Paper read before the Engineering Association of Ceylon (Kurunegala Local Centre) at Kandy, 28-1-27., and subsequently at the Annual Meeting held in Colombo on 31st March 1927.

SURFACE TREATMENT OF ROADS UNDER LOCAL CONDITIONS.

By W. G. SCOTT, District Engineer, Kandy.

There is an appalling ignorance displayed on the question of roads by speakers at public meetings and writers of letters to the Press. A public road with several thousand fast moving heavy vehicles per day passing over it, is very often compared with a private one, where the traffic amounts to only one or two vehicles per day.

The saner element of the travelling public do not pour forth destructive criticism because they realize that "the cobler must stick to his last, and not judge things beyond his comprehension." There are, fortunately, a few who do realize and appreciate the ever-increasing difficulties the Engineers have to contend with, in meeting the demands of road maintenance under the greater intensity of modern traffic with the limited annual allotment of funds at their disposal.

The Engineering Subordinate Staff has not kept pace with the supervision required by the more exacting methods of road maintenance, with the result that the work and responsibilities of the Engineers themselves have increased enormously during the last few years.

The continuous endeavour to instil enthusiasm and energy into the Subordinate Staff is a very trying one indeed, and one that I fear is not sufficiently appreciated.

There is more money spent to-day on the construction and maintenance of roads than for any other form of public works; and the problems are receiving great attention in every country.

The object of this Paper is to introduce the subject of the surface treatment of roads under
local conditions, so as to start a discussion, and obtain an exchange of views on the methods, which can best be adopted at the moment in this country with the labour supervision and funds at the disposal of the Engineers.

Nearly all our roads are too narrow with the result that weight is concentrated. Repairs are difficult to undertake when traffic has to be kept going at the same time. Accidents frequently occur when heavy vehicles meet, and one has to leave the hard core road. Especially is this so on embankments where the villager in his enthusiastic endeavour to increase food production, extends his paddy field a few inches further into the road every year.

The villager, however, is not alone in this respect. Certain estates, in their zeal for clean weeding scrape into the road side to an alarming extent. It is quite a common sight to see a vertical face of from 2 to 6 feet, where at one time the materials carried to spoil must have taken up their angle of repose, which is certainly not vertical. It is surprising that more accidents do not occur by the road side giving way when cut into this manner, and the public ought to be safeguarded.

Roads in Ceylon are put to many uses other than for vehicular and pedestrian traffic. They form at many places the only market, playground, workshop, garage, a drying ground for dhoby and for every kind of local produce such as copra, cocoa, arecanut, etc., etc., besides being considered the dumping ground for all refuse and weeds from gardens and estates. The explanation for the beautiful crop of weeds on certain sections of our roads, is not far to seek.

Valuable buildings are allowed to be built close on the road, without any consideration to future widening, as there is no law to prevent it. The cost of such widening, when eventually taken in hand, will be enhanced enormously unless reservations are declared at once.

The height of the floor level of the building above the road must also be considered in this connection, as one case came under my notice where the applicant built his house 25 feet from the centre of the road with the floor level 25 feet above it.
Metal Piles.

Complaint is often made that Metal is piled on the road, without the complainant stopping to think where else it could be piled. One road in Kandy District is lined with houses and fences for several miles without a break. It is also so narrow that it is with great difficulty Lorries and Buses can pass one another, and reversing to find a place of sufficient width has constantly to be resorted to. Metal is required for resurfacing and attempts, to rent out land temporarily for piling of metal have been unsuccessful. There is therefore no alternative but to pile on the Road itself. It is, however, a heart-breaking business to find the metal scattered about by Motor Buses and Lorries charging over the top of the piles.

The present method of piling road metal in single cube piles on the roadside is wasteful, and an uneconomical one. An Engineer, requires "second sight," enormous energy, and patience to get 90 cubic feet in a pile. Overseers and coolies vie with one another in their devices to make 60 cubic feet look like 100, and they succeed. Wherever the grass is cut off all round the pile, it is time to become suspicious, but even without this clue, the Author has many times been deceived.

