

PROPOSALS FOR AN ALL-INDIA SURVEY OF BULLOCK CARTS
BY MEANS OF RANDOM SAMPLING.

BY

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1. Every ton of produce moved in India, whatever its ultimate destination or method of transport, must travel by cart for the first stage of its journey. The bullock cart has continued unchanged for five thousand years and there is little reason to suppose that it will be supplanted in our time by any other method as a primary means of transport. So long as the road transport requirements were such that they could be met by this type of conveyance, it was a comparatively easy matter to maintain roads in suitable manner.

2. The bullock cart, however, specially the iron tyred variety, is a serious destroyer of the road. Ordinary water bound macadam which formerly wore into tolerably smooth ruts under slow traffic, breaks up rapidly under the combined grinding action of the slow iron tyre and the suction and scattering of the fines caused by the fast rubber tyred wheel. Modern tar or asphalt painted surfaces seem to be able to withstand the iron tyred wheel even less, the water proof skin being quickly broken by the high concentration of load.

3. Road Engineers have been much disturbed by the destructive tendency of the narrow iron tyre and there have been frequent discussions in various engineering societies in India on this subject. Whilst no engineer denies the destructive action of the iron tyred bullock cart, opinion is divided as to the extent to which this is a problem and even more divided as to the means necessary for its solution. There are all shades of opinion from the heroic remedy of placing all of India's seven million carts on pneumatic tyres, at a cost of something like a 100 crores, or the even more heroic suggestion of converting India's 70,000 miles of metalled road to concrete at a cost of 150 crores, to the other extreme which maintains that there is no bullock cart problem.

4. Whilst the special type of cart which takes 35 and sometimes as much as 50 maunds may give spectacular proof of the damage done and the figure for the load concentration per square inch may be startling, casual observation in all parts of the country gives the impression that the general capacity of a cart averages less than 15 maunds. Similarly, in many parts, one may go miles and meet hundreds of carts without seeing a steel tyre. It is arguable that a steel tyred cart carrying only 10-15 maunds, cannot cause very much damage, even if the tyre is narrow to begin with and gets rounded with use, but the wooden tyred cart can hardly be accused of being a serious road destroyer.

5. The only type of road that will stand up to the heavily loaded steel tyre is concrete, the really sensible wheel for any road transport purpose is the pneumatic tyred one. What should be one's

objective then, the concrete road or the pneumatic tyre? Would the answer vary for different areas? It would depend upon the numbers of heavy carts, the work they are engaged on, and the milage of road they use.

6. Though the total number of bullock carts in each province, perhaps in each district, is known, little information about these is available: for example, the type of carts, the loads they carry, the number of days worked or the milages travelled. Existing information such as figures of population, number and size of villages, area of agricultural land, agricultural produce, land revenue and its incidence, road milages, when examined against the "cart population" of each province, show some interesting regularities and some curious anomalies.

7. Such statistical information as has been published or is readily available, has been collected in the annexed table. It is interesting to observe from this table the inter-relation between the size of villages, density of population, density of cultivation, and to compare these with the cart population of the province. Other figures bearing on the problem have been collected in the same table. In order to judge their inter-relation and to compare the provinces, averages have been deduced from the information collected.

8. One may expect that the number of carts would depend upon the agricultural produce and the population in an area, and this assumption is largely borne out in actual practice. This is noticed if the provinces are placed in the order of the number of carts per thousand tons of produce, or per thousand of population, or per square mile of agricultural area.

Carts per 1000 persons.		Carts per 1000 tons produce.		Carts per square mile	
1.	C.P. 69.3	1.	C.P. 296	1.	C.P. 22.3
2.	Bombay 38.7	2.	Bombay 183	2.	Madras 19.2
3.	Bihar 37.6	3.	Madras 137	3.	U.P. 18.0
4.	Madras 25.1	4.	Orissa 120	4.	Bengal 17.6
5.	Sind 22.5	5.	Sind 95	5.	Orissa 14.2
6.	Orissa 20.4	6.	Bihar 94	6.	Bihar 14.1
7.	U.P. 20.0	7.	U.P. 82	7.	Bombay 11.4
8.	Punjab 11.6	8.	Bengal 72	8.	Sind 6.3
9.	Bengal 11.1	9.	Punjab 53	9.	Punjab 6.0
10.	Assam 7.1	10.	Assam 35	10.	Assam 5.8
11.	N.W.F.P. 1.8	11.	N.W.F.P. 8	11.	N.W.F.P. 1.3

9. It will be seen that C.P. is consistently first, whilst the Punjab, Assam and N.W.F.P. remain 8th or 9th, 10th and 11th respectively in each case. This is peculiar when it is remembered that the Punjab is considered a rich province, whilst C.P. is considered poor. Though both have about the same agricultural area, the Punjab produces more than double the C.P. Leaving aside Assam and N.W.F.P. which have very special geographical characteristics, the range between the remaining 9 provinces is enormous, the highest figure being as much as six times the lowest. The abnormally low cart population in N.W.F.P. and Assam and to a certain

extent, Sind, can be explained by the nature of the terrain which either due to mountainous, desert, or dense jungle conditions, militates against agricultural exploitation of the land.

10. One would expect some uniformity about the number of carts per 1000 tons of produce but here the variation is greatest, C.P. being 37 times as much as NW.F.P. and 6 times as much as the Punjab. The latter is surprising since these provinces produce nearly twice as much per square mile (line 47) as C.P. It cannot be explained by the supposition that one province produces more in the way of money crops than the other, because the opposite holds true between the Punjab and C.P. and there is conflicting relation between the production of money crops and the incidence of carts amongst the other ^{provinces.} population.

11. The difference can, therefore, only be explained by assuming that in certain regions carts carry more and/or work for greater number of days in the year than in others. Such an inference seems to be supported by the great variation in the number of bullocks per cart (line 71). For instance, in the Punjab which produces a sturdy draught animal, there is a population of about 12 animals per cart, whilst in C.P. where animals are small the figure is $3\frac{1}{2}$, a proportion which may at first sight appear to be contradictory. Comparisons of figures for other provinces, specially U.P., Bihar, Bengal and Madras show that there are too many variables to permit of general conclusions. It is revealing that the only average which shows a remarkable uniformity amongst all the Provinces is the figure of average production per head (line 49). The agricultural production for the whole of India, food grains plus money crops, amounts to the low figure of $5\frac{1}{2}$ maunds yearly, barely half a seer of food grains a day per head.

12. Engineers need no warning about the care with which averages are to be used for coming to any conclusion. Thus whilst the average village population, (line 30) should be regarded with caution, the averages in lines 3, 6, 9, 12, 15 and 18 are accurate and interesting and those in lines 24 and 27, practically meaningless. Similarly, the figure of average expenditure on roads, which is the average expenditure per mile for all roads, both metalled and unmetalled (line 59), should be taken as no more than indicating whether a province is hot or cold on its roads, and even then it gives no indication of extent or adequacy of the road system.

13. The moving of agricultural produce is after all the main reason for the existence of the cart and this produce may properly be taken as a fair index of its work. Averaging this produce, especially between high and low value crops, say from bajra to tea, must therefore be accepted with this fact in mind. With this reservation, one would not go far wrong in taking this average as a fair comparative measure of the work that the bullock cart is called upon to perform. It is true, it is not always carrying the final product of farming and is working on numerous other errands in the course of its existence; on the other hand, not all the agricultural produce of the country finds its way to the market or the railway. Indeed, it would appear from the average production of half-a-seer per head, per day, that the major portion of the grain produced must be a subsistence crop.

14. One is not far wrong in assuming as a rough generalisation, that the total extent of rural cart transport is equal to the total agricultural production. This is corroborated by the figure for total goods transported by the Indian railways which averaged 105 million tons annually for the 10 years preceding the war. Of this, about 25 million tons was coal alone. The railway figures are for traffic in both directions, that is to and from the ports, and amount to approximately double the agricultural production of British India. A valuable check on the extent of traffic by cart would be provided if figures were available of the total railway traffic originating and arriving in a district. To ascertain this for each district would perhaps entail too much labour, though it is conceivable that this may be worth while, for instance, for a proper appreciation of road competition or of deficiency in rural communications and similar investigation. It would serve our purpose however if this information was available for districts in which it is proposed to carry out the cart survey. Unfortunately information connected with railways is usually collected and published by systems or units of railways and it is difficult to get figures by areas. Traffic figures even for whole Province are not readily obtainable and it has not been possible, therefore, to give in the annexed table anything but the total railway mileage by Provinces; it has not been possible even to indicate separately Class I and Class II railways.

15. In connection with the railway mileage in each Province, it is interesting to note that the figures of average area of agricultural land served per mile of railway show an unexpected degree of uniformity. This is surprising in the face of the large variations between Provinces in the density of population, in production per square mile, and especially the great variation in road mileage per unit of population or of area. With the exception of Sind, a considerable portion of the railway mileage of which is a corridor to the North, there is also a fair uniformity in the figure of produce for each Province per mile of railway.

