

PAPER No. 225.

INTENSITY OF TRAFFIC ON PUNJAB ROADS.

By BRIJ MOHAN LAL, I.S.E.

A knowledge of intensity and character of traffic is essential for the sound planning of a highway system. The necessity of traffic surveys for this purpose has been realized for a long time by the road engineers of the Punjab. A beginning was made in this direction in the Punjab in 1929, when a census of traffic was taken on all roads. Counts were made of all types of traffic using the road including cattle, cycles and pedestrians. An average weight was allotted to each type of vehicle and the total tonnage thus obtained was expressed per yard width of the metalled surface of the road. Quite useful and informative traffic statistics were thus collected in the Province from the year 1929 to 1931.

A road conference was convened in Simla in September, 1931, to consider the various road problems in India. The Chief Engineers, Buildings and Roads Branch, Public Works Department, of all provinces participated in the conference. The importance of traffic statistics was not overlooked by this conference, and a standard form of traffic census was proposed for uniform use in all provinces (vide Appendix I). The conference decided that the object to be aimed at was maximum simplicity comparable with reasonable accuracy in arriving at the tonnage per yard width per 24 hours, passing over any road. It was considered that differentiation between mechanical and non-mechanical transport was necessary, but the collection of statistics of traffic of negligible tonnage, which did not usually travel on the metalled surface and did not substantially contribute to wear and tear of the surface would be unnecessary. It was therefore decided that motor cycles, three wheeler and pack or loose animals need not be counted. The average weights to be assumed for each type of vehicle were left to be determined by the chief engineers for their own province. The Committee also decided that for the purpose of comparable statistics, traffic counts should be made at different seasons so as to arrive at a fair yearly average. The number of counts necessary and the times of the year at which they should be taken were left for local consideration and decision. The Committee observed however that while it might be desirable at times to record counts of spate traffic at fairs and other special occasions, care should be taken to differentiate between special counts of that nature and those aimed at arriving at a fair yearly average.

In accordance with the above suggestions the following standard weight was assigned by the Chief Engineer, Buildings and Roads Branch, Punjab, P. W. D., to each class of vehicle.

Motor traffic.

- | | |
|--|---------------|
| (1) Lorries and buses over 25 seats :— | |
| (i) Solid tyres | .. 3.75 tons. |
| (ii) Pneumatic tyres | .. 3 tons. |
| (2) Passenger buses up to 25 seats | .. 2.5 tons. |
| (3) Cars and taxis | .. 1.4 tons. |

Non-motor traffic.

- | | |
|--------------------------|------------|
| (4) Four wheeled carts | .. 2 tons. |
| (5) Two wheeled carts :— | |
| (i) One animal | .. 1 ton. |
| (ii) Two or more animals | .. 2 tons. |

No differentiation was to be made between loaded and unloaded vehicles.

Census of traffic on the above lines was commenced in all the divisions in 1933. Counts were made in June and December each year. It will be seen from the form in Appendix I that no differentiation has been made therein between bullock-carts having iron tyres and those without them. As iron tyres caused the most damage to road surfaces, it appeared necessary that a record of iron tyred carts should be kept separately. Therefore in the Ambala Circle, such a record was also kept.

The above method of recording traffic statistics was again thoroughly examined by a technical sub-committee appointed by the Indian Roads Congress in December, 1934 to consider and report on a number of technical problems concerning roads. The following report was submitted by the above committee on the problem of traffic census :

“ The Sub-Committee feel that there has been in the past a tendency to elaborate traffic statistics unnecessarily. They believe that only two classes of traffic—motor vehicles and bullock-carts—are of real importance in wearing out roads, that there is little to be learnt from counting tongas and ekkas and nothing from counting pedestrians, cycles, cattle, etc. They also consider that for ordinary rural road conditions where the metalled carriage-way varies in width from say eight to sixteen or even twenty feet and berms may be of varying width and condition, information as to total numbers and weight of vehicles is of more significance than the same information reduced to a figure per yard width of hard surface.

It is therefore recommended that unless special refinements are wanted and particularly specified such as counts of other vehicles and pedestrians, for the proper design of road widths and footpaths, the following procedure be adopted. Traffic counts will be made and recorded in total number of vehicles under (a) motor transport (subdivided into (i) buses and lorries and (ii) cars; and (b) bullock-carts (subdivided into those with iron or wooden tyres and if necessary into two-wheeled and four-wheeled carts). Average unit weights for each, *i.e.*, the average for all vehicles loaded and unloaded having been determined, the total tonnage will also be stated. The width of the metalled carriage-way will be recorded but up to a width of 20 feet the weight per yard or foot width should not be worked out. For widths of metalled carriage way exceeding 20 feet, where there is segregation of different classes of vehicles, the width of the separate lanes may, if considered necessary, be determined in each case and separate statistics compiled for different lanes."

On the basis of the above suggestions, the forms and methods of census were again changed, and forms A and B (vide Appendices II and III) were introduced in May, 1937. The census is now taken in the months of May and November, as in these months the wheat and cotton produce is being carried to the markets, and the bullock-cart traffic is probably the highest in these months. Form A is meant for compiling results of census of all roads in one division for submission to the Superintending Engineer and Form B for use by Sub-Divisional Officers for recording results of census for each counting station. The average unit weight allotted to each vehicle was again reconsidered and the following unit weights were finally adopted.

Lorries and buses over 25 seats	..	4 tons.
Buses under 25 seats	..	3.5 tons.
Cars	..	1.5 tons.
All bullock-carts	..	1.5 tons.

These weights have been adopted on the basis of the actual weighing of a large number of vehicles of various types during a detailed census of traffic on roads in Delhi Province from October, 1934 to April, 1935. The results of this census were presented in the form of a paper by Mr. R. L. Sondhi, I.S.E., before the second meeting of the Indian Roads Congress held at Bangalore in January, 1936.