Single cube piles all along the road side are objectionable for the following reasons: —

(a) Excessive amount of measuring necessary.
(b) Ease with which piles can be disguised, and difficulty in readily detecting shortage.
(c) Time which piles must necessarily remain on roadside.
(d) Very large surface area in comparison with its volume to collect dust, dead leaves and rubbish.
(e) Damage and loss in shrinkage by vehicles running over piles, people squatting and airing, bedding, etc., on same and scattering the metal about.—School boys finding a plentiful supply of missiles ready to hand.
The Author endeavoured to introduce the system of large piles in Colombo District, some years ago, and for this purpose acquired land for metal depots of 25 cubic capacity at approximately ¼ mile apart, along the Urugodawatte Road. The metal in those depots was piled 4 feet high and piling on the road platform was stopped. Depots were also acquired on Galle Road and Negombo Road.

The question of large piles off the road platform, becomes more pressing to-day for a reason which is only becoming apparent. As mentioned later, under the heading 'Life of a Tarred road,' it is difficult to determine how many years a well consolidated road will last with periodical patching and tar painting. An instance is given where the surface is still good after 3 years of heavy traffic. Metal for relaying surface crust must be kept in reserve somewhere, but naturally leaving single piles along the road side for several years, is out of the question.

Large piles in our small quarries are not advisable, as they would require to be remeasured monthly to calculate the shrinkage from unnatural causes which would undoubtedly take place.

The Author has given this question a good deal of thought, and has come to the conclusion—

(1) That the acquisition of land for large metal depots off the road platform is a very urgent necessity.

(2) That one or two depots per mile should be constructed having a stone paved area surrounded by a 4 feet high masonry wall with concrete coping round 3 sides. The ends nearest the road of the side walls would be given a 45% slope, the angle of repose of the metal when filled in.

(3) That supervision would be greatly facilitated if a standard depot was adopted —say 25 cubes. Two or more depots could be made side by side if necessary.

Built depots as described above are to be seen all over the roads in Scotland.

**Uniformity in Quality of Materials.**

This is very important in Road Engineering. In order to get good wear-resisting qualities in a road surface, it is necessary to have a really hard
aggregate of uniform quality. This can much better be obtained from large, than from small quarries. Metal breaking cooiles will go and take any old boulder from the road side, because it is weathered, and easy to break. To prevent this, is a very difficult matter as an Overseer invariably shuts his eyes to it, and expresses surprise when it is pointed out.

Whenever possible large quarries should be opened out to serve several miles of road. Supervision will be facilitated, and the cost of developing will amount to less per cube outturn. The extra cost of transport will be more than compensated by the more uniform quality, and cleaner metal obtained. It is all a question of values and quality. One cube of good material properly used may be equal to many cubes of bad.

In developing quarries, the Author has adopted the following method with some success. A breaking platform is constructed 7 or 8 feet above the level at which the carts stand to load. This, at some places is quite a simple matter by taking advantage of the natural features and a little blasting or earth cutting. At others, however, it is necessary to build a wall with the soft stone forming the top crust of rock, and filling in behind with the overburden excavation. On the platform thus formed, breaking sheds are built with jungle posts, and the roof clad with empty tar barrels flattened out. The uses to which empty tar barrels can be put to are innumerable. Several loading platforms have been constructed out of these instead of using stone, and they are easy and speedy to erect.

Against this bank or wall, a double screen consisting of 2 perforated plates one above the other is erected at such a height as will allow a bullock cart to stand under it. Broken metal thrown on this automatically becomes screened. The larger aggregate rolling down into the cart, while the chippings and dust pass through into the respective compartments provided. A sketch of this arrangement is tabled, and a quarry can be visited to-morrow where it can be seen-working.

