

SUPPLY OF ROAD METAL IN THE PUNJAB.

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Introduction—Quarrying—Distribution—New Quarry Sites—Selection of stone—Limestone—Other stone.

Introduction.

The following paper is an attempt to indicate the resources of the Punjab in the matter of road metal, and the method of its distribution to the Public Works Department, District Boards and Municipal Committees.

In 1920 the estimated quantity of road metal, excluding *kunkar*, required by these authorities for maintenance of roads amounted to 7,600,000 cubic feet, to which must be added an unknown quantity for new construction. This figure does not include the requirements of the Railway, the Irrigation Branch, or the Military Works Service as these are outside the scope of the present paper. As, year by year, the mileage of metalled roads increases and the standard of maintenance rises the demand for stone metal will steadily increase.

Up to April 1921 each official requiring road metal made his own arrangements with the result that competition arose in a restricted market. The effect of this was that the rates increased and very few obtained as much as they required. In addition to this the fluctuating demands of various authorities prevented the best use being made of the railway facilities available. The Punjab Government, therefore, appointed a special officer to control the whole of the supply to the Roads and Buildings Branch of the Public Works Department and such of the local bodies as cared to avail themselves of his assistance, and to arrange with the Railway Administration for the necessary transport. This officer is known as the Quarry Engineer, he was appointed in October 1920 and on April 1st, 1921, took over control of Sarai Kala quarry, which is the chief source of supply. The effect of this unity of control was that the rate for road metal free on rail at Sarai Kala, which up to that date had ranged from Rs. 8 to Rs. 10 per 100 cubic feet, dropped immediately to Rs. 7-4-0, at the same time the quality improved, and there is every prospect that all will receive as much road metal as they require during the year 1921-22 instead of only a fraction as they did in 1920-21.

Quarrying.

The method of obtaining the metal is similar in all quarries. A contract is let for supply of road metal loaded in railway trucks, and the rate includes quarrying, breaking, carrying to the railway

and loading. In most quarries the stone is measured in the trucks and 1-13th is subtracted to allow for the unevenness of the surface. Where a weigh bridge is available the trucks are weighed and a factor applied to convert the tons to cubic feet. The contractor gets the various operations done by piece work. The stone is quarried from the place which seems to the workman to be the most convenient, and no attempt is made to take advantage of the slope of the strata. The breaking is invariably done by hand, the specification being that the stone shall pass a 2" ring.

A beginning is being made at Sarai Kala with the installation of stone crushers and tramway, and if this experiment is successful it will no doubt be extended. No pneumatic drills have been installed yet, but it would probably pay to install them. It was intended to make arrangements for the automatic loading of trucks and the use of hopper trucks, but as the stock supplied usually consists of covered wagons which would otherwise be returning empty, these proposals have been dropped.

Distribution.

The distribution throughout the Province, by railway, of the large quantity of stone involved amounting as it does to 19,000 wagon loads, requires careful organization and close co-operation between the officers in charge of the quarries, the Railway Traffic Department, and the consignees. As the Railway does not undertake the storage of stone the quantity loaded daily at the quarry should not be greater than that which can be carted away daily at the destinations, otherwise congestion occurs, wharfage charges accrue and the smooth passage from quarry to roadside becomes disorganised.

It has been found that the best arrangement is to despatch the same number of wagons each day from the quarry. These are sent in batches of five to different stations. Wagons are not as a rule despatched to the same station two days running as, if this is done, the two consignments are liable to arrive together, causing congestion.

The metal is carried from the railway to the roadside in country bullock carts, a method which is both slow and expensive. The Government have purchased a few lorries and trailers which will probably be of value for distributing metal for renewals; it is possible, however, that in the case of new construction, a tramway may provide the most economical solution to the problem.

New Quarry Sites.

In order to meet the large and growing demand for road metal it is necessary, besides working the existing quarries to their full capacity, to open some new ones, in selecting which there are three main conditions to be met.