16. The railway system of India would seem to be better planned than the road system which shows great variation between the Provinces, in the road available for the same amount of produce or the same numbers of people. It is perhaps in this particular aspect that the warning against averages uttered in para. 12 is most apt. The average of a mile of metalled road per 6.2 square miles of agricultural land would not be considered bad by the standards of other agricultural countries; only it must be remembered that the metalled mileage does not serve agricultural area alone and that the quality of metalled road in one region may be very different from that in another. A curious coincidence is that the average for the Punjab, the Province with some of the best roads in India, should be the same as that for Bengal, reputed to be one of the Provinces most lacking in roads.

17. The average amount of produce, and hence transport, for a bullock cart, is shown to be 250 maunds (line 53); at the highest (omitting N.W.F.P., and Assam), it is 500 maunds and the lowest, 100 maunds. At the most this would mean an average of ten to twenty trips for a cart in a year. This makes one doubt if there is a bullock cart problem. Of course, the problem exists because we have all been concerned, at one time or another, at the havoc caused on roads within our charge by the bullock

cart. But what length of the 70,000 metalled miles of India is subject to this grinding and how many of India's seven million carts are the offenders ?

18. There is no data on which a conclusion can be arrived at or consideration based and all the necessary information has to be collected. Hence the necessity of a bullock cart survey (not census) for India. It is required to know, what types of carts there are, what they carry, how many days they work, how many days they use the roads, how many are the property of professional cartmen, what are the materials and dimensions of their tyres, etc., before a considered opinion can be formed on the extent of the bullock cart problem and the measures to meet it. The Indian Roads Congress has attempted to collect through members of the Council, sketches or diagrams of the types of carts in common use within the sphere of their activities. Sketches for about 60 types of wheels and carts have been received from all Provinces except Madras and from some States and are filed in the office of the Indian Roads Congress. This information is by no means exhaustive, the chief lack being particulars of tare weight and carrying capacity, and it only serves to show the very great diversity of types that may be expected.

19. A census of the six million odd carts in British India to obtain these particulars would mean enormous labour, expense, and a lot of time ; results, however, to practically the same degree of accuracy can be obtained by a properly conducted random sample survey. Mr. Yeatts, Commissioner for the 1941 Census, informs the author that random sampling of 1 in 50 frequently gave results within one-half per cent of the full count. For the purposes of a correct appreciation of the bullock cart problem, no such high degree of accuracy is required.

20. No survey of bullock carts and their working can be complete without particulars of the bullocks also. Regarding their draught capacity, the author is informed by the Animal Husbandry Commissioner that the height of the animal behind the hump is a simple and reliable working index of the animal's pulling power. This height is measured in inches. During the course of survey, it would be a simple matter to enumerate the number of working bulls and their height.

21. If 1 in every 200 of the 6½ million bullock carts in British India is to be counted, over 30,000 carts would have to be surveyed. Assuming that an enumerator can survey four carts in an hour, he would be able to deal with 20 carts in a day, allowing for time to get from village to village. This means about 1600 man-days for the work. If 20 enumerators were employed the count would be made in 80 days, say four months allowing for transfer from area to area, rest days etc. The problem is therefore one of quite manageable proportions.

22. It would be obviously impracticable to so average a census throughout the length and breadth of India that every 200th cart throughout its six million was picked up by the enumerator. Some sort of selection sampling is obviously called for. The problem is how to make such a selection fully representative and at the same time practicable. The object of this paper is to obtain a discussion on the possible means of assuring this.

23. One way would be to pick every 200th village and make a full enumeration of the carts in the selected villages. The number of villages to be surveyed in each of the province, on this basis, with the approximate number of carts, and the time in man-days, would be :

	Villages	Carts	Days		Villages	Carts	Days
N.W.F.P.	150	300	15	Bihar.	350	2500	125
Punjab	180	1700	85	Bengal.	420	4300	215
U.P.	500	5400	270	Bombay	110	3400	170
Sind	30	450	22	Madras	180	6300	315
Assam.	170	350	17	C.P.	200	5600	280
Orissa.	140	900	45	Total	20430	31200	1560

From the above list, it appears that whilst to some provinces like the Punjab and U.P., too little time is given, too much is given to others, say C. P. The following 'weighted' figures may therefore be accepted for the number of days required, including wasted days in each province.

N.W.F.P.	20	Sind	40	Bihar	200	Madras	420
Punjab	200	Bombay	250	Bengal	300	Orissa	100
U.P.	320	C.P.	200	Assam	40		
Total	540		490		540		520

The grouping also shows a convenient way of dividing up the whole continent into four territories, roughly North, West, East, and South.

24. Nearly 2500 villages picked at random throughout India ought to give a very representative sample. It is possible, however, in such an arrangement, an unduly large amount of time is spent in travelling to the selected villages distributed over a whole province. Another method would therefore be to select the villages with some idea of geographic convenience. Though not as strictly accurate as the first method, there should be no material difference in the result if care is exercised to select samples from representative areas.

25. An advantage of either of the above methods would be that a complete count of the bullock carts in a village would be taken and the results compared against the All-India Live-stock Census. The regularity in the totals for several years as well as uniformity and inter-dependence in the figures in this Census may be considered as internal evidence of accuracy. All the same it is advisable to reserve opinion upon this internal evidence until the method of enumeration has been verified. For instance, uniformity might result from extensive copying of the previous record for the purposes of fresh enumeration.

26. A third way of taking the count would be to move quickly from village to village going through more villages, but to take the particulars of a few carts only. In one way it may take more time, as more villages would have to be 'educated' during the process of extracting information, but it may be quicker in another way, in that no time need be taken up on obtaining a thorough count and extracting information.

27. No statistician will accept a sample as representing the whole, unless the results are substantiated by a full count for part of the investigation. Though a high degree of accuracy is not necessary for our purposes, i.e. to ascertain the use and abuse of the road and the remedial measures required, a full count would be useful in establishing accuracy

and to ascertain the reliability of the Live-stock Census. If this is considered desirable, the sampling should be by area or unit, but within such area or unit the count must be complete. There must also be a full count in a larger area or unit which would include a fair number of smaller ones.

28. The choice of method will also be influenced by the amount of information it is desired to collect in addition to the bare physical particulars of the carts, such as details of ownership, extent of professional carting in a village, number of days worked, extent of milage on pucca roads, katcha roads and in farm work etc. Such information can be of the utmost value and the opportunity for obtaining it should not be missed, if a cart survey is undertaken. But zeal should be tempered with discretion, otherwise there is the danger of defeating the object of the census by trying to cram too much into the inquiry.

29. No scheme of statistical survey ought to be launched without first putting through, what might be termed a 'pilot' scheme. This scheme would be a replica on a small scale of the main scheme, or it may be a small portion of the actual scheme. The object is to discover in time, how the scheme will proceed, how labour may be saved at some stage or another, what snags one is likely to be run into and to get an advance picture of the final result so as to plan ahead its analysis and any modification in questionnaire demanded by such analysis.

30. In drawing up a questionnaire it is necessary to bear in mind that whilst the opportunity of making the inquiry as comprehensive as possible should not be lost, this object will not be served by making the questionnaire too lengthy and detailed. It is therefore necessary to decide beforehand what aspects of the inquiry are most essential and then judge what further information can be elicited concurrently without clouding the main objective. The method of asking the question is also almost as important as the question itself. The man to be interrogated will be the village peasant and not only must his mental limitations be kept in mind, but also the villager's natural suspicion of any interrogation. The capacity and psychology of the enumerator or interrogator also requires equal study because on him depends the translation of replies into a factual record. The questionnaire should therefore be as simple as possible, every question should be carefully considered so as to be without any ambiguity. A question should be incapable of more than one construction being placed on its meaning, and must be capable of being answered simply and directly. Questions should be so worded as to invite answers that can be recorded as a figure or a yes or no or as a statement limited to four or five words.

31. In order to judge the abuse, it is necessary to know the use made of the road by the bullock cart, and the primary object of the inquiry would be to determine the use and abuse of the road. It would therefore be necessary to enumerate the following particulars for this purpose.

Tyre material and width,

Weight unloaded, and carrying capacity; possibly, size.

Extent and number of journeys, (on metalled and unmetalled road separately).

To get proper information about tyre conditions, it would be necessary to obtain wheel diameter and method of spoking. Hub and axle dimensions would also be relevant. A mooted point is whether the method of supporting the axle should be enumerated or not. With the type and carrying capacity, it would be necessary to ascertain the number of animals employed for draft and the number of wheels.

32. A secondary, but quite important aspect of the use of the road is the purpose for which the road is used and the type of user. For this, it would be useful to know the proportion of professional cartmen, the proportion who engage in carting in the slack season, and the proportion of owners with more than one cart, also to what extent carts are owned by large land owner and if these are leased to their tenants. Care is specially due under this head, not to make the inquiry too elaborate.

33. A valuable by-product of a bullock cart survey would be a picture of the extent or otherwise to which villages are served by roads. This could be obtained by recording the distance of each village visited from the nearest public road and the length of metalled and unmetalled road traversed before reaching a market town or railway station. What portion of his produce is retained in the village and what portion carted to the market? Questions will have to be carefully worded so as not to confuse the enumerator and so that "wild guesses" by villagers are not recorded as facts.