The advantages of this method are that it is automatic, and that there is no extra cost for screening.
The Author had great trouble at first in convincing the metal breakers that the broken metal did not decrease in bulk, when the \( \frac{3}{8} \) in. chippings and dust were removed, but this was overcome by making actual tests over the screens with hand carts.

With a rotary screen as fixed to a stone crusher, chippings will pass through the respective holes true to size, but with the screen under discussion it was found that a large amount of \( \frac{3}{8} \) in. chippings was carried down the slope by the larger aggregate. Holes of 1 in. diameter, are now being adopted for chippings and \( \frac{3}{4} \) in. diameter for the removal of dust. The dust cakes and tends to clog with smaller holes during wet weather, but naturally a certain amount of small grit passes through in dry weather. However, it is a case of devising means to get the best out of the most adverse conditions.

Since writing the above, the Author has designed and constructed another type this week using \( \frac{3}{8} \) iron bars running down the slope placed \( \frac{3}{4} \) in. apart as the top screen and \( \frac{1}{2} \) in. bars spaced \( \frac{3}{4} \) in. and \( \frac{7}{8} \) in. apart for experiment as a lower screen. Which of these spaces or an intermediate one will prove the better, the Author has not been able to determine as they are only being fitted up in a quarry to-day and can be inspected to-morrow.

**Relaying Surface Crust.**

The durability of a road principally depends upon the adhesion of the particles of stone forming the crust.

A surface crust of clean metal of uniform quality requires less rolling, and becomes better consolidated, as there is nothing to prevent the stones wedging firmly together. This physical interlocking of the stones is more necessary in the case of water-bound roads, with and without a waterproof surface seal coat in the shape of tar or bitumen painting, than in the case of tar macadam and grouted roads where a binder of tar or bitumen is used.

Earth, cabook, dust, and other extraneous matter lubricate the joints between the stones and prevent the interlocking, necessary to make a stable road more especially when subject to the extreme variations in temperature of a tropical climate.
The old road surface should be picked up to a depth of 3 in., and the whole of the materials graded by the aid of a double screen. Deep picking is recommended in order that the old and new metal may be consolidated in one thick layer of 4 in. consolidated to 3 in. to eliminate movement. The size of metal used should not be greater than half the thickness. A favourite complaint by the Road Overseer is that the metal is insufficient, and the Author's advice invariably is "pick deeper and get more." Many of our bridges and culverts are overburdened owing to failure to pick sufficiently deep, and consequent periodical raising of the road level.

When the picked up material is removed by a mamoty, the hollows cut out by the pickaxes below the general surface become levelled over with the dust and finer material. If this is not removed by sweeping brooms, a proper binding with the subcrust and adequate interlocking of stone particles in the new surface crust cannot be obtained.

The screened half metal should be thrown on the top to close the surface, only after consolidation has been thoroughly completed. The voids in the newly laid metal will gradually become filled up by water, carrying the smaller particles of binding into the body of the road.

**Pot Holes.**

The entrance of water into the body of a road is one of the many enemies of the Road Engineer. To obtain a perfectly cambered water-bound road is impossible. A slight depression of say 1/16 in. will hold water and may become a pot hole 3 or 4 in. deep in a few days during the monsoon. A rubber tyred vehicle passing over this hollow agitates and splashes out the water which flows back when the front wheel has passed only to be repeated by the rear wheel. This continual agitation washes the finer particles away in the form of mud, making the depression increase until shocks from heavy vehicles set up internal attrition. More mud is washed out by the endless stream of traffic resulting in a beautifully clean pot hole, and a few more epithets hurled at the Road Engineer. One of the Kandy roads was a mass of pot holes some 3 in. deep only 10 days-
after resurfacing had taken place. There was continuous rain during the period.

There are, however, other reasons for pot holes, many of which it might be possible to eliminate by a more intelligent sub-ordinate staff.

(a) Metal of varying qualities—a basket of dirty metal (usually taken from the bottom of the pile where it becomes mixed with earth) being thrown down in one spot, or unscreened old materials.

(b) Picking not carried deep enough to get sufficient thickness of crust consolidated at one time.