One is that the quarry must be so close to the railway that the stone can be placed on rail at a reasonable cost. The transport of the stone from the quarry to the railway by bullock carts, camels, or donkeys is usually too expensive. Either a siding must be run into the quarry or some mechanical device adopted to transport the stone from the quarry to the railway.

The second condition is that the quarries should be distributed through the Province as much as possible so that the lead on the railway shall be a minimum. The cost of the road metal from various quarries free on rail at Lahore Junction is given in the appendix from which the large effect of the railway freight on the total cost will be apparent.

Selection of stone.

The third condition is that the stone must be suitable for road metal. In the past *kunkar* has been much used ; it makes a smooth road and is excellent for very light traffic, but smoothness, however desirable, is bought at too high a price if the road must be remetalled every two or three years. It is anticipated that in a few years only unimportant local roads will be metalled with *kunkar*.

In selecting a stone to take the place of *kunkar* the tendency has been to choose limestone on account of its excellent binding qualities. It crushes under the roller and so is easily consolidated. But a stone that can be crushed by a ten-ton roller has little chance of standing the grinding action of bullock or the pounding of lorries. This is exemplified on the Grand Trunk Road where Sarai Kala stone is used. Many of the miles on this road have to be remetalled every five years, although the traffic is light compared with what may be expected in the next few years.

A road to bear heavy traffic must be made of hard stone, but when this has been attempted in the Punjab, difficulties in consolidation have been encountered. These difficulties are not insuperable, but until they have been overcome, limestone will remain the most popular material.

Limestone.

The chief outcrops of limestone near the railway occur in the hills between Rawalpindi and Campellpur ; in the Salt Range ; at Salogra about midway between Kalka and Simla ; and east of Kalka.

Between Rawalpindi and Campellpur there are quarries in the Nummulitic limestone at Sarai Kala and Hassan Abdal which yield dark grey fine grained limestone, the most popular road metal in the Province. The development of these quarries is dependent

on the capacity of the railway, which, although it is the link between India and the North-West Frontier, and serving a large area, consists only of a single line whose capacity is limited by heavy grades. The quarry at Sarai Kala is worked by the Quarry Engineer; that at Hassan Abdal, by the Wah Stone and Lime Quarry Limited which is installing modern plant to be driven by electrical energy from the generating station in connection with the cement factory there.

The Salt Range is tapped by the Railway Engineering Department at Pai Khel near Mianwali, and by the Irrigation Branch at Garibwal (sometimes called Bhaganwala) near Pind Dadan Khan and at Tarki. By the courtesy of the officers concerned stone for roads is obtained from these places when it can be spared.

The advantage of Pai Khel is its accessibility from Multan and surrounding districts, but, as much of the stone is obtained from the bed of a *nullah*, it is liable to vary in hardness and thus make a rough road. Owing to the fact that the sidings are laid in the bed of a *nullah* this quarry is closed during the monsoon.

At Garibwal also the stone is obtained from *nullahs*. As the boulders are small and mixed with sandstone the road metal has rounded surfaces and is uneven in quality. This quarry is not, therefore, drawn upon except in emergency but the Government has under consideration a scheme for opening a quarry near Garibwal in the Nummulitic limestone from which the boulders are derived.

At Tarki, on the North-Western Railway main line between Jhelum and Rawalpindi a grey fine-grained limestone is quarried from the hillside. This is the nearest quarry to Lahore from which limestone is obtainable, but the saving in freight is effect to a large extent by the heavy siding and shunting charges, and development of the quarry is limited by the capacity of the railway in the same way as that of Sarai Kala.

The geology of the Salt Range is of great interest, but is outside the scope of this paper. A short sketch of the subject may be found in *The Imperial Gazetteer of India, Punjab, Volume I*, and a fuller discussion in the *Memoirs of the Geological Survey of India, Volume XIV*.

A quarry is not likely to be opened at Salogra as the cost of freight on the Kalka-Simla Railway is prohibitive. Another difficulty, though not an insuperable one, is the break of gauge at Kalka.

There is another outcrop at Mallah about eight miles from Chandigarh. It is possible that this may be developed for road metal, but its distance from the Railway is a disadvantage.