On each occasion, the census in each Sub-Division is taken for a period of 72 hours continuously, generally on the same days on all the counting stations. The counting is done by road mates and coolies who are in most cases illiterate, and the method of recording numbers is to make a stroke with a pencil for each vehicle passing across the station in the appropriate column for the type of vehicle on a sheet of paper. This system of taking a census by illiterate staff cannot be considered

ideal nor can the results obtained be considered sufficiently reliable. The work of the above staff is aided and supervised by Road Inspectors and Overseers but as the census proceeds continuously for three days and nights, the superior staff who have no relieving hands, cannot themselves be present for the whole period of the census. Moreover, in most cases there is more than one counting station in the beat of one Road Inspector. It is therefore not possible to get the census taken by the normal literate staff. We have had to remain content with this system of enumeration as it does not involve any additional expenditure, and it does give, after all, some idea of the volume of traffic.

In the traffic census at Delhi referred to in para 5, the staff consisted of one Head Enumerator at Rs. 50 per month in general charge and six enumerators and six peons at Rs. 30 and Rs. 15 respectively. The enumerators worked in three eight-hour shifts throughout the 24 hours, each shift consisting of two enumerators and two peons. To obtain dependable figures of intensity of traffic, it is necessary to employ educated staff somewhat on the above lines, say a set of three enumerators and three peons in each division, who could work in three eight-hour shift throughout the 24 hours, each shift consisting of one enumerator and one peon. A great disadvantage of such a scheme is that the census cannot be taken at all the stations in a division on the same dates, but by planned rotation, counts can be obtained of traffic for various seasons at each station. To make a trial and to see whether the census by a special staff does give figures more reliable and different from the census taken by illiterate staff, a set of three enumerators has been appointed to count traffic round about Lahore from December, 1938, and it will be possible to remark on these results at the session of the Congress.

Great care and thought is necessary in deciding stations at which census should be taken. Each road has to be divided into sections, carrying approximately constant traffic. The dividing line between these sections is usually a road junction, an important town, a railway station or a brick-field area. A census station is then chosen for each section of a road at a convenient place. These sections of the road are selected with very great care so as to record all variations in traffic on the road as far as possible.

The intensity of traffic considered in figures of total weight can be divided into the following categories:—

Miles carrying traffic of the following intensity in tons:—

(i) 0 to 500 tons	.. Very light.
(2) 500 to 1000 tons	.. Light.
(3) 1000 to 1500 tons	.. Medium.
(4) 1500 to 2000 tons	.. Heavy.
(5) 2000 to 2500 tons	.. Very heavy.
(6) Over 2500 tons	.. Intense.

Appendix IV of the Paper is a table showing the number of miles of roads in each provincial division of the Punjab carrying the various intensities of traffic as classified above. This table has been compiled from the results of the census of traffic taken in the various divisions in November 1937. It will be seen from this table that in the whole province, the roads can be classified as below :—

(1) Very light	2324 miles	..	70 per cent.
(2) Light	525 "	..	16½ per cent.
(3) Medium	297 "	..	9 per cent.
(4) Heavy	75 "	..	2½ per cent.
(5) Very heavy	7 "	..	¼ per cent.
(6) Intense	61 "	..	1¾ per cent.
Total	3289 "	..	100 per cent.

It is apparent from these figures that a major percentage of our roads carries very light traffic. Appendix V of this paper shows the intensity of traffic on each Arterial road separately. From the table in this Appendix it will be seen that the Grand Trunk Road from Delhi to Attock carries the heaviest traffic on the road. Forty-four miles of "Intense traffic" class are on this road, and these are between Amritsar and the Ravi at Lahore and near Rawalpindi. Other miles of "Intense traffic" are the following :—

- (1) 5 miles on Lahore-Multan Road at Lahore.
- (2) 3 miles on Delhi-Multan Road at Bahadurgarh.
- (3) 5 miles on Rawalpindi-Murree Road at Rawalpindi.
- (4) 4 miles on the Mall Road, Lahore.

Seven miles carrying very heavy traffic (class 5) are the first seven miles of the Lahore-Ferozepur Road, say from Lahore to Model Town. The miles carrying heavy traffic (1500 to 2000 tons) are as below :—

- (1) 49 miles on the Grand Trunk Road between Beas and Amritsar, Lahore and Gujranwala and near Rawalpindi and near Ambala City,
- (2) 5 miles on Lahore-Sargodha Road near Lahore,
- (3) 13 miles on Lahore-Ferozepore Road near Ferozepur,
- and (4) 8 miles on Amritsar-Sialkot Road near Amritsar.

Thus from the point of view of total tonnage, only 143 miles in the whole province can be said to be carrying heavy traffic.

It is however the number of bullock-carts using a road that determines the damaging intensity of traffic, as it is the narrow iron tyred bullock-carts which destroy the road surface more than anything else. Columns 8 to 11 of the table in Appendix IV give the number of miles in each division carrying a certain number of bullock-carts. For the whole province these miles can be classified as below :—

I. Light—0 to 250 carts	.. 3116 miles.
II. Medium—250 to 350 carts	.. 69 miles.
III. Heavy—350 to 500 carts	.. 44 miles.
IV. Intense—Over 500 bullock-carts	.. 60 miles.

The sections of road carrying 350 to 500 carts are as below :—

(1) Grand Trunk Road :—

- 9 miles Lahore to Gujranwala, miles 41 to 50, near Gujranwala.
- 7 miles Lahore to Ferozepur, miles 0 to 7, near Lahore.
- 9 miles Lahore to Rawalpindi miles 82 to 91, near Lalamusa.

(2) Lahore-Multan Road.

- 19 miles Lahore to Multan, miles 59 to 78, near Pattoki.

The sections of road carrying over 500 bullock-carts are as below :

(1) Grand Trunk Road :—

- 2 miles near Amballa City—miles 125 to 127.
- 3 miles near Shalamar Lahore—miles 304 to 307.
- 4 miles Lahore to Beas—miles 0 to 4.
- 5 Miles at Rawalpindi—miles 165 to 170.

—
14 miles.

(2) Lahore-Multan Road,

- 5 miles near Lahore.
- 22 miles (78 to 100), near Montgomery.