(c) Failure to sweep dust from pick holes.

(d) Thorough consolidation to eliminate movement.

(e) Sufficient camber to ensure effective drainage during monsoon.

To obviate (a) the Author tries to insist upon metal being piled without disturbing the grass.

Frequently large patches of one stone deep are to be found missing from the road surface; these, in the Author’s opinion, are due to (b) and (c).

**Surface Painting.**

The object of surface painting is to bind the surface together and provide a waterproof covering. Time should be given a newly consolidated road to close up before painting.

It is essential that the surface to be treated shall be stable, dry, free from dust, cow-dung, caked mud or clay earth, and that the work should be done when the road is hot more especially when bitumen is used.

It frequently happens that during the monsoon, it is impossible to surface paint for several months after relaying and consolidating the surface crust, by which time there may be many 'pot holes', and the surface very rough. This can be to a great extent obviated by blinding daily where necessary.

The Author has been employing special coolies on this work; but again it is a case of being at the mercy of our subordinate staff. An Overseer who takes a pride in his road is the exception. The Author is fortunate in having one or two who try to assist him with the result that 12 months after consolidation the untreated surface was found in such good condition, that the cost of special coolies was more than justified.
Sweeping is carried out entirely by manual labour, using bass and soft coir brooms. Steel wire brushes have been found good for removing cow-dung, caked mud, and clay earth. Soft hair sweeping brushes as used for factory floors, being used for the last film of dust which it is very essential, should be removed so that the tar or bitumen may adhere to the clean metal below.

It is advisable to roughly sweep a long stretch of road early in the day, as it frequently happens that top dust is dry, while the road surface below is damp, more especially at the sides where the dust is thickest.

Road Board Tar.

Road Board tar, Tarco, Tarvia, and similar preparations are heated to 220°F. and applied to the road as quickly as possible with pouring cans provided with Baffles. A broom should follow immediately behind the pouring can, and the tar brushed quickly so as to increase the area covered as much as possible. This varies greatly, partly due to the so-called 40-gallon drums containing considerably less. The Author has, however, been able to obtain a covering capacity of as much as 18 squares per barrel, or 2½ gallons per square as a first coat, although 14 to 15 is more usual.

When the tar lifts behind the brush, it shows that it is not touching the stones, but is adhering to the fine film of dust which has not been removed. The hollows and rough places retain the tar in small pools. Clean dry chips thrown immediately into these will absorb it, and greatly improve the finished surface, if rammed with a stamper or hand roller. If sufficient chips are not available sand may be spread over the remaining portion, but it should be as coarse clean and dry as possible. Since using Baffles on pouring cans the Author has found that as the operator becomes more expert in getting a uniform coat—brushing the hot tar on the road can be omitted and a saving in labour effected.

Bitumen is heated to 350°F. and applied in the same manner as tar, but it should be more evenly applied and fully covered with chips or it will bleed; on a hot day. Granite chips are the ideal covering for all surface painting as they absorb the excess tar, and level up the surface. With
bitumen, which is a much thicker carpet, the chips are essential.

Failures may be due to—

(a) Damp surface.
(b) Tar or bitumen not up to correct temperature. (Thermometers should always be provided).
(c) Last film of fine dust not properly removed from road surface.
(d) Wet or dirty sand covering.

The Author has had many failures—most of which could be explained. One, however, baffled the experts of the Firm who make the preparation used, viz., Spramex. A small portion was laid down as a first coat on the Peradeniya Road and sanded. It was a dreadful sight about mid-day when iron tyred carts passed over it. Patches, a square foot in area, stuck to the iron tyre which revolved like caterpillar wheels and deposited the patches some distance ahead. These patches became rolled in by motor traffic and formed a bump:

The Author put this failure down to incorrect temperature and proceeded to lay another section on Kadugannawa Road. He was more unfortunate here owing to a larger number of iron tyred vehicles using this road. He paid a great deal of personal attention to this, and kept on putting chips and sand daily. The chips seemed to be swallowed up as soon as put on, and it still bled and stuck to iron tyres in huge patches. Adhering to these patches, was an enormous amount of small rounded stones from \( \frac{1}{2} \) in. down to dust. The Author was puzzled about these as he had inspected the clean road before the asphalt was laid down.