Other stone.

Stone, other than limestone, is obtainable from the Salt Range, Sakhi Sarwar beyond Dera Ghazi Khan, Pathankot, Devi, about five miles from Bhiwani, and the neighbourhood of Delhi.

The only sources of supply in the Salt Range at present being worked are *nullahs* at the foot of the hills. Some fine grained quartzite is found in a *nullah* near Garibwal but it is mixed with inferior stone. Should the demand arise it might be possible to open a quarry in the formation from which this stone is derived.

The stone at Sakhi Sarwar is 40 miles from the railway. The cost of transport over this distance, even by tramways, is prohibitive. If ever the railway is extended in this direction this stone might prove useful.

Quartzite boulders are obtained from the bed of the Chukki at Pathankot. These when broken to pass a $1\frac{1}{4}$ " ring and well consolidated make a very durable road; but, owing to the hardness of the stone, roads composed of it require careful maintenance to prevent them becoming loose. Owing to its proximity to Amritsar and Lahore and the surrounding districts in which the demands for road metal are heavy, it is anticipated that this will be an important source of supply especially when cement or bituminous concrete roads are adopted.

Samples of nearly all the stones in use, or proposed for use as road metal, were sent to the Director of the Geological Survey of India. The stone at Devi (near Bhiwani) is the only one on which he reported really favourably. It is an igneous rock of the acid type obtained from a small hill about five miles from Bhiwani. It is not being worked at present, but in spite of its distance of five miles from the railway it will probably be of importance when road development in the Hissar District takes place. It may even be found desirable to send this stone to other parts of the Province in spite of the disadvantage of the break of gauge on the railway.

The stone in the Delhi District is of importance as it is the only stone in or near the southern portion of the Province which is near the broad gauge railway line. It is a hard blue stone known as Alwar quartzite and is used on the roads in Delhi and the surrounding districts. The binding material is an earthy *bajri* which is found with the stone. The most convenient place to open a quarry for this stone is at Tughlakabad, 12 miles south of Delhi, and just on the border between the Gurgaon and Delhi Districts. The East Indian Railway already have a quarry at this place, and it is possible that the Punjab Government may also open one there.

In addition to the sources of supply referred to above there are a few quarries from which less suitable stone is obtainable, such as Sangla Hill in the Lyallpur District and Hundewali in the Shahpur District. These are soft shales and are not suitable for road surfaces. Sandstone boulders are also obtained from the bed of the Ghaggar river near Chandigarh. This, though hard to break, is not durable. It makes a dusty road and soon wears out.

It will appear from the above that the deposits most likely to be of value as road metal in the future are at Sarai Kala, Pai Khel, Garibwal, Pathankot, Devi (near Bhiwani) and Tughlakabad (near Delhi).

APPENDIX.