- (3) Delhi-Multan Road, 3 miles near Bahadurgarh.
- (4) Rawalpindi-Murree Road, 5 miles near Rawalpindi.
- (5) Lahore-Moga Road, 4 miles near Lahore.
- (6) Sonapat-Rohtak Road, 7 miles near Rohtak.

Total. 60 miles.

It may also be stated that more than half the number of miles under class I (0 to 250 carts) carry even less than 100 carts.

Regarding types of bullock-carts, it is to be stated that iron tyres are mostly in use near towns for carrying bricks and other goods on hire. The agriculturists generally do not use iron tyred carts. Iron tyred carts are mostly used in the following sections of roads :—

- (1) Kalka-Simla Road, average 50 carts.
- (2) Lahore-Ferozepur Road near Ferozepur, 150 carts.
- (3) Delhi-Multan Road at Bahadurgarh, 1000 carts out of which 500 are four-wheeled.
- (4) Sonapat-Rohtak Road near Rohtak, 400 carts out of which 100 are four wheeled.
- (5) (a) Grand Trunk Road at Karnal, 200 out of which 50 are four-wheeled.
(b) At Ambala Cantonments, 200 out of which 50 are four-wheeled.
(c) At Ambala City, 600 out of which 125 are four-wheeled.
- (6) Ambala-Kalka Road, about 150.
- (7) Saharanpur-Kurukshetra Road near Abdullapur 100 carts.
- (8) Delhi-Multan Road near Multan, 150 carts.
- (9) Lahore-Lyallpur Road near Lyallpur, 100 carts.
- (10) Rawalpindi-Kashmere Road near Rawalpindi 500 to 600 carts.
- (11) Grand Trunk Road near Rawalpindi—500 carts.
- (12) Grand Trunk Road near about Lahore—150 carts.

From the above statement it will be seen that the number of iron tyred bullock-carts is heavy only at Bahadurgarh, Rohtak, Ambala and Rawalpindi, and that four-wheeled bullock-carts are in use only in the eastern part of the province.

It is very interesting to compare these figures of traffic intensity with those of the neighbouring provinces. The result of the traffic census in Delhi Province referred to in para. 5 showed that the intensity of traffic on all roads beyond Municipal limits was under 1000 tons except on the Delhi-Mutra Road where it was 1300 tons. Traffic statistics have also been collected in the United Provinces of Agra and Oudh, and a paper on them was read by Lt.-Col. W. de H. Haig, Chief

Engineer, before the second Indian Roads Congress, 1936. He classified the traffic in those provinces as below :—

(1) 0 to 500 tons	..	..	1827 miles.
(2) 500 to 1000 tons	..	..	940 miles.
(3) 1000 to 1500 tons	..	..	279 miles.
(4) 1500 to 2000 tons	..	..	78 miles.
(5) 2000 to 3000 tons	..	..	40 miles.
(6) Over 3000 tons	..	..	27 miles.

Thus except that under class 2, there is a greater mileage in the United Provinces than in the Punjab, the traffic intensity in the two Provinces is nearly similar.

In Appendices IV and V, the traffic has also been classified in terms of the number of motor vehicles, in columns 12 and 13. This grading shows that only 657 miles carry more than 200 motor vehicles, while 2632 miles carry less than 200 motor vehicles. Out of the latter about 2000 miles carry even less than 100 motor vehicles. The largest number of motor vehicles runs on the Mall Road, Lahore which reaches as high a figure as 2600. The Amritsar-Lahore Road also carries more than a thousand motor vehicles.

Columns 14 and 15 of Appendices IV and V show the classification of the roads from a consideration of the total number of all vehicles including tongas and "tuntums". Though the tongas do not cause damage to the road surface, their existence in large numbers does reduce the carrying capacity of the road. Where the number of such vehicles is very large, the metalled width demands an increase. According to this classification, 509 miles carry more than 500 vehicles, while 2780 miles carry less than these. The Grand Trunk Road alone has 222 miles carrying more than 500 vehicles.

To show the variations of traffic from section to section of each road at a glance, a graph is prepared for each traffic census for all the roads in each division, showing the number of bullock-carts—iron tyred and wooden tyred—and motor vehicles separately. From these graphs a combined graph has been prepared for the whole of the Grand Trunk Road in the Punjab *vide* Plates I and II. The total weight of traffic has also been shown by a dotted line. From this graph, it will be seen how traffic increases near each big town. The maximum intensity is 6949 tons at Lahore between the District Courts and the Ravi for a length of two miles, but the largest stretch carrying very heavy traffic is between Lahore and Amritsar with an intensity of 4416 tons. The greatest number of bullock carts with iron tyres run at Rawalpindi and Ambala, the number being 577 and 547 respectively; out of the latter at Ambala 126 are four-wheeled carts. The maximum number of motor vehicles

between Lahore and the Ravi reaches a figure of 1889. The width of the unmetalled surface in each section has also been shown on this graph.

The type of road surface in common use in the Punjab is water bound macadam surface painted with "Shalimar" tar which is re-painted generally once in two years. In some miles, subsequent painting with hot or cold bitumen and thin tar and bitumen carpets have been tried as an experimental measure. Tar painting has stood quite well up to a traffic of 1500 tons, but beyond this, painting has generally been required every year, and even the frequent patching up has been necessitated. In a recent note by the Chief Engineer, the following specifications have been tentatively suggested for various intensities of traffic:—

"In terms of 12 feet wide metal, the usual specification for tarring in the Punjab includes 8 tons of tar and 2000 cubic feet of $\frac{1}{8}$ " to $\frac{3}{4}$ " bajri for the first coat and 4 tons of tar and 1200 cubic feet of $\frac{1}{8}$ " to $\frac{3}{8}$ " bajri for subsequent coats. With these specifications and using Pathankot bajri, it will probably be found (this should be verified by close observation and not merely accepted without question) that with traffic up to about 250 bullock carts a day (25 per cent of which consists of bullock-carts with iron tyres) the following life of paint coats may be expected:—

I coat	..	..	..	About 5 months.
II coat	..	..	..	About 12 months.
III coat	..	..	..	About 18 months.
IV coat	..	..	..	About 24 months.

