roads, the road network which had existed in Punjab in medieval and modern period up to mid nineteenth century were relatively backward as the province was majorly driven by village economy. Many roads were inaccessible during monsoon season. Only the major roads were maintained. The condition of roads during the Sikh rule remained under developed and below average. In fact, most of the villages lacked connectivity by *pucca* roads. However, the main roads connecting big towns which had existed since the earlier period were stone paved (Kaur, 2002, p. 13, 28).

The Mughal engineers also built permanent, temporary and boat bridges with employing wood and masonry. The boat bridges or pontoon bridges were made by tying together several boats with hooks and iron chains in the river. The boats were covered with wooden boards which were firmly fixed by iron nails to enable riders and passengers to cross them. This technique was used in the construction of boat bridges of a permanent nature such as that at Delhi and Agra (Kumar, 1984, p. 225). Earth and straw mixed together was thrown upon the planking to make the footway of these bridges (Bernier, 1916, p. 380).

The masonry bridges consisted of four structural elements namely foundation, piers, arches and abutments involving the basic skill of arch construction. During the rule of Akbar, stone bridges were erected on arches (Habib, 2008, p. 103).[1] The first and most important component of the masonry bridge was the foundation, on which the piers were raised. These were constructed on a firm base such as rock, below the bed of the river to sustain the weight of the piers and arches. The piers sustained the vertical thrust of the arches and the pressure of the water, therefore, they were made very

[1] One of the best masonry bridges built in stone was 654 feet long bridge at Jaunpur (on Gomti river in UP) which was built in 1567–1568 on parity between pier width and the width of the arch span.

thick and not raised very high above the water level. They were built as individual units capable of sustaining the load of the superstructure. The arches were built using voussoirs. The shapes of arches were pointed like a horse-shoe, which did not demand much precision. A combination of timber and brick was used for constructing bridges which were joined by lime mortar (Kumar, 1984, pp. 248–64).

In Punjab, the most important river navigation system was the Indus river system, which included five important rivers namely Indus, Ravi, Jhelum, Sutlej and Chenab where generally flat bottomed and shallow-draught boats called *kiśtīs* were used in the seventeenth and early eighteenth centuries.

After annexing Punjab, the focus of the British was not only on repairing old roads and bridges, but also to construct new ones because a network of roads was necessary for the expansion and continuation of the British Raj. The British government started road construction in Punjab during the Regency Period of 1846–1848 (Thorbun, 1970; The Administrative Report of Punjab and its Dependencies, 1850–1851; Sarkar, 1926; Das Gupta, 2011).[2] Three types of metalled roads were made by the British in colonial Punjab (i) concrete (ii) macadamised (pioneered by Scottish Engineer, John Loudon McAdam around 1820) and (iii) asphalt or bitumen (Journal of Indian Roads Congress, 1944, p. 2). For all types of metalled roads, stones and sand were used as raw-materials. The macadamised roads had single-sized small angular stones (gravels) mixed with road dust placed in shallow layers and compacted thoroughly. The powdered road dust itself acted as binding material when mixed in water. Concrete roads were made using crushed rock and sand along with cement and water as binding material while the asphalt roads were made by broken stones (*kankar*), sand and asphalt. The binding substance in asphalt roads was bitumen (Law & Clark, 1901, p. 131; Report of the Indian Road Development Committee, 1928, p. 108).[3]

For constructing all types of roads, the surface was first cleared of obstructions and levelled. The mixture was made in the bitumen boilers and then cement and asphalt were added in concrete mixers. This material was spread on the road which was then pressed by the road rollers. Two to three layers were laid to prepare a hard, durable road surface (Indian Engineering Industries, 1949, p. 246). After metalling of road to a thickness of 3 inches, the metalled road was allowed to settle for about one month. The road surface was then brushed and coal-tar was applied with a spraying machine. Similarly, asphalt bitumen surfacing was done after some time of metalling. Where the traffic was heavy, asphalt grouted macadam (penetration system) was applied. It consisted of a bottom layer of stones (2 to 2.5 gauge) upon which hot asphalt was applied at the rate 1.5 to 1.75 gallons/sq. yard; intermediate layer of stones (3/4 to 1 inch gauge) over which a coat of hot asphalt was applied at the rate 0.5 to 0.75 gallons per yard and then on the uppermost surface, fine clippings were spread and rolled along with sand (Law & Clark, 1901, p. 131; Report of the Indian Road Development Committee, 1928, p. 108). Several machineries such as presses, drilling and milling machines were used for road making along with mixers and boilers. The asphalt and concrete mixers were actually revolving drums driven by internal combustion power engines (Thomas, 1944, p. 50).