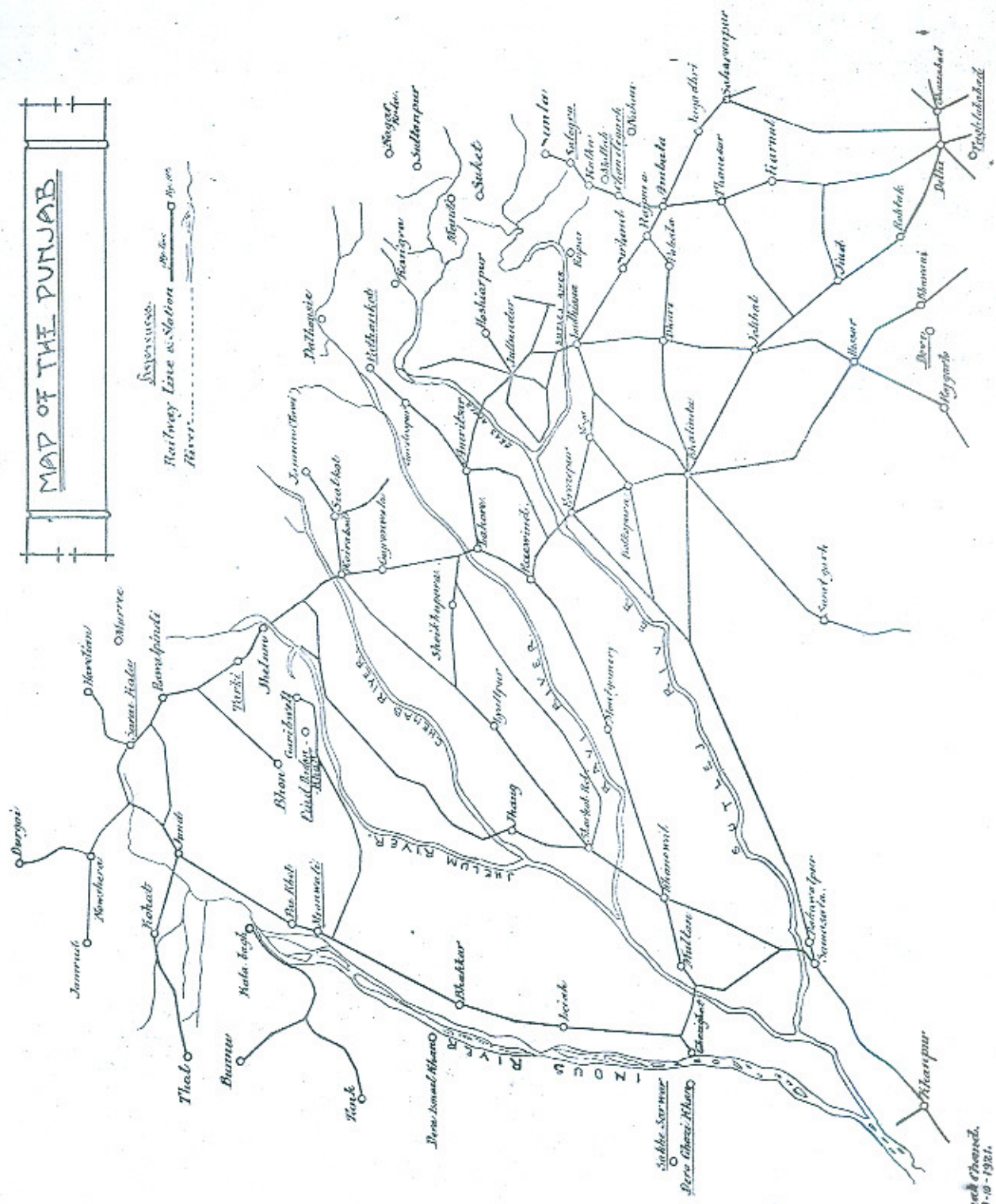
Name of quarry.	Cost per 100 cubic feet of ballast loaded in wagons at the quarry.	Shunting and siding charges.	Railway freight.	Cost per 100 cubic feet free on rail at Lahore Junction.
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Sarai Kala ..	7 4 0	0 2 0	11 4 0	18 10 0
Tarki ..	7 0 0	3 14 0	7 6 0	18 4 0
Pai Khel ..	6 6 0		14 14 0	21 4 0
Garibwal ..	7 0 0	0 8 0	8 0 0	15 8 0
Pathankot ..	13 0 0		5 10 0	18 10 0
Chandigarh ..	9 0 0	..	13 1 0	22 1 0
Tughlakabad ..	8 0 0	2 0 0	21 6 0	31 6 0

The following constants are useful in calculations:—

- (1) The average capacity of North-Western Railway wagons is 436 cubic feet.
- (2) The average number of maunds on which freight must be paid, per 100 cubic feet of ballast despatched, is 130.

MAP OF THE PUNJAB

Stations
 Railway Line & Station
 River



Mansel & Co. Secy.
 9-10-1921.

DISCUSSION.

BAWA BUDH SINGH—In the absence of Mr. Pound, introduced the paper and said that the subject discussed in the paper was very important for a road engineer. The present-day problem, which was perplexing the engineer, was to find a suitable material to meet modern requirements for metalling his roads.