With a softer bajri it would be advisable not to eke out the life so long. With heavier bullock-cart traffic, it is open to us either to shorten the period between coats or to adhere to the same intervals between coats, and to increase the gauge and quantity of bajri as well as that of tar. For instance, when the bullock-cart traffic is say 350 per day, it may be necessary to change the specification for the 1st coat to 10 tons tar and 2500 cubic feet of $\frac{1}{4}$ " to 1" bajri and for subsequent coats to 5 tons tar and 1500 cubic feet of $\frac{1}{8}$ " to $\frac{3}{8}$ " bajri. It would probably be feasible to go on increasing the quantity of tar to 12 tons and 6 tons using 3000 and 1800 cubic feet of $\frac{1}{4}$ " to 1" and $\frac{3}{4}$ " bajri respectively for the initial and subsequent applications, to correspond with the volume of bullock-cart traffic. Where there is a large departure from the normal, it would be advisable to apply the tar in the autumn or early spring and only to heat the tar to about 200° F. to prevent the tar flowing from the centre of the road to the sides. This specification is the limit of capacity for the normal tar paint methods in use. Beyond this loading some other design of surfacing becomes necessary."

It will be seen from para. 10 that there are only 173 miles in the province which carry a traffic of more than 250 bullock-carts. Out of these only 60 miles carry more than 500 bullock-carts. The specifications of heavier painting are being used for a number of miles in the Province. On the Grand Trunk Road, the section from mile 304—two miles beyond Shalamar—to Lahore, carries a very heavy total traffic in tons. In the last ten years, a very large sum of money has been spent on this section in widening the road, and experimenting with various types of surfacing. One inch thick bitumen and tar carpets have been laid in the mile beyond Shalamar carrying more than 500 bullocks carts; but have not been successful. A cement concrete track on the left side of the road has been recently laid to provide for the heavily loaded bullock-carts. As both motor and non-motor traffic are heavy in this section of the road, it appears that a concrete road for full width would have proved cheaper in the long run. Generally, where traffic is more than 2500 tons per 24 hours, a 20 feet wide cement concrete road appears to be the most economical alternative in the long run.

Generally, the metalled width of arterial roads in the Punjab is 12 feet. It is only near towns, and between Amritsar and Lahore that the width is greater, and ranges from 16 to 40 feet. Though for fast traffic, 20 feet is now considered the minimum safe for two lanes of traffic, it is too ambitious to dream of all roads in the Punjab to be widened to 20 feet. It is however suggested that all roads carrying more than 500 vehicles should have a width of 20 feet. The number of such miles is about 500, and out of this about 100 miles are already 20 feet or more in width.

The last column of the table in Appendix V shows the expenditure per mile on maintenance of each arterial road in the year 1936-37. It will be seen that while this figure for the Grand Trunk Road carrying the heaviest traffic is Rs. 1,805, the average for the whole province is Rs. 1,264. As the traffic on 70 per cent of the roads is very light, it seems obvious that by judicious planning and improvement in methods of maintenance, this figure could be brought down considerably. The object of this Paper is simply to invite the attention of road engineers to this aspect of the problem. A careful and systematic recording of traffic statistics will greatly help in deciding the type of surface and thus keep maintenance cost of roads proportional to the intensity of traffic on them.

APPENDIX I

Traffic count at _____ on _____ (date) to _____ (time) on _____ (date). Recorded by _____
 From _____ (time) on _____ (date) to _____ (time) on _____ (date). Width of road surface (asphalt, madadam). Width of surface (12) feet. (4) yards. Width of formation (35) feet.
 Total weight of all traffic in (12) hours = _____ tons. Weight per yard width per 34 hours = _____ tons.

Motor traffic.				Non-motor traffic.					
Lorries and buses over 25 seats.		Buses up to 25 seats.	Cars and taxis	Miscellaneous.	4 wheeled carts.	2 wheeled carts.		Passenger vehicles.	
Solid tyres.	Pneumatic tyres.				One animal.	2 or more animals.	One animal.	2 or more animals.	

Note:—If desirable to obtain particulars of diurnal fluctuations, the time may be noted here every 3 hours and a line ruled across.

Total No : _____
 Average weight. _____
 Total weight. _____

Total weight motor traffic _____ Total weight non-motor traffic _____

APPENDIX II

FORM A.

Census of traffic on roads in the _____ Provincial Division for the month of _____

Item No.	Place of observation.				Date and time of observation.		Nature of surface.	Width of surface.	Width of formation.	Motor Traffic No. per 24 hours.				Bullock carts No. per 24 hours.				Total weight per 24 hours.	Other vehicles No. per 24 hours.
	Name of road with number.	Mile No.:	Furlong No.:	Name of town.	Date.	Time.				Lorries and buses over 25 seats.	Buses up to 25 seats.	Cars.	Total.	Four-wheeled.	With iron tyres.	Without iron tyres.	Total.		
1					6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

APPENDIX III

Form B.