34. The second most important objective of the survey would be to obtain information on which decision could be arrived at about conversion to pneumatic tyres. Though it may be inopportune to talk about rubber tyres at the present time, development in this direction is bound to come after the war. That it should be encouraged no one will doubt, but to what extent, and whether it should be forced, subsidized or otherwise artificially fostered, can only be decided from such an inquiry. The pneumatic tyre scores in every way, except under wet and muddy conditions. It decreases the draught required and increases carrying capacity, (a) because of the smaller road resistance and (b) because of the more efficient axle bearings. Against this are its initial higher cost, necessity for maintenance, and deterioration when standing idle, especially in a deflated state. When agricultural produce averages only $5\frac{1}{2}$ maunds per head and about 270 maunds per cart, what will the peasant do with the increased capacity? Knowledge on the following points would be a factor in arriving at conclusions:

- How much use in wet and muddy conditions?
- What are the idle periods and of what length?
- Can increased carrying capacity be utilised?
- Particulars of existing axles, hubs, the wear on these, their efficiency, lubricating etc.

35. On the other hand, supposing it were possible to partially rationalize the work of the cart so as to bring the load factor to say 50 tons a year, not an unreasonable figure, two million would suffice for all the cart transportation in India moving on public roads. If the whole of this number were to be put on pneumatic tyres, it should be possible to

produce the complete assembly of axle, bearings, wheels and tyres under Rs. 150/- (The cost of the front axle assembly excluding brake and steering parts, of a 1½ American truck at factory is about 40 to 45 dollars). Would it be profitable and also possible to enforce conversion by means of a subsidy or would it be to the ultimate advantage of the national economy for Government to spend the Rs. 30 crores and make a present of those sets to cart owners ?

36. From the pneumatic tyre, we now come to the consideration of other alternatives for preventing the break up of metalled roads under cart traffic. One method would be to foster the use of the wooden tyred wheel and encourage the use of felloes of greater width. Another one would be to build on rims of treated or untreated wood on the felloe on the lines discussed in Mr. Murrell's paper (I.R.C. No. C/41 of 1941). Concrete roads are another possible alternative, especially if the survey proves that the really destructive cart is found only over a small fraction of India's total milage. No special questions on this subject seem to be called for, as all the information required will probably be elicited by the previous questions.

37. Road Engineers are apt to devote attention to tyres, whilst agricultural engineers lay more stress on the wheel bearing (see Note on bullock Cart wheels mounted on Ball Bearings by Messrs. Patel and Paranjpe, Appendix VII G of the proceedings of the second Meeting of the Board of Agricultural and Animal Husbandry, held at Lahore in December 1937 and the criticism on the paper at pages 100-102). Not an inconsiderable advantage of the rubber tyre is the fact that it enforces the use of ball or roller bearings. The economic advantage of using hubs giving minimum friction is obvious, but the road engineer is also interested in a satisfactory type of hub; the weaving motion given to a wheel by a slack or worn bearing accelerates the damage caused by iron tyres. It would therefore be worth while keeping the wheel-bearing in mind when devising the questionnaire.

38. It was shown earlier (para 17) that the number of trips might average as low as 20 a year. It would make a difference if the period of use of the road is concentrated or distributed, also whether this would be in the wet season or dry. How should this information be collected, should it be enumerated by the season or by the month or should the periods be merely left as wet and dry and the use described as concentrated or distributed? It would be interesting to know if carts carried more in the dry season than in the wet and if heavier loads were carried when travelling on metalled roads than on katcha. The questionnaire might also include an inquiry about the chief obstacles to the satisfactory operation of the cart,—loose surface, mud, sudden humps or dips, nallah crossings in the flood season, steep approaches to these, lack of communications or any other special difficulty.

39. The fulcrum of any investigational survey is the questionnaire, the success of the whole investigation depends on the merit or otherwise of the questionnaire and no care bestowed on the consideration of this can be too much. A tentative *pro forma* of the questionnaire (appendix) is attached; as this is merely meant to serve as a basis for discussion, it errs admittedly, on the side of length. It is more difficult to decide what to

omit than to think out items for inclusion and it is hoped that discussion will produce suggestions for simplifying rather than elaborating. This *pro forma* is in no sense meant as a model and any suggestions for recasting it will be welcome, the object being to produce as comprehensive yet as simple and fool-proof a questionnaire as it is possible to devise.

40. The problem of reconstruction and the development of India's road system will form a very prominent feature of its post-war reconstruction plans. The matter is being considered by the Government of India and also by the provinces. At least one province is well ahead with its post-war road programme. Any road development plan made without proper consideration of the needs of its primary transport would be one-sided. The information sought under the contemplated survey would be valuable for this purpose ; indeed one can say that any assumptions made without some such searching investigation would be suspect.

41. Who should carry out such a survey? Roads and road traffic is, rightly or wrongly, entirely a provincial subject. The provinces are also in the position to know agricultural requirements more intimately than the Centre. At first sight it would therefore appear that each province should undertake a local survey, but such a step, on closer consideration, has little to recommend in it. Eleven different provinces would have to set up as many different organisations, the survey would lack in uniformity and there may be no common yardstick by which results in various provinces could be compared. The experience gained by one set of workers or in one set of conditions would not be available for other places, and both the time and cost would be greater than if one single authority were to undertake the work.

42. The Central Government, at the instance of road engineers, (the I. R. C.) has made itself responsible, through the Central Reserve of the Road Fund, for research in connection with roads. We engineers are inclined to focus our attention on technical research on the fabric of the road and neglect research on the very fact for which the road exists, that is its use. Moreover, whilst research in one country on the technics of the road is useful for road technicians in another country, the problems arising from road usage are special to each place. It is suggested therefore that the Central Government should undertake this survey, but that in carrying out the work the co-operation of the provinces should be invited and the utmost use made of their local knowledge and the facilities that they may be able to offer. As engineers are primarily interested in obtaining this information it is hoped that the I.R.C. will take an interest in the scheme and that its members in the provinces will take an active part in collecting data. The matter is, however, not one entirely for engineers, and it is hoped that the Agricultural and Revenue Department of the various provinces will also assist in making the survey a success.

43. Work of this sort cannot be carried out successfully and never expeditiously, if it is left to someone as an addition to his normal duties. It is hoped that an officer will be placed on special duty to do this work entirely or as part of similar investigational or planning work. This officer might be an engineer or he might equally well be an agricultural or revenue official or an economist or a statistician. It would be a help if he

had experience of census work. This officer would probably require four regional assistants (see para 23) to organise, train and supervise the actual enumerators in their region, direct their work, collect their reports and analyse the replies. The assistants might be some young economists recently qualified, who desire practical experience in investigational work. Or they might be agricultural assistants loaned by provinces; these men would know village and agricultural conditions, they would have been in service and be conversant with organisations and probably better able to direct the survey and get the best out of the time and effort put into enumeration than a raw recruit who may have a higher specialised economics or statistics qualification.

44. The first cog in the machine must be the enumerator. On his capacity to understand what information is wanted and why and then the ability to extract this information from the villager, will depend to a large extent the success and the accuracy of the scheme. These men may be recruited from college graduates or undergraduates studying transport or agricultural economics who may be in need of practical experience, or in need of a field of investigation for their theses. It is doubtful if 20 or 25 such men could be found and the experience of collecting data for the Indian Census or for the live-stock census may be useful.

45. It is also to be considered how the enumerators are to work. As has been suggested in para 43, these enumerators might be revenue, veterinary or engineering subordinates and some may be students. Would it be quicker to work in pairs or singly? Would it be profitable to increase the number of enumerators, using local men in each locality or would it be more advantageous to utilise the experience that fewer enumerators would accumulate as they proceed with their work? The answer will probably be the experienced enumerator with the local patwari, headman, patel or lambardar at his side. The preliminary 'pilot' surveys will serve to provide the correct answer.

46. Attention has so far been concentrated on the bullock cart as transport for primary produce. The bullock cart, however, is used in India for much other transport, though it is hoped that such use will decline rapidly in the future. Perhaps the greatest damage to roads is caused by professional carts transporting secondary products, especially in the vicinity of large towns. There are therefore certain obvious omissions in the foregoing, such as the tonnage of goods imported or manufactured, the major portion of which has to be carried by cart at one stage or other, the need for investigation of special conditions near towns and cities, the need for a parallel check on the use of roads and of the damage caused by carts serving urban needs.

47. India's sea-borne imports amount to approximately 5.6 million tons annually. Though at the port, very little of this tonnage would be handled by carts, at its destination it is likely that a good deal of this is carried by carts. Similarly, India's total manufacturing production which was 10.0 million tons in 1940, must have been handled by carts at the last stages of its journey. One may therefore assume the total amount of goods handled by carts to be about 60 million tons primary produce, plus 15 million tons other produce, plus an unknown figure made up of the needs of road construction, building, industrial needs, civic needs and the internal needs of farming. This figure can hardly be as high

as 25 million tons. The total tonnage moved by carts must therefore be in the vicinity of a 100 million tons or about the same as that handled by railways.