The paper was only an introduction to, and did not pretend to deal exhaustively with, the subject of stone supply.

The comparative value of the various limestones and other stones to a Road Engineer had not been discussed. He might add that Tarki limestone was not grey but whitish, and again all stone at Sangla and Hundewali was not soft shale. Very good stone was obtainable at Hundewali. The rock at Delhi, belonged geologically to the Aravali Range and the rocks at Sangla, Hundewali, Chiniot, etc, were also pronounced to be stragglers of the same system and had therefore a very remote ancestral affinity. The author's remarks under the head "Selection of Stone," were liable to mislead engineers; with due respect to Mr. Pound's opinion, he did not agree with his unkindly remarks about limestone on page 47, where he said "But a stone that can be crushed by a 10-ton roller has little chance of standing the grinding action of bullock carts or the pounding action of lorries".

Mr. Pound advocated the use of hard stone, but referred to consolidating difficulties. There were in practice no such difficulties, as they could easily get 15-ton rollers. The real trouble with hard stone or quartzite was that it did not bind well, it refused to yield to traffic, and every piece of this stone kept its haughty head erect, and they had to cover their crests with blinding material which, in the plains of the Punjab, was no other than clay. All this added to the cost of maintenance, and the road surface was usually rough and sticky. It did not wear uniformly and was therefore unsuitable for motor car traffic, as its sharp edges appeared after a year or so. On long lines of communications they could not expect to spend large amounts of money on annual blindings. Delhi Province was fortunate in having a large store of red rock bajri, with which they blinded their roads and over and above that they spent a lot of money on watering them. On the Grand Trunk Road between Gujrat and Rawalpindi, they had a hard quartzite surface, as hard as probably Mr. Pound would like it to be. All the miles were first consolidated in the eighties of the last century, and traffic had made no impression on them in the 2nd decade of the present century.

They had ultimately to say good-bye to this revolting stone which refused to yield to traffic, and had to replace it with more soft hearted variety from Sarai Kala, Tarki and the Salt Range.

Limestone was the best material available for our roads, unless they resorted to concrete, tar macadamized or other modern road surfaces, but all these were unsuitable for their provincial roads on account of their prohibitive cost. Limestone was available in inexhaustible quantity in the Salt Range.

The author had referred to the Devi quarry near Bhiwani (page 49, para. 5) and the stone of this quarry was favourably reported on by the Geological Survey but he wondered if the verdict of a Director of the Geological Survey would always coincide with that of a Road Engineer.

He thought it was very necessary that the Buildings and Roads Branch should issue a handbook containing all the information about the various stone metal quarries, with guiding notes about the quality and utility of various samples.

He could not close these remarks without complimenting the new Department of Quarries on the success attained by it during the first year.

MR. D. MACFARLANE drew attention to the statement that arrangements had been made with the North-Western Railway whereby consignments of stone metal were despatched in batches of 5 trucks daily. He pointed out that in his division (Rawalpindi) which dealt with very large quantities of metal, consignments seldom, if ever, arrived at the various stations with any regularity, trucks being delivered, sometimes 15 in one day and on other occasions singly or in couples with many days break in between. According to their agreements contractors were forced to arrange for unloading 5 trucks daily, and this irregularity in delivery caused either heavy demurrage charge for which the contractor was supposed to be responsible, or expense to him in keeping labour idle. This invariably resulted in claims which were difficult to settle, in spite of carefully worded agreements and he wished to know if other Executive Engineers had experienced the same difficulty.

MR. COCKBURN said that Mr. Pound was incorrect in stating that with the appointment of a Quarry Engineer and the resulting unity of control the rate for road metal free on rail at Serai Kala had dropped from eight and ten rupees per 100 cubic feet to seven rupees four annas. On the contrary the rate at Serai Kala at the end of 1919 was from Rs.5-12 to 6-4 per hundred cubic feet, therefore although with the appointment of the Quarry Engineer there had been a better distribution of road metal and the quantity so distributed had increased, a reduction in rates could not be attributed to his efforts.