Traffic census at _____ on _____ Road.
 From time one _____ to _____ time one _____ date.
 Nature of road surface (_____) Width of surface (_____) Feet. Width of formation _____

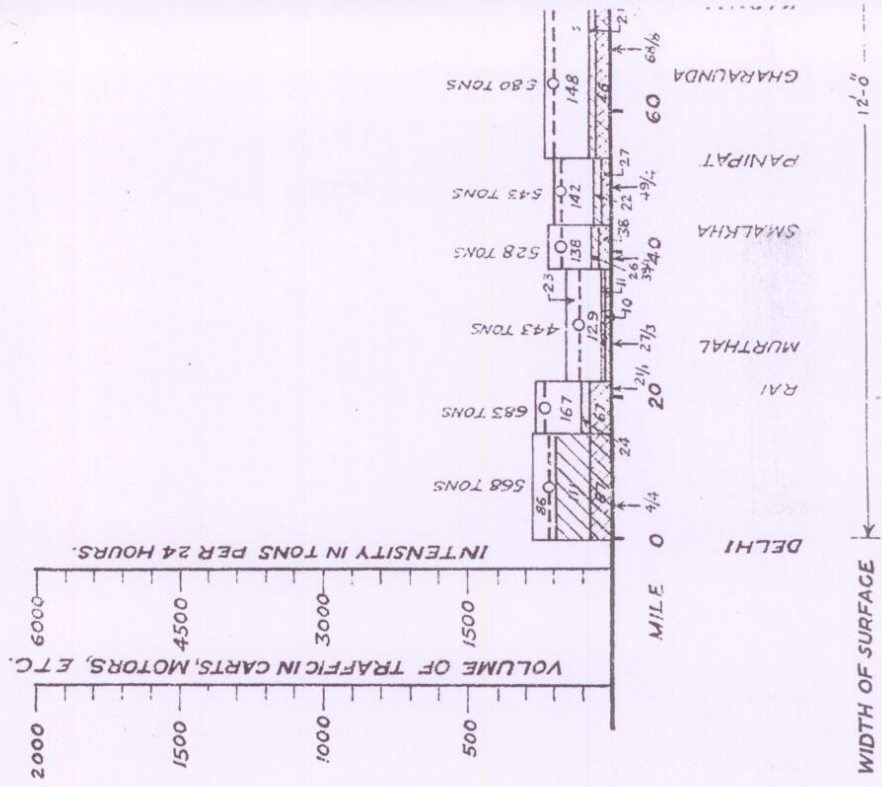
Total weight of all traffic in 24 hours.

*Census should be recorded during the months of May and/or November. On certain hill roads the census should be recorded during the month of September or when traffic is at its maximum.

Date and time.	Number of motor Vehicles			Number of non-motor Vehicles			Total.	Total Number of other Vehicles.	Remarks.	
	Lorries and buses over 25 seats.	Buses under 25 seats.	Cars.	4-wheeled Carts.	Two-wheeled carts.	Without iron tyres.				
1	2	3	4	5	6	7	8	9	10	11
Total No.										

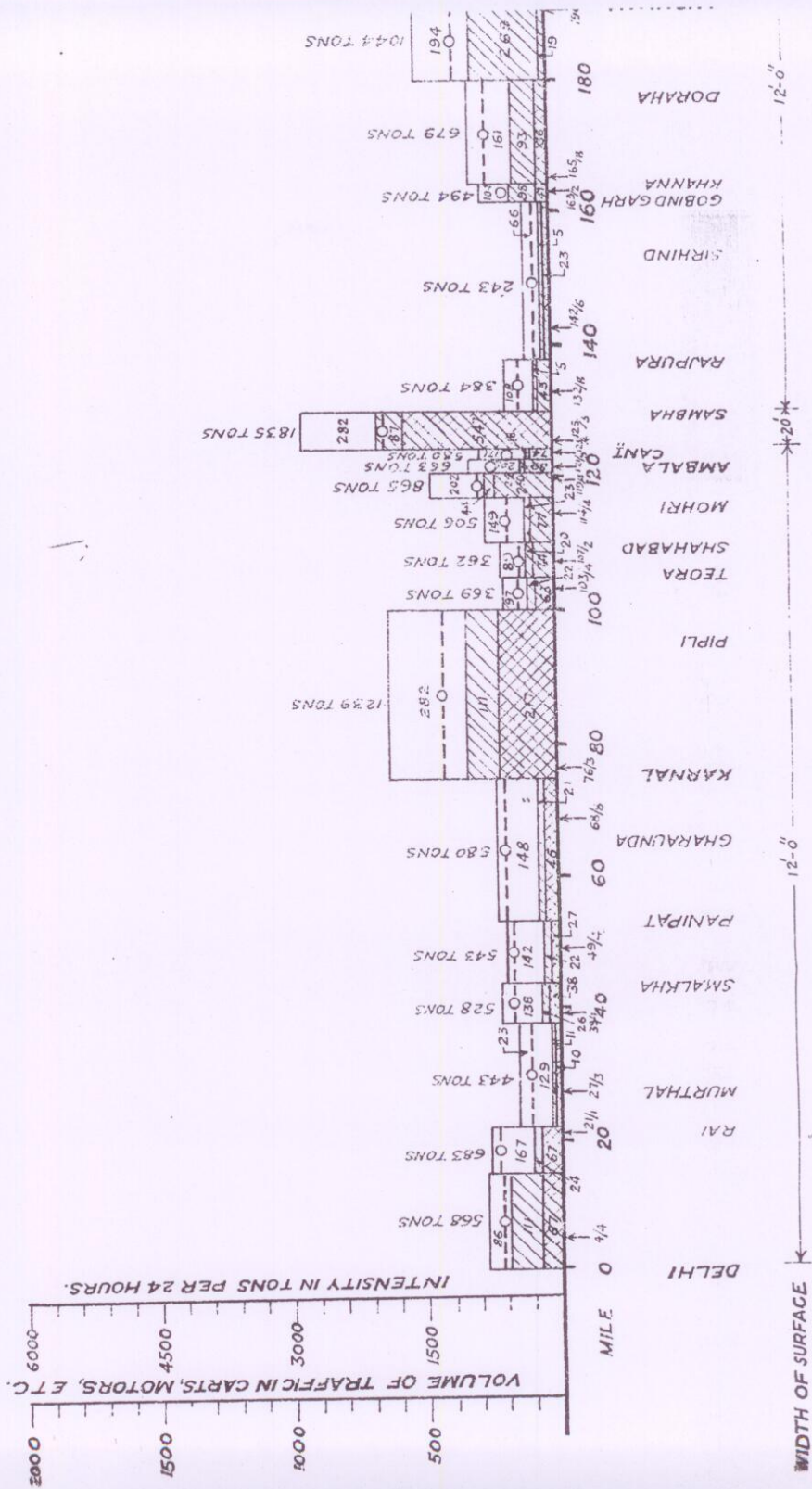
Average weight. 4 tons. 3.5 tons 1.5 tons 1.5 tons.