When the British annexed Punjab, Grand Trunk Road was given special attention from a political and military point of view as it bonded together all important northern cantonments and maintained communication with Peshawar, which was the biggest frontier station. The Grand Trunk Road was most important metalled road in colonial Punjab and was one of the longest roads in the world. The British had started improvements on this route in 1839 (Royal Geographical Society, 2004, p. 8). Lord William Bentinck undertook initial task to construct Grand Trunk Road between 1830 and 1835 and a very large proportion of work on this road was completed before 1848. After 1855, it was extended to Peshawar, a total distance of 1500 miles starting from Calcutta. In Punjab, it passed through Karnal, Ludhiana, Lahore, Jhelum and Attock before extending upto Peshawar (Mac George, 1894, p. 81). The Grand Trunk Road was constructed throughout as an embankment, well drained and well metalled. The central portion was metalled to a width of sixteen feet with broken stones, laid eight inches thick and rolled and beaten down to a thickness of six inches. It was raised to almost forty feet in areas of floods and inundations. Good timber trees were planted along the foot of embankment slopes at intervals of 50–60 feet. Except in case of widest rivers, the Grand Trunk Road was permanently bridged throughout (Mac George, 1894, p. 82). In the low lying regions, considerable embankment was constructed. The earth work was completed

[2] The work was classified into military works (cantonments and forts), public works (for civil purpose), roads, bridges, viaducts and canals. The roads were further classified as military roads, roads for external and internal commerce. This program resulted in an estimated 2,500 Kilometres (1,600 miles) of metalled roads being constructed by the 1850s in India.

[3] Technically, asphalt is hard rocky bituminous limestone of pure carbonate of lime naturally impregnated with bitumen which acts as binder. Asphalt limestone consists of 90 to 94 percent of carbonate of lime and 6 to 10 percent of bitumen. For construction of roads, the rock was powdered and heated to 212 to 250 degree F. When it melted, it was mixed with sand or gravel. The asphalt used in British Punjab was known as Maxphalt and Spraymex.

with *kankars* and stones while embankments were made of bricks (Sarkar, 1926, pp. 17, 19).[4]

Bridge construction work in colonial Punjab was initiated with boat bridges (pontoon bridges) to travel across the rivers and streams. Here, it is important to mention that technology of pontoon bridges existed in Mughal period as well. In fact, the Mughal engineers made pontoon bridges by tying together several boats with hooks and iron chains in the river. The boats were covered with wooden boards which were firmly fixed by iron nails in a manner that they would not shake at all when riders and passengers crossed them. But this technique seems to have been used in the construction of boat bridges of a permanent nature such as that at Delhi and Agra. The temporary boat bridges used by the army were much simpler structures. In these boat bridges, boats were tied together only by grass ropes and the roadway laid over these bridges was made of branches of trees, bushes and hay (Kumar, 1984, p. 233).

During the colonial period, for making pontoon bridges, flat bottomed boats were lined up and secured by fastening to anchors for stabilization. In some cases, deck was made on rectangular iron floats (pontoons) coupled together in pairs and held in position with 1 ¾ inch chain cables fastened to anchors of 3 tons each placed upstream and downstream (Irvine, 1903, p. 212; Tyrell, 1911, p. 109).[5] Boat bridges were made at Jhelum where wood was abundant and a saw-mill worked with water power. At Attock too, there was work sheds of Indus boats along with a saw-mill. Many boat bridges were constructed on rivers Ravi, Chenab, Jhelum and Indus but once the road construction and railway work commenced, the boat bridges lost their importance (Sarkar, 1926, pp. 44–45).[6]

Two types of permanent bridges over rivers were constructed employing new technology of road bridge construction. The first were the iron bridges and the second masonry arched bridges. The major improvement in technique of bridge building in colonial Punjab was through the use of iron in building the piers as well as arches. The technology of iron bridges consisted of deck arches and stone piers constructed on cast iron cylinders. In each span, wrought iron riveted plates were placed to act as arch ribs which were braced together with struts (Tyrell, 1911, pp. 312–13). Such bridges were about 200 feet in clear span between the points of suspension and the abutments were about 42 feet high to the roadway and were built on solid rock near the surface. The chain piers on the abutments were 33 feet high above the road and the arched passage ways built through them were about 9 feet and 15 feet wide. The bridge platform was about 200 feet long, 12 feet wide and weighed nearly 53 tons. The iron suspension chains which passed over iron rollers were firmly anchored into masses of masonry 16 feet below the surface of the road. The chains were made of solid round bars of iron and bolted together in pairs to support the road platform that was raised nine inches from the middle. It was formed of two lines of flat iron bars and was suspended on each side of the bridge from vertical rods carrying cross joints and longitudinal wooden planks. The planks were embedded in a composition of resin boiled in linseed oil mixed with ashes (Mac George, 1894, pp. 93–94).