Kankar was still used on the Grand Trunk Road in the Amritsar District, in sections where quarries from which good

kankar could be obtained lay close to the road. The use of kankar on roads in the future would be governed chiefly by the existence of good kankar at a reasonable price in the tract of country which the road traversed, the importance or unimportance of the road would not be the determining factor.

Sakhi Sarwar as a possible source of supply of road metal might be ruled out altogether. The position on the far side of the Indus, 40 miles or more from rail head, would render the cost of metal prohibitive, even if metal of suitable quantity could be obtained there. Very little of this metal was used even in the Dera Ghazi Khan District.

As to stone from the bed of the Chakki at Pathankot, the statement at the end of the paper, showed that metal from the Chakki cost exactly the same at Lahore Railway Station as Serai Kala metal, although the lead by rail was very much less; unless the cost of this metal could be reduced considerably, it was not likely to be extensively used.

As to the statement that Chakki metal when broken to pass through a 1¼" ring and well consolidated, made a very durable road, the remark might be permitted, that stone broken to such a small gauge was not now obtainable and had never within the speaker's experience been obtainable at Pathankot.

MR. A. S. MONTGOMERY called on Mr. Mitchell to answer some of the questions raised in the discussion. Government did not intend to put down special plant at Serai Kala because the Wah Cement Company were going to do this for them. Sakhi Sarwar supply was out of the question being too far away. Pathankot stone was unpopular with motorists because of its roughness but if broken small it should be satisfactory for the ordinary traffic of the country. The Communications Board had pressed the use of Pathankot stone on local bodies. The high rate of Pathankot stone was probably caused by vested interests. The use of Serai Kala stone by Amritsar was quite indefensible. Two hundred miles length of stone had been distributed through the Quarry Engineer no small achievement in the first year's work.

LIEUT-COL. B. C. BATTYE pointed out that on completion of the construction of a tramway from Rupar to Nangal for the Nangal subsidiary project a good supply of quartzite and granite boulders would be available from the bed of the Sutlej River where it debauched on to the plains. He would like to know the cause of difficulty in consolidating with granite in this country. He suggested that the Kalka-Simla Railway, which had been built primarily for carrying loads uphill should be able to

quote very favourable rates for the carriage of stone down hill from the Salogra quarry.

MR. J. ASHFORD said that in Amritsar a considerable quantity of Pathankot stone had been used on the Municipal roads, but it was found that it did not bind well and so worked loose.

During the period of the war when he was chairman of the Municipal Works Sub-Committee he had to consider stone metal supplies. Serai Kala stone could not be had as the railway there was very congested with military traffic, he accordingly instituted enquiries for other sources of supply. A very satisfactory stone was found in the vicinity of Kalka and a quantity obtained. Certain roads were metalled with it and it had stood well. Stone obtained from this source was cheaper, and as there was not the same congestion on the railway as to the north, supplies were readily secured. It would seem desirable to develop this source of supply for parts of the Punjab where railing charges came less than from Serai Kala.

MR. VESUGAR said that a road with heavy traffic like the first eight or ten miles of the roads from Lahore to Amritsar and the Ferozepore had a life of $1\frac{1}{2}$ to 2 years and not 5 years as the author stated. On other roads as long as the width was under 16 feet the traffic ran in a single track making ruts. The life depended on how soon these ruts wore through. It seemed to make no difference whether the width was 10 feet or 16 feet, but beyond 16 feet width, the tendency to make ruts ceased and the traffic wore the road evenly. This was noticed when the Murree road was first widened to 16 feet and then to 20 feet.

An experiment with quartzite metal over the Leh Bridge where traffic was very heavy was made and after $3\frac{1}{2}$ years of trial turned out a failure.

The camber seemed to have no connection with the formation of ruts.

MR. A. I. SLEIGH said that Colonel Battye had asked for an explanation of the reason for the high rates on the Kalka-Simla Railway which precluded the P. W. D. getting road metal from Salogra. In March 1921 Mr. Pound and the speaker met to discuss the way in which the Railway could co-ordinate with the P. W. D. in supplying road metal to the P. W. D. in the Punjab.