48. The main habitat of the bullock cart is the village, 94.4 per cent of the total being in villages. Though the proportion of the carts working in the urban areas may be small, (5.6 per cent) their number is still considerable, nearly quarter of a million. Moreover, these carts work more intensively than the village ones. It would not be wrong to assume, as a very rough generalisation, that all agricultural product is handled by the village carts and all manufactured and imported products and building materials are handled by the urban carts, because the small amount of agricultural produce going by cart into town, would be offset by the small amount of the other finding its way into the village. This would mean that about 355,000 carts handled 40 million tons annually, or an average of 112 tons (about 3000 maunds) a year. This is a very different story from the average agricultural handling of 250 maunds by village carts (see para 17). One can now begin to understand the heavy damage by carts in the vicinity of towns.

49. There are 76 towns (population 50,000 to 100,000) in British India, and 43 cities, (population over 1 lakh). It would not be difficult to enumerate these 119, with perhaps a few selected ones of under 50,000 population, say 150 in all. These would require a special type of count. In this case it may not be necessary to enumerate the total cart population, and it may be more important to survey the cart traffic on the roads, especially the main approach roads. The questionnaire as designed for villages may suit, after modification, or an entirely different questionnaire may have to be designed. The experience gained by enumerators in the villages would be of only partial use in the cities. In that case should the same enumerators tackle the cities after completing their work in the villages or should the city survey be carried out by other agency? All these towns and cities are bound to have an S.D.O. and many will have an Executive Engineer on the spot. All of them will have municipalities with records such as octroi registers. If an instruction sheet is made out with care, the local P.W.D. officer, ought to produce very valuable information with a little perseverance both in enumeration and in the examination of the municipal record.

50. It is doubtful if one can depend on obtaining voluntary workers for any part of the scheme, except for a limited amount of work of an advisory or directional nature. The enumeration alone will probably take 4 months but before that can start, the staff will have to be educated to the work intended of them say, another 2 months. After enumeration, the results will have to be tabulated. This work may take about 4 months — in practice it may take longer but with a lesser total staff than during the enumeration period. As an average, one may assume therefore that the cost will be that of the entire staff—one officer in charge, four regional assistants, and about 20-25 enumerators, say about Rs. 4,000/- to Rs. 4,400/- a month, including stationery, travelling and other expenses and that the work would take about 9 or 10 months. At the outside, this survey should cost about Rs. 50,000. If the knowledge collected at this cost would enable us to lengthen the life of 20 miles of metalled road, out of

India's 70,000, it will have been more than repaid in one year alone. This represents an expenditure of about $1\frac{1}{2}$ pie for every cart in India, and one may reasonably assume that the result of the investigation will improve the earning capacity of each cart by this modest amount.

51. The proposed survey deals only with the eleven provinces of British India. This is simply because existing statistics are easy to obtain and analyse. The Indian States, however, have no negligible number of bullock carts, possessing a total of 2,422,881 carts. For the sake of interest the following figures of the number of carts in the various states are given from the 1940 live-stock statistics :

Baroda	100,189	Gwalior	160,223	Mysore	33,766
Bombay States	226,331	Hyderabad	561,417	Punjab States	260,809
C.I. States	301,815	Kashmir	3,223	Rajputana	122,566
Eastern States	310,185	Madras States	33,766	U.P. States	21,381

In the case of the States too, therefore the matter is worth investigating. If a survey is ever embarked upon, there is no reason why it should not be extended to at least States with a cart population of more than 50,000, provided these States desire to come into the scheme.

52. A parallel check on road conditions and road data (metalled milage) would be of the utmost use and should not be difficult to arrange, especially as this lies in our own hands. Most of the 70,000 miles of metalled roads in India are under P.W.D. control directly or indirectly. If statistics of existing road conditions were attempted, it would be a simple matter for every S.D.O. to report, through the Executive and Superintending Engineers concerned, information about the roads directly or indirectly under his charge. This report would consist of the milage under various classifications, such as, concrete, tar-mac, grouted, painted, metalled with limestone, trap, quartzite, sandstone, kankar, brick, etc; it would give brief particulars of the ruling crust-width, bank-width; there would be brief remarks on average life and cost of maintenance and brief notes on special features and conditions peculiar to the district or area where necessary. The S.D.O's report may in turn be supplemented by remarks by the Executive Engineer and by the Superintending Engineer. It should not be difficult for engineers to evolve a questionnaire, for use by engineers to bring out information about damage by carts, particulars of lengths so damaged and the causes and aspects of failure.

53. Similar check of the use of these roads by carts is as essential as data on road conditions, but it can only be made by an organised traffic census. The writer is of opinion that road traffic census for the whole of India should be maintained as a continuous record, and for the sake of uniformity and efficiency, it would be the care of a small organisation which would exist exclusively for this purpose and cover the whole of India. It would naturally make use of local resources for a lot of observation work, but its merit would be that of a single unit to codify results in a uniform manner. This is not the place to pursue the matter further, as it might well make the subject of a separate paper.

APPENDIX

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ALL INDIA BULLOCK CARTS SURVEY.

Province.....	District	Taluq.....	
	Village		
Population.	Revenue.	Date of Survey	
Cultivation Area.	{	Wet. acres.	
		Dry. acres.	
		Garden..... acres.	
		Total :— acres.	Forest.....Others.....Total area.....
			M. F. M. F.
Distances	{	from metalled main road	
		or roads.	Metalled.....Unmetalled.
		from Railway station :	
		(name).	Metalled.....Unmetalled.....
		from nearest market :	
		(name).	Metalled.....Unmetalled.....

I. CROPS.

1. Give the area under the various crops (for each kind of crop, information is to be recorded separately under single, double and treble crops.
2. Yield per acre of the different kinds of crops.
3. State the time of :—
 - (1) Sowing and/or transplantation.
 - (2) Harvesting.
 (In the case of more than one crop, state separately the months).
4. Give the total Government taxes under each crop for a year.
5. Give acreage of lands that can raise higher value crops (with particulars of crops), with improved road facilities.
6. Give acreage of additional lands under each crop that can be brought under cultivation with improved road facilities.

7. With improved irrigation by gravity or/and wells, give acreage of additional land under each crop that can be brought under cultivation.

II. CARTS.

8. Please give brief description of the carts. Use separate column for different types.
9. Number of carts owned by Ryot.
10. Number of carts owned by big land-owners.
11. Number of carts owned by professionals.
12. Weight of carts empty. Mds.
13. Weight carried on metalled roads. Mds.
14. Weight ordinarily carried on katcha roads— Mds.
 (a) In wet season Mds.
 (b) In dry season Mds.
15. Track— In.
 (distance centre to centre of wheels).
16. Diameter of the wheel. In.
17. Depth of felloe. In.
18. Width of rim. In.
19. Steel tyres—width and thickness. In.
 (If no iron tyre, say Nil).
20. No. and type of spokes.
21. Diameter of hub. In.
22. Length of hub. In.
23. Inside diameter of metal bush. In.
24. Length of bush. In.
25. Lubrication, type or method. If neglected, please make appropriate remark.
26. Type of axle, brief description and particulars of supports.
27. Length of axle and diameter at ends. Ins.
28. Cost of cart complete. Rs.

29. Cost of wheels only. Rs.
 30. Cost of axles. Rs.
 31. Approximate life of cart. Yrs.
 32. Approximate life of wheel. Yrs.
 33. Approximate life of axle. Yrs.
 34. Total number of working bulls
 in the village.
 35. Height of the animal Ins.
 behind the hump.
 36. Average cost of each Rs.
 draught animal.

AGRICULTURAL CARTS.

37. Number of days in a year that
 carts work.
 38. Give the average distance MLS
 travelled in a year
 (a) On metalled roads.
 (b) On Unmetalled roads.
 (c) Farm tracks.
 39. Are carts leased by big land-
 owners to their tenants or by
 cartowners to poorer farmers—
 state average days leased and
 terms.
 40. Is the agricultural carting dis-
 tributed—
 (a) throughout the year or
 concentrated in parti-
 cular months.
 (b) State the months of
 peak traffic.
 41. (a) No of agricultural carts
 plying for hire in the
 slack season.
 (b) No. of days employed in
 hire work.
 (c) Nature of work done
 on hire, such as carting
 of produce, building
 materials etc.
 (d) Earning in rupees per
 cart, in a year on such
 hire work.

PROFESSIONAL CARTS.

42. State the average number of
 days in a year professional
 carts work.

43. Give the average lengths of travel per day
 - (a) On metalled roads.
 - (b) On unmetalled roads.
44. Give the number of professional cartmen owning more than one cart.
45. What is the total weight carried by professional carts in a year ?

III. GENERAL.

46. Give particulars of the chief obstacles to the satisfactory operations of carts, such as loose surface, mud, sudden humps or dips, nallah crossing and their approaches, gradients, or any other special difficulties.
47. How many additional carts will use the roads if these defects are removed ?
48. How many additional days and miles will each cart work, or additional load it will carry if the defects are removed ?
49. Total quantities in a year carried from villages—
 - (a) To Railway Station. Mds.
 - (b) To market. Mds.
50. Give details of
 - (i) Any periodical markets, fairs etc. held in the village ;
 - (ii) the average number of outside carts coming to the market from neighbouring villages and towns ;
 - (iii) the total value of transactions in each market day.
51. (a) State particulars of any industries in the village, with approximate quantities produced and value ;
 - (b) Give particulars of raw material with quantity

- imported from outside for these industries ;
- (c) Give lengths of metalled and unmetalled roads, used by carts getting the raw materials;
 - (d) Give particulars and quantities of the finished product exported to each place with names of places.
52. Can new industries be opened or existing industries improved by better roads ?
53. Give the average number of idle days with reasons i.e bad communications, weather or lack of materials for transport—
- (a) Agriculturists.
 - (b) Professionals.
54. What are the prevalent rates of carriage per mile per maund—
- (a) On kutchha roads,
 - (b) On metalled roads,
 - (c) Combined.