The masonry arched bridges were made of bricks and stones with piers and abutments founded directly into the hard sub-stratum and sometimes on cylindrical walls and blocks of masonry sunk to sufficient depth in sandy beds. In case of dry river stretches, the whole river bed was traversed by a paving of stone set in mortar. Occasionally piers were constructed of iron or timber (Mac George, 1894, pp. 83, 92). As the strength of masonry arch bridges depended on piers and abutments which were exposed to full force and velocity of the water current, the base of the foundations was secured in solid rock by boring at various depths. While securing the foundations in river, the entry of water was stopped by employing a technique called cofferdam[7] in which a single and double row of pointed piles were formed (Kumar, 1984, p. 252). When the piles were driven down to the required depth, the water was pumped out by using steam pumps. The piers and abutments of the bridge were built from rock faced ashlar (stone masonry formed using stones) and heated with rubble masonry (rough uneven stone set in mortar) for strength (Mac George, 1894, pp. 99, 101). Improvement in construction of masonry bridges was made by strengthening the arches, piers and abutments with iron rods and bands at the point of rupture (Tyrell, 1911, pp. 408–09).[8] Some more bridges on the Grand Trunk Road were completed between Lahore and Gujranwala and Lahore and Beas using these new bridge techniques. Six large bridges were completed of which one had three arches of 30 feet span. One bridge which ran over a stream in Wazirabad

[4] In 1853, the Grand Trunk road between Lahore and Gujranwala was completed for 59 miles.

[5] The natives did not make use of grapnels (anchors). Instead of these, they followed the tedious mode of driving stakes into the river bed. The result was a bridge less secure; Remarks by Major R.S. Roberts, Asiatic Miscellany, (1785–86), p. 419, as cited in W. Irvine, *The Army of the Indian Mughals*, London, 1903, p. 212.

[6] During the period of 1849–1901, several of the boat bridges were abolished on account of the construction of railway bridges. The Delhi boat bridge was the first to be abolished in 1858, the Beas Bridge was no longer maintained after 1870 and the bridges at Wazirabad, Jhelum and Phillaur were abolished in 1884–85.

[7] A cofferdam was a box made by driving four rows of timber sheet piles, open at the top and bottom, but completely surrounding the site of the proposed pier. The cofferdam was emptied to obtain a dry river bed for excavation work.

[8] Arches were reinforced with metal and iron frames embedded in Portland cement or in the concrete using curved roller beams.

had an improved lattice bridge with three openings of 65 feet each. The earth work was completed with *kankars* and stones while embankments were made by bricks. The road between Lahore and Beas was completed with necessary earthen and masonry viaducts for drainage of Bari Doab (Sarkar, 1926, pp. 17, 25). An important road bridge was constructed on river Indus for crossing over to Attock.

As a case study, it is worth to mention the construction of one bridge of stone and masonry on Sohan River on the Lahore-Peshawar road. This bridge consisted of 15 brick arches each of 63 feet span, carrying a cut-stone cornice and a level roadway of 26 feet width. The arches were supported on piers and abutments of coursed rubble masonry, 35 feet high from the lowest foundation to the springing of arches. The bridge was built in three sections of five spans each. The abutments piers and end abutments were 12 feet and the intermediate piers were 9 feet in thickness. The foundation footing was embedded in red clay at a depth of 17 feet below the river bed and was protected by a continuous flooring of stone blocks. The foundation of piers was laid in masonry (Mac George, 1894, p. 96).