During this discussion it was pointed out to Mr. Pound that two of his proposed sources of supply should not be considered :—

- (i) *Sakhi Sarwar* for the reason already given by Mr. Cockburn and others during the discussion of this paper.
- (ii) *Salogra* on account of the difficulty and cost of trans-shipment.

Mr. Pound might well have omitted these sources of supply in the paper as they were both impracticable propositions.

The Kalka-Simla Railway charged lower rates for down traffic than for up traffic. So far this Railway had not quoted any reduced rate for road metal as the traffic was not sufficient to justify any reduced rate. Mr. Pound did not mention if he addressed the Kalka-Simla Railway on this subject or not; this should have been done as it was possible for him to estimate the quantity of road metal which it would be *convenient* to the P. W. D. to get from Salogra.

MR. E. R. FOY said that while the subject under discussion was the sources of supply of stone ballast for road metalling, it might not be out of place to consider other materials for road surfacing. The material he had in mind was bitumen, which if suitably graded both chemically to withstand certain definite maximum temperatures and physically in relation to the voids in the soil, it could be mixed with earth and when rolled was said to produce a hard and durable surface. Such material was now being experimented with at Rasul to find an impervious lining for canals and Mr. Craven, the expert of the Standard Oil Company, was in charge and was willing to give full information on the subject. The speaker would not attempt to go into detail but would leave it to those interested to consult Mr. Craven merely remarking that the roads in the military camps of America during the war were made to a large extent of such materials and were said to have withstood the heavy traffic of guns, lorries, etc., incidental to large military camps.

This material was therefore suggested as deserving of further and more careful investigation as a possible alternative to stone metalling.

MR. K. G. MITCHELL stated there were a good many points which had been raised in the discussion to which he appeared to be expected to reply, and that while he had made such notes as he could it was probable that in replying he would forget certain of the points raised. He hoped, however, that if this happened his attention would be drawn to any omission.

Mr. Cockburn had disputed the correctness of the rate quoted by Mr. Pound as obtaining at Serai Kala prior to control. He thought that when Mr. Pound wrote his paper he probably had in his mind the rates which were being paid by local bodies rather than those being paid by the Public Works Department. His assumption of control at Serai Kala had been undertaken really with the object of assisting local bodies as Public Works demands were already being suitably dealt with by local Public Works Officers, and it was probable that in considering the reduction

in rates which he had brought about for the benefit of these bodies he forgot the fact that the Public Works Department was previously getting a cheap supply.

He failed to understand Mr. Vesugar's statement that the life of a mile of Serai Kala metal was as low as a year and a half, and he thought that there must be some mistake. If this was so he would like to challenge Public Works Department Officers in Lahore as to why they continued to demand Serai Kala stone when he was trying to persuade them to use Pathankot stone which had admittedly a longer life; longer even than the four years usually assumed for Serai Kala stone, and the only objection to which was its roughness. He thought, and he was afraid Mr. Montgomery would not like him to say so, that the standard at present aimed at for the surface of Provincial metalled roads, was higher than necessary, or than what the Province could afford. He contrasted the difference between a heavily used unmetalled road, which was almost impassable at most seasons except to the stouter country carts, and certainly impassable during the rains; and the ordinary road metalled up to a reasonable standard. The latter, if it provided a surface over which all sorts of traffic could travel at all season of the year, provided all that was really necessary, and the provision of a surface over which it was possible to drive a motor car at 40 miles an hour was really a luxury. This desire for smooth motoring surfaces brought in again the question of Pathankot stone which was considered to give an unpleasantly rough surface, but he reminded the meeting that the population of the Province was 25 millions and the number of motor cars something in the neighbourhood of five thousand and stated that he thought that too much weight was attached to the criterion of whether or not a road was suitable for fast motor traffic.