GRAPH SHOWING V



GRAPH SHOWING VOLUME OF TRAFFIC ON GRAND TRUNK ROAD FROM DELHI TO LAHORE

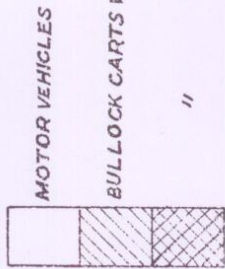
VERTICAL $I'' = 500$ NOS.
 HORIZONTAL $I'' = 20$ MILE.
 SCALE INTENSITY $I'' = 15$ 100 TONS.



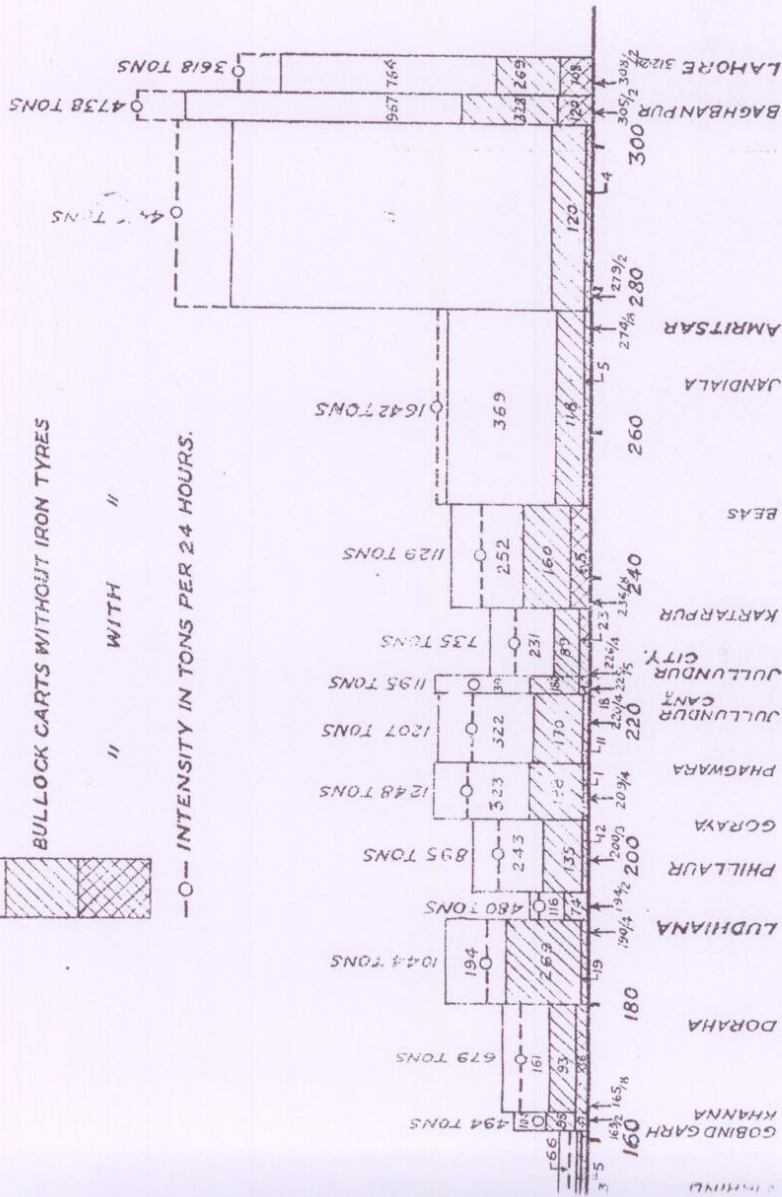
TRUNK ROAD

PLATE I
PAPER NO. 225

REFERENCES



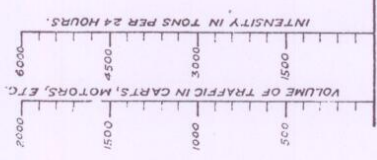
—○— INTENSITY IN TONS PER 24 HOURS.



PUNJAB ENGINEERING CONGRESS.
1933.