3 River transportation technologies in colonial Punjab

River navigation in the rivers Ravi, Chenab, Jhelum and Indus continued through various types of private boats which plied and carried the Punjab commerce to sea. These boats were in use since the Mughal period and they catered to the transport, trade and commerce in the region. The country boats which were used for transportation were *beri*, *zarak*, *kiśtī* and *dondā* or *dondī*. There was another boat called the *dugga* which was also a very strong boat plying in river Indus. It had neither mast nor sail. The *beri* was a flat bottom boat constructed on a skeleton of longitudinal beams with transverse ribs consisting of *deodar* planks which were scarf jointed and secured by small iron clamps. The sides were held together with large iron clamps. The mast crossed the boat from side to side and carried an oblong sail which was wider than the boat. The sail was made of coarse cloth. The mast carried its pulleys on which moved a rope fixed between the forestays. At the end of the boat, there were set of arches where the boatman could sleep. *Zarak* was a heavy traffic boat which sailed in Sutlej. It was much heavier and broader than the *beri*. It had a thatched hut erected on the deck for accommodation during long voyages. The *kishti* was a flat punt boat built without any curves. The bottom was broad and flat made of planks nailed to transverse ribs. The sides consisted of straight boards fixed at an angle to the bottom. The planks were made of *deodar* wood while the sides were made of *kikar*, *śīśam* and mulberry. The smaller boats known as *dondā* or *dondī* were ferry boats which were much smaller and lighter and their stem and stern were pointed (Baden, 1872, pp. 253–57).

There are not many evidences that the British improved the construction techniques of country boat-making in colonial Punjab, but the process of boat construction has been described by Baden Powell, B.H. (1872) as under:

> The *hull* (body) of the boat was made by joining three detached pieces together, namely, two sides and bottom. The three pieces were first separately completed and then the joined together. When each of the three parts which were to form the whole *hull* was complete in itself, the sides were carried to the bottom of the boat and at once secured by crooked pieces of timber to the flat bottom of the boat. To bring the bow and stern up to the corresponding parts of the sides and where the bow and stern were to rise, the planks were lubricated to give them a tendency to curve upwards and this was further increased by the application of force. In the extremes thus risen, a trackle was stretched between them and by constant application of the heating mixture and pulling, the ends were made to rise to the required angle and these were then secured to the sides, while an advantageous curve was imparted by this process to the plank's in the boat's bottom. With the slight curve in the bottom planks, the boat had advantage in descending a river because if it struck a sand bank, it would turn like a top and would be safe against the stream.

The boats in upper Indus region were made from *śīśam* wood and at Attock from fir (Genus-*Abies*) brought from the forests of lower Himalayas. The iron used in boat making was supplied from Bombay and from the mines of Bunnoo and Bajour (Baden, 1872, p. 257).

Transportation by water was the cheapest in colonial Punjab due to the presence of perennial rivers like the Indus and the lower reaches of the Jhelum, Chenab and Sutlej. These were navigable almost throughout the year (The Imperial Gazetteer of India, 1908, p. 327). To improve river transportation, the British introduced steam vessel fleet named Indus Flotilla as early as 1835 in river Indus (Revenue and Agriculture Department Proceedings, 1880, p. 34).[9] The power of steam engines had earlier been demonstrated by the East India Company to navigate the Indian rivers (Sarkar, 2014, p. 232). For the Punjab Flotilla, three steamers known as Jhelum, Chenab and Napier were ordered from Bombay. They were of deeper draught and therefore, unsuited to shallow rivers like the Indus (Punjab District Gazetteer,

[9] During the rainy season, they proceeded as far as Kalabagh on the Indus, Jhelum city on the Jhelum, Lahore on the Ravi and Ferozepore on the Sutlej.

Table 1 The mileage of metalled roads during 1891–1944

Year	Road mileage of metalled roads(miles)
1891	1,036
1901	1,916
1911	2,619
1921	2,937
1931	4,073
1944	5,473

Source: The Imperial Gazetteer of India, 1908; Census of India, Punjab, 1931; Basic Road Statistics of India, 1949

1883–84, p. 95). In spite of these disadvantages, another steamer called Beas was added to the Flotilla in 1866. This too was also found to be defective as its boilers were too small to produce the requisite steam power with wood fuel. It also required more beam and length. To remove these defects, another steamer named Ravi was added to the fleet in 1869. It had two barges and it was constructed at Liverpool on the model of Beas. This was the best vessel of the Flotilla (Arora, 1930, pp. 45–47). Thus, in 1871, the five steamers attached with the Punjab Government Steam Flotilla were Napier with 90, Jhelum with 60, Chenab with 60, Beas with 35 and Ravi having 100 horsepower. For the smooth running of these vessels, a factory was established at Mithankot in district Dera Ghazi Khan for the petty repair work. But with the transfer of headquarter from Mithakot to Sukkur in Sindh province, the factory was also shifted to Sukkur in 1862. It was capable of doing brass work and even manufactured parts of the machinery like paddle wheels and shafts (Punjab Administrative Report, 1867–68, pp. 47, 49). To supply fuel for the working of steamers godowns and depots were set-up at Kalabagh in district Mianwali and Makhand in Sindh. But when difficulty was encountered in procuring the required amount of wood, attempts were made to use the coal of Kalabagh. Despite these efforts, the Punjab Government Steam Flotilla showed a loss of about fourteen lakhs annually and therefore, in December, 1872 the Government issued instructions to cease the operations of the Punjab Government Steam Flotilla (Arora, 1930, pp. 45–47).