IV. CONVERSION TO PNEUMATIC TYRES AND OTHER TYRES.

55. Give number of carts with pneumatic tyre equipment, and state who owns them and what work they do, and weight carried, and the number of months the carts stand idle.
56. Give number of cart-owners willing to substitute pneumatic tyres for their carts and on what terms.
57. Is there need for increased capacity per cart for carting produce etc. from and to village ?
58. Are there any other carts with roller bearings ?
Give number; What work they do and the weight carried.

Tuesday, October 15th, 1943.

Mr. Mahabir Prasad (Chairman) Called upon Mr. Vesugar to introduce his paper "proposals for an All-India survey of Bullock-Carts by means of random sampling".

The above paper was taken as read.

DISCUSSION

MR. VESUGAR (Author) in introducing his paper said:—The most attractive feature to me of the Gwalior session of the Indian Roads Congress is the way our interests have ranged from flights of fancy to the daily grind. We have talked about reconstruction when we are united in feeling that this shall not be on the scale of a paltry 50 crores but have argued whether it should be a grudging 100 crores or a solid 300. On the other hand we have kept our feet firmly on the ground; we have discussed the old and humble macadam and are now going to talk about the older and humbler bullock cart. I need not, therefore, apologise for introducing a paper which has no claim to originality or research and which is not a contribution to engineering as a science.

Whilst no engineer denies the destructive action of the iron tyre, it is possible that the total extent of this damage may be greatly exaggerated. Depending upon the extent of this damage the remedy will lie in converting roads subject to such damage to concrete or to converting bullock-carts in certain localities to rubber tyres. We cannot get a clear idea of the solution until we know the problem accurately. Such figures and statistics as are readily available bring out some curious facts and serve, if anything, to increase the perplexity in one's mind rather than solve it. It will be seen from the figures quoted in paragraph 8 (page 186) that there are some very grave variations but at the same time there are also some distinct trends. The amazing thing is that one finds the greatest variation where perhaps one would expect uniformity, for instance the number of carts per 1000 tons produce.

The table at the end of the paper is by no means exhaustive nor should every figure given therein be considered strictly accurate. I notice that certain mistakes have already crept in during printing e.g. Sind (line 7), or Central Provinces (line 48); there may be many others which may have escaped notice. But on the whole the table may be considered to represent a fairly accurate picture for British India as a whole and if it is incorrect in the extent or the assumptions regarding a certain figure, the error is the same for all provinces and the picture is not, therefore, materially vitiated. Uniformity all over India is perhaps only visible in the case of the figures and averages concerned with railways. Not only are the agricultural areas served per mile in each province comparatively uniform, but so are also the figures for population per mile of railway and the produce carried. If this means anything, it shows that the railways have been carefully projected. This may serve as a pointer to us in designing our Road net.

Perhaps, to our shame as road engineers, it may be stated that averages concerning roads are likely to be the most misleading. This is a strong reason for the establishment of a bureau for collecting road statistics. The most uniform figure in the whole table seems to be that given in line 49. Translated, this figure would mean that the total produce all over India is about 1 lb. per head per day, just enough for a bare subsistence leaving very little surplus for money purchases out of agricultural produce.

In para 12 [page 187], I have drawn attention to the danger of making deductions from averages and the danger of oversimplifications of facts. Nevertheless such averages do show broad trends. In paragraph 17 [page 188] it is worked out that the average number of trips for a cart per year are only 10-20. This would mean that the bogey of damage by the bullock-cart is very much exaggerated. All the same we have seen this damage with our own eyes and therefore, there is all the more reason for a statistical survey to find the reason why. If we could come to some final recommendations regarding the lines on which the survey should proceed half the problem will be solved. The next step after deciding the method is to try out the method by means of a pilot survey (we have heard rather a lot about pilot surveys during this session and sometimes I wish I had not coined this word). Before any work can be undertaken it is necessary to decide upon the questionnaire. Admittedly the one proposed at the end of the paper has become too long in trying to make it comprehensive. It has been drafted to make certain that nothing is left out; the difficulty comes in deciding what to leave out.

An important by-product of a bullock-cart survey would be to obtain a picture of the extent to which villages are served by or starved of road and to collect information which would help in projecting future village road construction.

I am afraid statistics are often distrusted. That is no argument that honest investigation of a problem can be carried out without statistics. It is said that truth lies at the bottom of a well, who knows it may lie at the bottom of a statistical table.

Mr. Kynnersley (Bombay):—Mr. Vesugar should be congratulated on bringing out an enormous number of very interesting facts. He may be criticised for taking many of the facts which are not directly connected with bullock-cart, but he has given very valuable analysis at the end. The only trouble is that when I tried to understand this analysis, I got rather appalled with the maze of figures. I do not know whether it is so with the majority of persons. Personally, I do think of traffic in terms of the miles per square mile of area. If you turn to the table at the end, you will see there items 60 and 61, agricultural area per mile of metalled roads and agricultural area per mile of all roads. If you read through these things, you get a certain amount of information, but I suggest to Mr. Vesugar that the meaning of this will be more easily understood in terms of milage of metalled roads, and of all roads per square mile of area.

From an analysis of the figures furnished, it is seen that the milage of metalled roads per square mile of agricultural area works out as under :—

Milage per sq. mile of agricultural area.		Milage per sq. mile of agricultural area.	
1. British India.	0'16	7. Bihar.	0'124
2. N. W. F. P.	0'264	8. Bengal.	0'097
3. Punjab.	0'093	9. Bombay.	0'218
4. U. P.	0'014	10. Madras.	0'333
5. Sind.	0'08	11. C. P.	0'122
6. Orissa.	0'16	12. Assam.	0'082

Madras has thus, the greatest milage of metalled roads per sq. mile of agricultural area.

It is a difficult question to decide, what increased milage the provinces should have, as this depends on several factors, which may not all be applicable, to any one province. We have, however, to decide this on some rational basis. The mass of figures given by the author have to be carefully checked, and analysed, before any general conclusions are drawn.

Mr. N. T. Gnanaprakasam [Madras].—The author of this very interesting and useful paper has invited discussion as to the possible means of securing a fully representative survey of the bullock-cart situation in the country.

I do not think there is any other method than that already advocated by the author, who has considered all possible ways.

If we refer to page 190 of the Paper, we find that three methods have been suggested for our consideration and I would say which I would consider best and why.

In the first two methods, we select about one in two hundred of villages in a District or Province and take a full count in those villages. If we do so, my feeling is that we do not get even one village to represent the different types and sizes of villages. Generally speaking, our villages can be classified mainly as [1] Wet or Delta [2] Dry or upland and [3] Tank or well irrigated, Forest etc. and each class can be sub-divided into at least five groups depending on the size [as determined by population]. Thus there will be at least 3 × 5 or 15 types of villages or towns and unless the count is taken for one, two or three villages of each group depending on the total number of villages in each group, we cannot secure anything like a representative survey.

Secondly, in the first two methods a full count is suggested in the selected villages. It is well nigh impossible to get all the carts in a village together at any one time. Neither do I consider it necessary because we are all aware of the monotonous similarity between the carts of one particular locality which are almost pattern moulded. In a District probably there may be three or four different kinds, varying only

in few dimensions. At any rate, it is so in the Madras Province. Hence much useful information cannot be elicited by a full count of carts, but on the other hand by surveying a greater number of villages more useful information on connected subjects can be got.

The third method has the advantage of giving us a representative or at least a more truly representative survey, provided villages representative of the fifteen or so different sub-groups are selected for survey. This selection can also be made to suit geographical or travelling conveniences, if possible.

To give figures, in Madras Province according to the first two methods a full account will have to be made in seven villages on an average, in each of the Districts. But you know that seven villages can by no means represent the different types and sizes of villages. But according to the third method about thirty villages may be surveyed taking only say 25 per cent. or even 10 per cent. count of the carts. This will give more representative information on all the aspects of the survey and will therefore be more satisfactory, and the extra money, time, and energy spent will be more than compensated by the better results which are bound to follow.

The questionnaire is drawn up in great detail and is therefore very comprehensive but my only observation is that most of the information must be collected and kept ready for the enumerator before he actually visits the selected village. The nature of the information required is such that most of it can be furnished only from official sources *e. g.* the particulars under the 1st group (*viz.*) crops etc. may be furnished by the officers of the Agricultural Department and those in groups III & IV by the officials of the Engineering, Agricultural and Revenue Departments. Again some information, such as the unladen weight of cart under group III, cannot be obtained in the village off hand and must be got through some Engineering official. Hence my suggestion is that the questionnaire may be sent to some local officials in advance for furnishing the information which may be collected and verified by the enumerator.