Spramex experts arrived and got no better results. The Author had to do patching to keep the road in order and was faced with the difficulty of not only finding metal to resurface the whole mile, but also the funds to do it with. The patching was done by tarring the holes, and filling with chips, and it was discovered that the portion painted with tar, dried up and stopped bleeding; so he had the whole road tar painted over the Spramex, and it is still standing very well although a bit rough due to patches of Asphalte being double thickness, where carried along and rolled in.
The explanation, the Author has to offer, is this. The Spramex was heated in the small 60-gallon boiler to the correct temperature, but although he was alive to it, must have got too cold and did not adhere to the metal. (Asphaltite is not absorbed by metal as is the case with tar). This Asphaltite carpet started to creep backwards and forwards under the fast moving motor traffic, grinding the angular stones into round pebbles and dust. An actual cut from this road is on view.

A portion of the Peradeniya Road near the Police Station was treated with Spramex as a second coat over tar, and although it required attention for a month until bleeding stopped, it is now an excellent surface and lasting well. The Author is confident, he can get good results from a pressure sprayer with this material and intends laying down a portion as soon as sufficient chips are available. A thin uniform coat appears to him to be only possible on a previously painted surface. The thinner the coat the better the results will be, as can be seen by comparing the sample cuts from the roads treated which are now on view.

**Colas.**

This is an emulsion of Bitumen which can be applied at normal atmospheric temperatures, the covering capacity may be adjusted to any given quantity by the dilution with water. No boilers for heating are required, and the work can be carried on in almost any weather.

A sample was sent the Author some months ago consisting of 5 drums; most of which were damaged on the Railway unfortunately. What remained was used on the Katugastota Road with rather disappointing results and can be inspected. The instructions given were to sweep the wet road. This may be quite simple with sandy roads, but the red clay would neither wash nor brush off. It merely painted an extended surface with the clay. This was partly the reason of the failure. Another was that the Colas had partly become demulsified, and the Bitumen had precipitated to the bottom of the drums. He understands, that this was one of the original difficulties the makers had, and the material could not be stored but had to be used fresh. They may have got over this now.
The Author received another consignment two days ago, and he is laying down some on a road not fully closed as a grout and also at another place where the road is closed, but fairly clean.

If this material is a success here, it will greatly facilitate work, as resurfacing and consolidation could be conveniently carried out in wet weather, followed immediately by grouting with Colas, washing and using the screened small metal together with some new chips and rolling them with the Steam Roller, all at the same time. The work described above will be in hand to-morrow and can be inspected.

**Patching.**

This can be done with a small patching set consisting of an empty tar drum on a wheeled cradle. The patch should be swept clean, hot tar painted on with a coir broom which had been previously dipped into the boiling tar, the hollow filled up with clean chips and stamped.

Another method adopted by the Author more especially for deeper holes is to fill them up with tar concrete, and stamp it in level. The tar concrete is made in his yard. The tar heater was made from an empty drum with a stop-cock fitted over the tray in which the tar and chips are mixed. The flue from the tar heater was utilized for heating the chips, but this proved insufficient, and a fire is now put under the tray. When the tar concrete is mixed, it is put into half tar drums for convenience in handling and transporting away for repairs.

Too great emphasis cannot be laid on the question of patching waterproofed surfaces. The Proverb "A stitch in time saves nine" is very applicable.

**Life of a Surface Painted Road.**

Naturally, this is a question of the stability of the subcrust and surface crust, which in turn depends upon some of the things the Author has touched upon previously.