He produced a map showing the sites of the various quarries mentioned in Mr. Pound's report which brought out more clearly the great distances at which more productive quarries were at present situated from the centre of demand. There were other quarries however, which could be worked to distribute more economically the demand to the more accessible sources of supply; but the stone from certain of these was at present viewed with disfavour (notably in the case of Pathankot and Tughlaqabad) owing to its extreme hardness and the absence of any cementitious properties. These stones would, he was convinced, give a far more durable road crust than the smooth wearing limestone at present popular, if some cementing material could be had to supply the natural deficiencies. He was experimenting in this direction and hoped that any member of the Congress who had any ideas on this subject and was prepared to carry out experiments would refer to him

as he thought it quite likely that the Board of Communications would be prepared to contribute towards the cost of such experiments. Colonel Battye had enquired why it was that a macadam road could be made in this country with hard stone, as he understood that the very hardest material was satisfactorily used for this purpose in England. The answer to this Mr. Mitchell thought would be found in the name of the type of crust under discussion. This was known as "water bound macadam" and depended very largely for its cohesion on the cementitious properties of finely ground stone material with a suitable moisture content: in very dry hot climates like that of the Punjab the moisture was dried out and the cement paste became nothing but dry dust, so that all but limestone was kicked up and formed a rough surface.

In reply to Mr. Foy who stated that roads had been made in America from bitumen and dirt he stated that this was known as asphalt carpet in England which was perhaps the highest grade of road surface made. It was formed by mixing between 12 and 20 per cent. of bitumen with properly graded fine sand and "filler". The Punjab plains probably afforded suitable material to mix with bitumen, but it appeared more than probable that a foundation would be necessary under the carpet. Mr. Foy stated that the roads he mentioned in America had proved durable, and were without foundations; but these roads were constructed as a war emergency without due regard to the cost and undoubtedly, as a purely commercial proposition, the asphalt road with a foundation would in the long run give better value for money than one without. He was, however, considering the matter and hoped to be able to carry out some experiments in course of time.

CORRESPONDENCE.

MR. DORMAN, referring to the appendix on page, 51, wished to know why the charges made for shunting and the use of the sidings at Tarki should so very greatly exceed these levied for using the longer Garibwal sidings. Tarki was the nearest limestone quarry to Lahore and Amritsar; the stone was of good quality, harder than that obtained from Sarai Kala, and greatly superior to the mixed stone from Baganwala; and his recollection of the place was that there was an ample supply just beyond the end of the canal siding. He could not quite remember to what extent this siding diverged from the railway, but he thought it would be worth while investigating the possibility of an aerial ropeway, worked by gravity, to some point on the main line below Tarki, where the Quarry Engineer could have his own sidings, with proper facilities for rapidly loading the broad gauge trucks, through shoots from storage bins. If this scheme were feasible, he would suggest a concentration of crushing plant at Tarki, rather than at Sarai Kala, where the

supply was comparatively limited, and where flooding interfered with the work in the rains, while most of the spoil had to be lifted out of the quarry pits, and all the metal had to be lifted into the trucks. Tarki was 70 miles nearer to the Central Punjab than Serai Kala (Taxila), representing a saving in railway freight of Rs. 4 per hundred cubic feet, and, with the ground judiciously laid out in terraces so as to provide adequate quarry faces, and taking full advantages of the locality for spoil-tips and drainage, practically the whole of the quarry transport could be worked by gravity, and it should be possible to land Tarki road metal in Lahore at a considerably lower rate than at present.

MR. POUND wrote that there was little for him to add to MR. Mitchell's able reply to the discussion.

The siding and shunting charges at Tarki were comparatively high for three reasons. The maximum output was only ten wagons a day; so that when the engine hire was divided by the number of wagons the cost per wagon worked out high. A special engine had to be sent from Rawalpindi for the shunting and a charge for lighting up equal to three hours hire was made. The Irrigation Branch charged a royalty of Rs. 1-13-0 per 100 cubic feet for stone loaded on its siding.

As to the quantity of stone which might be obtained from Salogra the Superintendent of the Kalka-Simla Railway had informed the writer that he could not handle more than three wagons of stone a day, and that only during certain months of the year; whereas it would hardly be worth while starting a quarry unless there was a reasonable chance of getting at least five wagons per day all the year round.