The questionnaire is composed of very pertinent particulars on which information is sought and it would be prejudicial to the survey if we try to curtail it in any manner or to any extent.

Mr. G. C. Khanna (Punjab) :—I will deal with one point of Mr. Vesugar's interesting and thought-provoking paper in some detail. In paragraph 5, page 185, he has raised the following question :

"The only type of road that will stand up to the heavily loaded steel tyre is concrete, the really sensible wheel for any road transport purpose is the pneumatic tyred one. What should be one's objective then, the concrete road or the pneumatic tyre". In order to answer this question we will have to work out transport costs in relation to road maintenance charges. These have been worked out in detail below :—

If a ton of goods is moved on a road, the total cost of transport

consists of two parts i.e. (i) cost of transport by vehicle per mile per ton of goods carried say C_v (ii) Cost of maintenance of road per mile per ton of goods carried say, C_r .

The total of C_v and C_r should be kept minimum for efficient and cheap transport. For a metalled road C_v or cost of carriage of one ton of goods per mile is about two annas only. The cost of goods on an unmetalled road is about 25 per cent. higher i. e. is about $2\frac{1}{2}$ annas per ton per mile.

Road Maintenance Costs.

It is a common practice to state the cost of maintenance of a road in rupees per mile per annum. This is not a correct method of describing the maintenance cost, as it does not bring into the picture, the traffic intensity on the road.

If A is the annual cost of a road in rupees, and T is traffic in tons per 24 hours, the cost of maintenance of road per ton of goods i. e. C_r is given by the formula.

$$C_r = \frac{A}{365 T} \dots\dots(i)$$

The factor C_r determines the true economical value of a road to the community. The annual cost A is composed of three items (i) cost of maintenance per mile per annum; (ii) amortisation charges for the net capital cost invested in the construction of a road and (iii) interest on residual value of the road.

$$A \dagger = M + \frac{(F - R)r(1 + r)^n}{(1 + r)^n - 1} + Rr \dots\dots(ii)$$

- Where M = Cost of maintenance of road per mile per annum.
- F = Capital or finance invested in construction of road.
- R = Residual or salvage value of road after n years of service.
- n = Life of road in years.
- r = Rate of interest on Re. 1/- per year.

Let us apply this formula to the Punjab figures, and work out the annual cost.

- M = Rs. 1,000/ (Cost of maintenance.)
- F = Rs. 15,000/- (average cost of metalling a road.
- R = Rs. 7,000/- i. e. after a certain number of years the road will become uneven and will require scarifying and reconsolidation to bring it to proper shape. Rs. 7,000/- is the value of soling coat Stone, bajri, etc. that will be still available. It will cost about Rs. 8,000/- to reconsolidate and reshape the road.

* All the figures taken in this article are prewar.
 † The 2nd term in this formula has been taken from Kemp's Year Book 1922 Edition page 5. The other two terms are obvious.

$n = 20$ years. If a road is given a subsequent coat of tar or bitumen, at intervals depending upon the traffic intensity, there is no need to reconsolidate it again. Some of the miles in the Punjab are 20 years old, and their surface is as good as new. Life of the road has been taken as 20 years to be on the safe side.

$r =$ Rate of interest. As money is cheap a rate of 3 per cent. per annum has been assumed. *Money for Haveli Irrigation Project has been raised by the Punjab Government at 3 per cent.

Substituting in (ii) we get :

$$A = \text{Rs. } 1,748$$

$$\text{and } Cr = \frac{1,748 \times 192}{1,000 \times 365} \text{ for traffic of 1,000 tons per day.}$$

$$= 0.9 \text{ pies or say 1 pie per ton mile.}$$

This figure is only 4 per cent. of the cost of carriage by vehicle.

Where the traffic intensity is less, the annual cost of road is reduced by giving subsequent coat of tar or bitumen after longer periods. The annual cost of these miles is therefore automatically reduced.

Roads on which traffic intensity is still lower, can be constructed to cheaper specifications. Soil-stabilized road can be made at a cost of Rs. 5,000/- and can be maintained at a cost of about Rs. 400/ per mile per annum. They can carry a traffic about 300-400 tons a day.

If we examine the figures of expenditure on roads in the United Provinces, where a large mileage of concrete roads has been constructed, we will find that road maintenance costs in terms of ton-miles of goods carried are even lower than in the Punjab.

A concrete road costs about Rs. 25,000/- to make; has a life of about 20 years and will have a residual value of about Rs. 12,000/-. If the road wears out after the period, it will be necessary to give a heavy coat of tar or bitumen. Its maintenance cost is about Rs. 150 per mile per annum. Substituting these figures in formula (ii) we get,

$$A = \text{Rs. } 1383 \text{ or Say Rs. } 1400$$

$$\text{and } Cr = 0.73 \text{ pies per ton mile for 1,000 tons of traffic.}$$

A concrete road can take a traffic of about 2,000 tons to 3,000 tons per 24 hours without any detrimental effect. The value of Cr works out to about 0.4 pies where traffic is about 2,000 tons.

We thus find that extra cost of metalling a road is only 0.5 to 1.5 pies per ton-mile of goods carried, and the extra cost of carriage by vehicles on an unmetalled road is 6 pies per ton mile.

*Finances and Economics of Irrigation Projects by Kanwar Sain, I.S.E., Director, Central Designs, Haveli Project. Paper No. 228, Punjab Engineering Congress.

The public thus incur, on its motor vehicles an expenditure which is 4 to 6 times that would be incurred on metalling a road.

If a toll is levied on new roads, it would be a commercial proposition for the Government. The amount of tax imposed on a vehicle should be less than the extra cost of running it on an unmetalled road. Let us examine whether roads are a success from financial aspect. Suppose there are two towns 32 miles apart, which are to be connected by a metalled road. The cost of metalling will be—

$$32 \times 15,000 = \text{Rs. } 480,000/-$$

The saving in cost of carriage on account of metalling the road will be 6 pies per ton-mile. Out of this sum of 6 pies let us assume that the Government levies a toll at the rate of 4 pies per ton-mile, leaving a balance of 2 pies for the encouragement of traffic. The gross earnings for the whole year with a traffic of 1,000 tons a day will be—

$$\frac{1000 \times 32 \times 4 \times 365}{192} = \text{Rs. } 2,43,000/-$$

The annual cost of the road for 1,000 tons of traffic will be

$$32 \times 1750 = \text{Rs. } 56,000/-$$

The total gain will be Rs. 1,87,000/-.

Deducting overhead expenses, the net yield will be 30 per cent. over the amount invested.

Where the traffic intensity is less, the annual cost will also be less. The profits will be reduced undoubtedly, but there will always be a sufficient margin. For instance, if the traffic on the road is only 500 tons, the income will be 15 per cent. If the traffic is only 250 tons, and we construct a road with black top, the yield will be 4 per cent. If a low cost road i.e. soil-stabilised road is constructed for such a low intensity of traffic, the income will be about 12 to 15 per cent.

The Irrigation Projects which yield 4 to 6 per cent. on the capital invested, after ten years of working, are considered "Productive"* and no Government ever hesitates to take these up.

Design of Road Crust.

Knowing the intensity of traffic that is likely to come on a road, it is now an easy matter to design the most economical type of road crust. The main consideration is, that value of *Cr.* should be kept minimum. If *Cr.* is assumed to be 1 pie per ton mile, the annual cost of different types of roads in terms of traffic using the road are given below :—

* Public Works Account Code Appendix Page 216.

Serial No.	Traffic intensity.	Annual cost of Road in Rs.	Proposed Road Crust.	Remarks.
1	Up to 100 tons	Rs. 200/-	Earth road.	For lower intensity of traffic, value of Cr will be more than 1 pie per ton mile.
2	100 to 300 tons	Rs. 200/- to Rs. 600/-	Stabilized soil road crust or brick track-ways.	do do do
3	300 to 700 tons	Rs. 600/- to Rs. 1400/-	Metalled road treated with tar or bitumen.	do do do
4	700 tons or over	Rs. 1400/- or more, depending upon traffic intensity.	Concrete road.	Value of Cr will be reduced for higher intensity of traffic.

Now I deal with the question of concrete roads versus pneumatic tyred carts.

In a general way it can be stated that where traffic intensity is low, it will be more economical to have carts with pneumatic tyres. Where the traffic is heavy as in towns, it will be cheaper to have concrete roads.

This generalisation can be proved by analysing costs of maintenance of a pneumatic tyred carts. We will have to make certain assumptions.

(1) The extra cost of maintaining a pneumatic tyred cart is about Rs. 30/- per annum.

[2] *Carrying capacity of the cart.* This varies from District to District. On an average 0.75 of a ton may be considered as the carrying capacity of a cart. "Casual observation in all parts of the country gives the impression that the general capacity of a cart averages less than 15 maunds". The load capacity of pneumatic tyred cart is not increased on account of pneumatic tyres, but on account of improved axles, and bearings. A solid tyred cart with ball bearings will be as efficient as a cart with pneumatic, tyres.

[3] *Distance travelled in one day.* A cart can travel fully loaded a distance of about 10 miles each day. On a particular day, it may travel more, but it is difficult to maintain an average more than this.