4 Impact of improved Road and River transportation facilities on the Punjabi society

There were 1,036 miles of metalled roads in 1891 which increased to 2,619 in 1911. By 1931, the mileage of metalled roads was 4,073 that further increased to 5,473 in 1944 in colonial Punjab as mentioned in Table 1 (The Imperial Gazetteer of India, 1908, p. 91; Census of India, Punjab, 1931, pp. 15–20, 49–50; Basic Road Statistics of India, 1949, p. 36).[10]

Besides roads, a number of road bridges were constructed in colonial Punjab. By 1931, there were road bridges over the Chenab and Palkhu at Wazirabad; Beas near Dera Baba Nanak; Sutlej near Ferozepore; Chenab at Chiniot; Jhelum at Khushab; a weir across the Sutlej river at Suleimanki; and over the Bakrala Nallah in the Jhelum district. A large number of smaller bridges were also constructed or rebuilt and boat-bridges were thrown across the river Chenab at Talibwala and a suspension bridge over the Choi Nallah on the Pindigheb-Campbellpur road (Census of India, Punjab, 1931, pp. 15–20, 49–50). In 1891, 29,920 persons were employed in road and bridge construction work. This number increased to 40,384 in 1901 and further went up to 1,25,478 by 1931(Census of India, Punjab, 1891, pp. 411–426; Census of India, Punjab, 1901, Table-XV; Census of India, Punjab, 1931, pp. 181, 241).

River Transportation was carried through boats and streamers in colonial Punjab. The number of workers connected with river transportation was 40,081 in 1901. The number of workers increased to 1,08,140 in 1911 but then declined to 49,064 in 1921 and further dropped to 27,831 by 1931 (Census of India, Punjab, 1901, p.464; 1911, pp. 320–353, 509–12; 1921, p.329 and 1931, p.181).

5 Conclusions

The road and bridge construction and navigation by steam boats were true examples of transfer of technology from the west to the colonies. As such, new technology was employed by the British in colonial Punjab to fulfil their economic and military needs. Major contribution was the Grand Trunk Road which ran from Delhi to Peshawar passing through major urban centers. With the construction of a network of roads and bridges, connecting villages with *mandis* and large towns, movement of raw-materials and manufactured goods to markets became quick and efficient. New trade centers were established and large grain markets came up. The import and export of goods increased manifold. The roads helped in expanding trade by providing affordable transportation for bulky and heavy goods and also for perishable items like fruits, vegetables and milk in colonial Punjab. Furthermore, travelling in general became comfortable and quick for common people. The road and bridge construction generated considerable employment as well. With the

[10] Besides, there were 19,762 miles of unmetalled roads in 1891 which by 1944, were 19,506 miles. Besides road construction, a number of road bridges were constructed in colonial Punjab.

metalled roads, gradual introduction of motorized vehicles was made possible.

The British tried to improve the river transport by introducing the Steam Flotilla but despite the government efforts, the river steamers could not succeed due to technical faults and heavy expenditure on maintenance and they were abolished in 1872. However, the public was exposed to new technology of steam vessels. River transportation in colonial Punjab continued through various types of country boats. In the second half of 20th century, transportation by river begin to decline in the colonial Punjab due to advent of railways as people started preferring safer and faster means of transport. In overall terms, new technologies in road and river transportation in colonial Punjab proved beneficial.

Glossary.

Berī —a flat bottom boat constructed on a skeleton of longitudinal beams with transverse ribs.

Cedrus deodara – Deodar (tree).

Dondā or *dondī*—smaller and lighter ferry boats.

Dugga—a very strong boat plying in river Indus with neither mast nor sail.

Kankar—Broken stones.

Kikar—Acacia nilotica (tree).

Kiśtī—a flat punt boat built without any curves.

Śīśam—Dalbergia sissoo (tree).

Zarak—a heavy traffic boat which sailed in Sutlej.

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