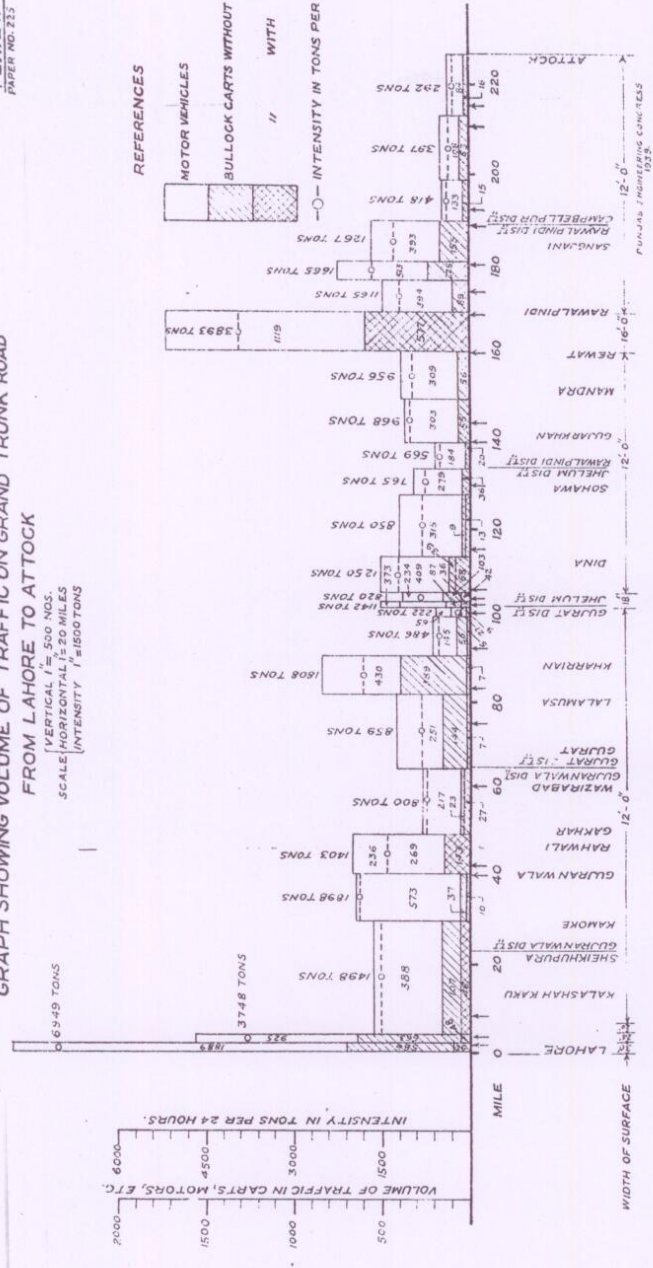
GRAPH SHOWING VOLUME OF TRAFFIC ON GRAND TRUNK ROAD
FROM LAHORE TO ATTOCK

VERTICAL 1" = 500 NOS.
SCALE HORIZONTAL 1" = 20 MILES
INTENSITY 1" = 1500 TONS



REFERENCES

- MOTOR VEHICLES
- BULLOCK CARTS WITHOUT IRON TYRES
- " WITH "
- " - O - INTENSITY IN TONS PER 24 HOURS



PUNJAB ENGINEERING COLLEGE
1938

DISCUSSION.

The **Author** in introducing his paper pointed out two mistakes in printing, viz :—

Page 123 line 2 "Unmetalled" should be "Metalled"

Page 124 line 1 "Para 10" should be "Page 120".

He stated that his paper was merely an attempt at an analysis of the traffic statistics which are being collected in the various executive divisions of the Buildings and Roads Branch, and had been written to invite the attention of the road engineers to the necessity of making use of the valuable figures of road traffic counts for designing economical and suitable types of road surfaces. It will be seen from a perusal of this paper that the problem of iron tyred bullock cart traffic is not as serious as it is generally supposed to be, as there are only 60 miles in the whole province which carry more than 500 bullock carts per day. Agricultural bullock carts have generally wooden tyres, and commercial iron tyred carts are gradually being replaced by lorries. It is of interest to know that the total number of all types of motor vehicles in actual use in the Punjab, as far as can be ascertained from the numbers registered each year, has increased from 9,830 in the year 1932 to 20,522 in the year 1938 distributed as below :—

Motor Cycles	952 to 1830.
Cars	4823 to 9866.
Passenger buses	900 to 1854.
Goods Lorries	3155 to 6972.

The number of each type of motor vehicle has thus practically doubled in a period of six years. The problem of destruction of roads by iron tyred bullock carts is therefore likely to get less acute every year.

As stated on page 118 of this paper an experiment has been made at Lahore of taking traffic census with a special staff consisting of three enumerators helped by three coolies. The wages of this staff amount to Rs. 126 per month and other contingent expenditure about Rs. 20 making a total of about Rs. 150 per month. The results of this census in some cases are widely different from those given by the ordinary staff. Thus in the case of mile 2 furlong 3 Grand Trunk Road near Chhota Ravi Bridge, the census taken in December 1938 by the ordinary staff showed an intensity of 6746 tons, while the one taken by the special staff in February 1939 showed only 3430 tons. It therefore appears that to get reliable figures of traffic intensity, employment of special staff is necessary.

Mr. **R. Trevor Jones** said that the value of a traffic census is to-day

an accepted fact, but we are still some way from profiting by the results obtained and knowing how to apply these statistics as a basis of road economics. It will be noticed in Mr. Brij Mohan Lal's very interesting paper that as far as we are concerned, we think in terms of bullock cart traffic as regards the specifications to be adopted.

As it is the advent of the motor vehicle which has necessitated the surfacing of roads by water proof materials it sounds somewhat paradoxical to design the surface to be adopted to accommodate the old-fashioned bullock cart. Until such a time however, as it is possible to segregate the various types of traffic using the road this seems to be a sensible method.

There is, however, the question of the widening of our metalling as mentioned by the author on page 124. It is interesting to note that the author has suggested a minimum of 500 vehicles as the criterion for a width of 20'. In a paper at the recent Indian Roads Congress, it was suggested that the criterion should be 2000 vehicles, but at the same time an attempt was made in computing the number of vehicles by taking into consideration the effect of the various types by the use of a suitable co-efficient. It is pretty clear, however, that widening of our roads is long over-due but with the funds at our disposal it is very difficult to know where to begin. But whether or not it is possible to lay down any hard or fast limits or critical figures which will prescribe the extent of metalling, it is obvious that traffic statistics will be of the utmost value in indicating urgent need for amelioration on existing roads.

Mr. **Nayar** agreed that traffic survey form the fundamental basis of design for any road. It seemed, however, desirable that a minimum lower specification should be fixed for the standard in each case. This limit is usually dictated by the comfort and convenience with which transport is possible and also by the safety to traffic likely to use the road. Scientifically it might be possible to stabilize an earth road to carry safely light loads which are common in a specific locality but it would be wrong to think of any national system of highways not being adequately metalled throughout even although in some reaches the traffic might be very light. The job of an Engineer is to effect the maximum of economy by catering for what in his estimation is likely to be the actual state of affairs with only a reasonable factor of safety.

It is rather unfortunate that the Highway Engineer in this country has to face two entirely inimical types of traffic. One is the fast pneumatic tyred motor vehicle and the other is the slow, hackneyed and conservative bullock cart. The requirements of the two so far as road surface is concerned are entirely different, and it seemed to him rather ridiculous to attempt to devise one type of road that might be suitable for both. Unless, therefore, we segregate the two types altogether it seemed that road maintenance in this province will continue to be the vexed problem

that it has always been. Perhaps legislation may have to be sought to secure segregation at a later date but before then we have still to devise and construct a cheap form of road that will provide a trouble free transport for the slow moving bullock cart.