(4) A cart works for about 300 days in a year allowing break down, holidays to the cartman, etc.

The extra cost of carriage by pneumatic carts is $\frac{30 \times 192}{10 \times 300 \times 3/4} = 2.5$ pies per ton-mile.

Some Local bodies who have heavy traffic on their roads have either banned the use of solid tyred carts, or encourage the use of pneumatic tyred carts by remitting taxes, as they find that solid tyred carts are destructive to their metalled roads. It has been shown above that concrete road is more economical than other types of metalled road where traffic intensity is about 700 tons, or more. Where the traffic intensity is less, the extra cost of making a concrete road over any other type of metalled road is about 0.3 to 0.5 tons per mile. This figure should not be confused with *Cr* which is the extra cost of making a metalled road over an unmetalled road.

Thus while extra cost of making a concrete road over other types of metalled road is 0.3 to 0.5 tons per mile where traffic is in the neighbourhood of 400 tons per day, and is nil where traffic intensity is 700 tons per day. The extra cost of running a pneumatic tyred cart is 2.5 pies per ton per mile.

It will be at once apparent that where traffic is heavy, pneumatic tyred carts afford an uneconomical solution to the problem. It is cheaper to construct a concrete road, and allow all types of traffic.

Where traffic intensity is low, and a road cannot be maintained at a cost of 2.5 pies per ton mile, the pneumatic tyred cart will be more economical. This cart has a considerable scope on village roads where traffic intensity is about 50 tons a day. A very considerable proportion of road milage of India carries this traffic.

Mr. M. A. Rangaswamy (Bihar):—The author of the paper has, in suggesting the questionnaire for an all-India survey of the bullock-carts, raised many interesting points in his paper.

Bullock-carts are the primary means of transport in India. The steel tyre wheel of the bullock-cart has a destructive action on the road surface (paras. 1 and 2 of the Paper, page 185). Every one will agree with the author for what is stated above.

What length of 70,000 miles (metalled) is affected by the carts and how many of 7 million carts are responsible for this? What is the extent of use of the road by the bullock-cart? Whether professional carts use them most, or the village carts carrying agricultural produce use them most? What are the possibilities of converting the wheels of ordinary bullock-carts to pneumatic ones? Is there a possibility of improving the wheels on the lines indicated by Mr. Murrell?

To answer the questions raised above and to find out, if there is really a bullock-cart problem, the author suggests a bullock cart survey.

I think that the main problem is to have a traffic census, and a continuous record of the intensity of traffic both of bullock-carts and other fast moving vehicles should be maintained. If this is done, one can easily find out what particular areas would need special treatment in road surfaces and what areas would need ordinary surfacing. There have been a number of experiments made for the last 15 years to give us an indication as to what type of road surface would suit particular kind of traffic. The I. R. C. in my opinion should lay down standards,

specifying certain kind of surfaces, for particular traffic intensities and segregation of bullock cart traffic and provision of creteways etc. as the situation may demand.

The cart survey, as it is suggested now, will no doubt help to gather a mass of information, on the type of bullock-cart now in existence, their period of work etc. but this information, at best, will serve to indicate the intensity of traffic at any particular time, at any particular place and possibly will help to find the information, needed, when the time comes for converting them to pneumatic tyred ones. It may serve to show the extent to which the villages are served by the road, and this was stressed by Mr. Kynnersley in his talk about the Pilot Road Schemes. For future reconstruction of roads, the main points we have to take into consideration is what type of road construction should there be, where there is heavy concentration of bullock-cart and other fast moving vehicular traffic? Will segregation of the carts in these areas by cement concrete creteways be desirable? What type of change should there be in the technique of construction to take the bullock cart traffic, in case, it is not possible to eradicate the use of the steel tyre, even by legislation or substitute the same by pneumatic tyre?

The proposed bullock cart survey, as is envisaged, will doubtless answer this point too. As regards the possibilities of improvements of the wooden wheels, there is no doubt that great possibilities exist; you have seen the exhibits of wheel, outside the building designed and tested by Mr. Murrell and with persistent effort and encouragement, and more discussions in the congress, time is not far off when really cheap and efficient types of wheel could be evolved.

Under item II carts, page 200, serials 37 and 38, it would be difficult to collect the information. Items 40 & 41 would answer the purpose, otherwise the questionnaire is exhaustive.

Mr. Ghose (Bihar).—We must do away with the offensive thing, the bullock-cart. Most probably, after the war, they will naturally be done away with. All the pneumatic tyres and vehicles that you see are surely not going to be wasted. After the war, someone like Tatas is going to buy up all these things and start a public carrier business. These carriers using lorries and buses will automatically kill bullock-carts by bringing all produce etc. from villages to markets, due to faster movement of transport.

It might be of interest to students of colleges to get these data which Mr. Vesugar has pointed out. In the Indian Science Congress, there is such a membership, and they can submit their papers through a permanent member. Some similar thing will help the Indian Roads Congress also.

I would add another thing. After the war, we will have more synthetic rubber, and I think in the Punjab and other places the cattle population is being decapitated. About 15 cows are required now to give you milk for chota hazri. Same is the case with bullocks. In China, they ate their bullocks, and there was no bullock cart problem. They are likely to disappear, and so we must have the survey quickly.

Rai Sahib Fateh Chand (U.P.)—My qualification for speaking on this Paper is that I was born in the village and brought up there, have served for 24 years in the villages. I appreciate the interesting

figures that the author has collected. But these can be of little help, I am afraid, to the Road Engineer. As I live in a village, I know what carts use the roads and what carts do not. In the aggregate, 94.4 per cent. of the carts live in villages because it is cheaper to maintain the bullock there. I must say that 90 per cent. of these do not use the roads at all. The carts in the villages are of two types, one long and the other a small one which I might call a single seat cart. The latter is meant to take those people to bazar etc. The long cart is meant to bring produce from fields to the village. They do not take that produce to the towns. The banias etc. come and collect these and take them to towns and cities in the 5 per cent. carts kept in the towns themselves. So no idea can be formed by taking a census of the population or quantity of grains etc. which is produced. Then it depends on mills and similar industries. If it is a sugar-cane area and there are mills, traffic on roads would be very heavy. This solution would be erroneous. My suggestion is that the survey should be of iron tyred and non-iron tyred carts. It is this number of iron-tyred carts which matters. Some 10 per cent. carts might use a road 30 times whereas other 90 per cent. might not use the road at all except when they go to melas etc.

Another point is that we can do a lot by regulation of traffic. The damage done is great, but the percentage of carts which cause them is small. If we can manage that percentage, we will be able to solve the problem. We allow only light traffic on service roads. In the same way, we can regulate traffic on other roads. If you once put a cart on a particular route, it will follow it always. This remedy of regulating the traffic has been tried in several districts successfully, particularly with reference to light traffic.

Another point is pneumatic tyres. They are taking the place of iron tyres because they can carry much more at much less cost. It is also a fallacy that a pneumatic tyred cart cannot go where an iron tyred one can. Also these tyres wear out much less.

Mr. A. S. Adke (Bombay).—I congratulate Mr. Vesugar for his very interesting paper. I was also born in a village. One point which was very clear from the Paper was that statistics available in India did not provide the details necessary to enable the bullock-cart problems to be properly tackled. It is very difficult to make plans when we do not know exactly how much damage was being caused by bullock-carts. I, therefore, suggest that we should turn to para. 42, page 194 of Mr. Vesugar's Paper where he suggests that the Central Government should undertake a survey on the lines suggested in detail by him, and that this Congress should pass a suitable Resolution asking the Government of India to have this work put in hand.

Mr. Abdul Aziz (Punjab).—In para. 39, page 193, Mr. Vesugar has called for suggestions for simplifying the proposed questionnaire. In my opinion, questions 5, 6, and 7 can be safely omitted. The information desired in question 5 is the acreage that can raise higher value crops with improved road facilities. The cultivators are not much influenced by road conditions as far as the growing of staple crops such as bajra, jowar, wheat, rice and cotton is concerned. It is the cultivation of perishable crops such as vegetables and fruits which can be extended when the facilities for the disposal of such produce are improved. The percentage acreage under these crops is very very small and its increase or decrease

depends primarily on irrigation conditions more than on road conditions.

Question No. 6 is about acreage of additional land under each crop that can be brought under cultivation with improved road facilities. Here again in order to bring additional land under cultivation it is the improvement in the irrigation conditions that is primarily desired.

Question No. 7 deals with the acreage that can be brought under crops but with improved well or gravity irrigation. I am afraid that to collect the above information will be rather a confusing job for the enumerators and the results obtained will be guess work. At present (and I am speaking of the time after the War also) the financial difficulties in the way of any general improvement on a large scale, of the well irrigation in the well irrigated areas are practically insurmountable. Similarly, it will probably be not of much help as far as the bullock-cart problem is concerned to hazard guesses on the possible development of areas for which there are Government Irrigation Schemes under consideration or in hand. For the present the survey should best be of the present bullock-cart traffic conditions.