Another item which requires attention in this respect is what is usually designated as "Goods Motor Vehicle". It is a matter of common knowledge that transport of goods by road is ever on the increase, and some of the vehicles have been found to carry as much as 7 tons. The number of such buses is growing every day, in spite of all the control and regulation available. It is, therefore, perhaps an under-estimate of the weight to reckon such buses at 3.5 tons over all weight. A specified weight of 5 or perhaps 6 tons would perhaps be more appropriate for such a vehicle.

The Author's suggestion on page 124 of putting in a 20' concrete road for traffic over 2500 tons seemed rather on the extravagant side. Where traffic is all of the pneumatic type, ordinary tarred roads have been found to carry as much as 4000 tons (or perhaps even much more) for years without any difficulty.

Mr. **Halcro Johnston** said that the thanks of the Congress were due to Mr. Brij Mohan Lal for collecting these valuable statistics of road traffic. The Engineers of the B and R. Branch P.W.D. have spent many weary hours dealing with them in the form of a 'return' to help fill the Government Secretariat record rooms; but this is, he believed, the first time they have been unearthed for general use.

Traffic statistics are invaluable to the road engineer in several ways; but their greatest use is surely to act as a basis on which problems of economic design can be solved. A road is just as much a commercial concern as a railway, and it is impossible to design a road correctly without taking into consideration the volume of traffic and the probable increase in that traffic.

The Author does not appear to have appreciated how valuable the statistics are for the purpose as he emphasizes only their value as a means of estimating the life of the road surface. He does not consider it necessary to record the numbers of pedestrians, bicycles, and animals because they do not wear out the surface. The same argument is responsible for the unfortunate orders that required all statistics to be expressed per yard width of road surface, so reducing their value considerably.

The most useful classification for roads is one based on the traffic carried. Classified in this way the so-called arterial roads no longer appear as single units but rather as chains of short lengths of road of different kinds and of by no means equal importance. This is clearly illustrated in Plates 1 and 2 in the case of the G. T. Road.

The value of the paper would have been increased if the Author had given also figures of the time-rates-of-change in volume of traffic which are just as valuable as the figure for a given date.

It appears that the figure of 'intensity of traffic' represent tons per 24 hours; this is not made clear in the paper. The date to which the statistics refer has also been omitted.

Do the arrows shown in plates 1 and 2 indicate the positions of the census stations? The traffic at points between stations would be more accurately indicated if the figures for each station had been plotted as points and these points joined by straight lines in the ordinary way, the figures themselves could with advantage have been omitted and shown in tabular form.

The **Author** replied as follows:—

I agree with Mr. Trevor Jones that instead of designing our roads for bullock carts, they should be designed for motor traffic, and attempts should be made to segregate the bullock cart and other slow moving traffic. But for financial reasons, this ideal is not at present practical politics except in cases of such portions of roads which carry a very heavy traffic. An attempt has been made to do so on the Grand Trunk Road between Lahore and Beas by making the side road land fit for vehicular traffic by clearing it of all jungle growth, filling depressions, and temporarily bridging small nullahs and water courses.

Regarding the minimum number of vehicles for which the metalled width should be 20 feet, I suggested a figure of 500 vehicles, because it appeared from the analysis of traffic statistics that hardly 400 miles in the whole Province carried more than 500 vehicles per day of 24 hours, and travelling in such miles showed the necessity of their width being increased to 20 feet.

Mr. Nayar considers my suggestion of concrete roads for a traffic of over 2500 tons as too extravagant. A glance of Appendix V of the paper will, however, show that there are only 57 such miles in the Punjab. There is no doubt that on about 30 miles of the Lahore—Amritsar section where the traffic is just over 2500 tons surface treatment with tar oil is giving satisfactory results, but this is due to the traffic being not much over 2500 tons. What I, however, suggest is that where traffic is more than 2500 tons, the construction of a concrete road should be considered, if other types of road surface have not proved successful.

Regarding the counting of pedestrians, bicycles and animals, Mr. Halcro Johnston is referred to the bottom of page 116 of the paper, where it is stated that the Sub Committee appointed by the Indian Roads Congress did not consider it necessary to count such traffic. I, however,

admit that though the counting of these is not necessary to arrive at the wearing capacity of a road surface, a census of such traffic would be useful in designing separate foot-paths for pedestrians and tracks for cyclists and animals, where such traffic is heavy, specially in urban areas. Orders regarding expression of figures per yard width of road surface have already been cancelled vide last three lines on page 116 of the paper. Figures of time-rates-of-change in volume of traffic as suggested by Mr. Halcro Johnston are not available. Such figures could only be recorded if a special staff be employed as suggested by me in the paper. Figures of intensity of traffic of course represents tons per 24 hours, and the figures in the paper are for May 1938. The arrows shown in plates 1, 2 indicate positions of the census stations. Instead of joining the point by straight lines in the ordinary way, I consider it better to show uniform traffic between some miles on each side of the station. The traffic does not change gradually from one point of census to another, but it changes suddenly in volume at junctions of roads, and vehicle stands. Therefore, in plates 1 and 2, instead of joining the figures of census stations by a straight line, an attempt has been made to ascertain the points of change of volume of traffic, and a constant figure has, therefore, been assumed between such points. Though this may not be quite accurate, it is in my opinion better than joining by a straight line the figures at two census stations. Attention is invited to page 118 para. 3 in this connection. Figures have been shown in this paper, because the vertical scales are too small to enable correct figures to be read against them. They could, however, be shown in a separate tabular form, but this was not done to avoid the trouble of referring to another page.

Mr. Bashi Ram has enquired about the correctness of figures of Rs. 5, 573 maintenance per mile of Sohawa-Talaganj Road. This is the maintenance cost per mile of the metalled portion of this road which is only 40 miles in length, and not of the remaining unmetalled portion. It appears that this metalled portion was renewed during 1936-37, thus raising the cost of maintenance per mile to such a high figure.