Questions 47 and 49, page 201, will also be difficult for the enumerators or the cart owners and Lambardars to answer as the enumerators will have no data or definite observations to go by. Now in the North West of the Punjab the bullock-carts are conspicuous by their absence in most parts of Attock, Mianwali, Jhelum, and Rawalpindi Districts. Villagers are not at all cart-minded, admittedly chiefly due to the peculiar topographical nature of their country. Here the donkey and camel have still undisputed sway. It will be very hard to say, and even if a guess is made, it will be of no statistical value, as to how many carts will appear if the village roads are improved; hence questions 47 and 49 are suggested to be omitted.

Question No. 28 on page 199 is about the cost of a cart complete. The figures of cost will be required for *plain carts*. In the Colony Areas of Lyallpur and Sargodha Districts, I have seen ornamental carts owned by many zamindars costing as much as Rs. 1,000/- although the plain cart would cost only about Rs. 300/-. The additional cost is incurred on embellishing the wood work by sticking on brass and copper plates stars etc.

The questionnaire is exhaustive and it is difficult to say whether any information can be omitted.

Mr. Murrell (Bihar).—Mr. Vesugar has given us an exceedingly thoughtful paper. I must confess that my first impression was that the survey, if carried out, would result in collecting more information than one human mind could usefully employ.

As pointed out by the author, however, this matter of the bullock-cart concerns not only the road engineer, but all administrators of agricultural, veterinary, forest, mining, and other interests who have at heart the prevention of waste and the increase of efficiency.

What a pity we never had such a paper as this years ago. In that case we would perhaps by now have definite information on which to design post-war road surfaces.

To have the best possible programme for post-war road work, we must provide good rather than expensive roads. A good road is that which serves the purpose with the least expense in construction and maintenance. An unnecessarily high and expensive type is a bad road.

Thus the Engineer should be able to say to the Administrator "I will see that you get good roads if you will obtain legislation to prevent undue wear and tear".

Before we can decide properly what wear and tear is undue, we should have the information made fully available by a survey of bullock-carts.

A paper like this need much more than discussion in the Indian Roads Congress. It needs following up. Here again I suggest the formation of a "Bullock-cart wheel Committee", or simply a "Bullock-cart Committee" of the Indian Roads Congress to take up this matter, with the least possible delay, with the Central Government, as also the question of large-scale experiments on the broad wooden tyre.

We must have that Bullock-cart Committee.

Mr. Lokanatha Mudaliar (Madras).—I shall start my comments by stating straight-away that I am a believer in the pneumatic tyres for the bullock cart used regularly and constantly on transport, as distinguished from the villager's cart used for joy rides and on occasional transport.

There is a fallacy in working out the cost of pneumatic tyred carts basing the calculation on taking the present costs. I wish to draw attention to the difference between ephemeral costs and permanent value. Costs change fast, with world events. If the Government decide, it ought to be possible to make tyres cheap enough to be practical. The economy in cattle and labour by the use of the pneumatic cart has been ignored. It was mentioned by a Food Adviser to Government that 800 carts of the present type would be required to haul the goods equivalent to one train. He added that the paucity of carts and the condition of the roads made transport of food-stuffs difficult.

If we had developed the pneumatic tyred carts, we would be saving 75 per cent. of this number, for producing food in the field. I had made 43 pneumatic tyred water carts in a District Board to supplant lorries for road watering purposes. These carts were later used on famine works and proved their immense use as also established the fact that these carts could be taken on all sorts of cart-tracks. Pneumatic tyred carts are used by Municipalities and Mill owners to great advantage.

I made a number of experiments on improved bearings of the steel tyred wheel but results were not encouraging and led to the conclusion that the pneumatic tyre is the *sine qua non* of improved bearings. So the pneumatic tyre is to be welcomed for the mechanical efficiency furnished by it.

In the survey the cost of maintenance of cart per ton should be given preference to and abridging the many other details about cost.

Mr. Ali Ahmed (Assam)—Mr. Vesugar deserves great credit for the useful facts and figures collected by him and compiled in his paper. At the beginning of his paper he has, however, made a sweeping statement with which I cannot but differ. He says "Every ton of produce moved in India, whatever its ultimate destination or method of transport must travel by cart for the first stage of its journey". I am sure he would not have made this statement if he had not postponed his proposed tour of Assam during the last month. In Assam particularly in the Surma Valley districts agricultural produce is carried either over the shoulder of the villager in a "*Bainji*" or in small boats by water routes before it reaches the weekly *hat* or market, from whence the traders remove it either by motor transport or by boat to large towns or Railway Station. Some twenty-five years ago there were hardly any carts used in transport in the Surma Valley, the same applied to other districts of Eastern Bengal, the main reason being that water-borne transport is both cheap and easy and boats carry the greater part of the produce in its initial stages and a good deal of long-distance transport is also feasible by large boats and steamers. In these areas, therefore, the bullock cart does not play the part which it does in other parts of India and this explains the reason why the number of bullock carts is comparatively small in Assam.

The statement made in para. 9, Page 186 of the paper that "the abnormally low cart population in N. W. F. P. and Assam and to certain extent, Sind, can be explained by the nature of the terrain which either due to mountainous, desert or dense jungle conditions, militates against agricultural exploitation of the land", needs modification, for while this could apply to carts per square mile, it could hardly do so in regard to carts per 1000 persons as these ratios could not be affected by presence of mountains, deserts or dense jungle where there is no population. In the case of Assam it is mainly due to cheap water-borne transport that the number of carts is so small, and it is difficult to apportion the fraction of produce which is carried by carts.

In paragraph 34, Page 192, Mr. Vesugar has stated that agricultural produce averages 5½ md. per head. It can easily be inferred from this that damage to roads due to steel tyre bullock-carts occurs only where such traffic is concentrated near towns and railway stations. The concentrated cart traffic near Lucknow where loaded carts come mostly inward is an example and here as we had seen during the Roads Congress at Lucknow, separate concrete strip had been provided at the sides, for bullock carts, whereas the main central carriageway was black-topped for the use of motor traffic. As the problem of an All India Bullock-Cart Survey is of stupendous dimensions, I think it will be sufficient if attention is concentrated to those areas only where bullock-cart traffic is extensive due to their industrial importance or location of trade centres. This limited Survey can, I believe, go a long way in determining the dimensions of the problem which the road engineers have to face for devising ways and means to reduce the damage to road by bullock-carts.

Mr. VESUGAR (Author) replying to the speakers and winding up the discussion said :—

Mr. Gnanaprakasam has made a definite suggestion that alternative 3 may be followed in collecting the statistics and has shown why this is the only possible method in Madras. I wish he had not approved of the questionnaire so whole-heartedly and instead suggested drastic reduction.

Mr. Khanna makes a very interesting and economically sound suggestion, that in considering the movement of goods the incidence of the cost of haulage should be considered in conjunction with that of constructing and maintaining the "permanent way". His conclusions on the types of roads justified according to the intensity of traffic, are interesting. The development of this theme would need a paper to itself and I hope he will write one some day. The conclusions about concrete road surface versus rubber tyres is illuminating, and I have no doubt that these indicate the way towards a possible solution.

Mr. Rangaswami feels that what is required is a traffic survey and not a bullock-cart survey. I am afraid I cannot agree with this. A traffic census would have to be over the whole year and over 200,000 miles. I cannot see any means of doing this by either random or selective sampling. Further, a traffic survey may serve for the limited purpose of deciding on types of road crusts but the same result could be obtained through a cart survey with the additional advantage in the latter case that a complete picture of the problem of primary transport in India would be obtained at the same time. The results required by a traffic census should be possible, under the "self-help" scheme suggested at the end of the paper in paras. 52 and 53.

Mr. Ghosh mentioned that in China they ate their bullocks and thus there was no bullock cart problem. He hoped that transport will be quickly mechanized. I may mention that in Russia they killed off their horses for another reason with the result that, although millions of people died owing to the ensuing famine, an enormous number of tractors and combines came into being. I trust mechanization especially of transport will come into India soon as a process of evolution and without any suffering to the people. However so long as the bullock is required for drawing the plough, the bullock-cart will also remain as a means of primary transport. I am informed on very good authority that a reduction of the cattle population and concentration on improvement in breed both for draught and for milk would give a much stronger net animal power than at present. This is, however, outside the purview of the road engineer. Mr. Ghosh has also made a good suggestion about interesting college students in road matter. I would go further and suggest a drive to make each school and college adopt a particular road or group of roads not only for improving the physical aspect of communication but also for promoting road and traffic-mindedness.

Mr. Abdul Aziz has pointed out that with the improvement in transport conditions, it is not the acreage which increases but the character of crops. This is obvious and we may, therefore, omit from the questionnaire the numbers he desires to cut out.

It was pleasant to hear Mr. Mudaliar speak from practical experience of working with pneumatic tyred carts. His experience about bearings is valuable. He has come to the conclusion that it is a waste of time trying to improve wheel bearings and the correct solution lies in having pneumatic tyres with the type of hub that goes with this kind of wheel. I have always suspected this and I am glad it has been substantiated from experience.

Whether this suggested bullock-cart survey comes off or not, I hope we shall make the efforts to gather the information required for sound assessment of this problem that lies in our own power to collect. As pointed out at the end of the paper to get these statistics does not entail any serious amount of extra work, I hope, therefore, that a beginning will be made at least with our trying to help ourselves.