A portion of the Peradeniya Road laid down exactly three years ago was surface painted with tar under favourable conditions. It has been re-painted twice and is still in such excellent surface that the Author is unable to prophesy how many
years it will last, with repainting only, as and when found necessary. The traffic on this road amounts to 4,000 tons per day.

Portions of the roads round Kandy, before surface painting was made possible, had to have the surface crust relaid with 100 cubes or more of new metal per mile 3 to 4 times a year, as the pot holes rapidly reached alarming proportions. It will not be difficult to realize what a boon, tar for waterproofing a road surface has been.

Where very heavy iron tyred traffic passes over the painted surface, more frequent patching, and re-painting is necessary. The Kandy Station Road is repainted about every three months, but here the traffic amounts to an average of six thousand (6,000) tons per day.

An answer to the question “Is Bitumen or tar the better for surface painting, cannot be given satisfactorily, as it is a question of traffic and relative values of materials used.

Bitumen for roads where all traffic is rubber tyred is economical in the long run, provided traffic is not limited, by width of surface, to defined wheel tracks. With tar on a well swept surface the wear is taken up by the larger stones forming the crust. Bitumen appears to have little adhesive power to stone whilst tar possesses this quality, and is therefore more suitable for roads where the greater proportion of traffic is iron tyred.

Plant.

Up till recently we have had no modern plant. Our small 30-gallon and 60-gallon boilers capable of heating 3 and 6 barrels respectively per day were quite unequal to the large mileage necessary to be treated, when uncertain weather had to be taken into account.

With 140-gallon Power Sprayer, I have been doing ½ mile per day on a 20-feet road.

<table>
<thead>
<tr>
<th></th>
<th>First Coat</th>
<th>Second Coat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tar—Barrels</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Sand—Cubes</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Firewood—Yards</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Spraying Cooly</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pump Coolies</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Fireman</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>First</td>
<td>Second</td>
</tr>
<tr>
<td>----------------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Bulls—Pairs</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sweepers</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Gritting Coolies, patching and sanding</td>
<td>12</td>
<td>16</td>
</tr>
</tbody>
</table>

What I speak of here as a second coat, is one applied when the road surface has become well worn.

I hope, if weather is favourable, to give a demonstration of the Sprayer at work to-morrow.

The Sprayer arrived fitted with shafts and saddle chain complete for a horse; but on learning that horses were not available on indent from the Colonial Stores, I had to design and fit an arrangement for bulls, which has proved satisfactory.

I have tried to obtain, but so far without success, a bullock drawn rotary scavenging brush, as I feel that this would speed up work in the sweeping process by taking the bulk of the dust off, leaving less for hand brooms to do. I was informed, these were imported by Colombo Municipality many years ago, and were subsequently given up. Perhaps, our President will be able to give us some information on the subject.

**Baffles for Pouring Cans.**

When working with a tar boiler, ordinary watering cans fitted with a baffle are a great convenience, as they distribute the tar evenly over the road surface, and save following up with a brush or squeegee. Baffles made by the Author can be seen at work to-morrow.

Tar Macadam and Asphalt carpets can only be laid down when large quarries and expensive plant are available, with a sufficiently trained staff to work it. This form of treatment will have to be taken up on several of our arterial roads out of Colombo. It is a specialist's work and cannot be undertaken by Engineers with District routine work to carry on.

It is too big a question to go into, in this short Paper, and must form the subject of a later discussion.

The most serious difficulty against good repairs being effected is that heavy fast traffic must use
the only part of the road available for it, at the same time as repairs are in progress. Widening out to a double line of traffic width is a most pressing need so as to distribute the weight over a greater area and be able to undertake repairs on half the width at a time. Should this be carried out, surface painting and grouting are sufficient for our rural roads for some years to come.
METAL DEPOTS EACH 25 CUBES

PLAN

ELEVATION

ISOMETRIC PROJECTION
DESCRIPTION OF COLAS TREATMENT

(Mentioned on page 12).

A.—Consolidation ordinary—fully closed. Colas painting, covered with wet screenings and rolled with Steam Roller—4½ gals. per square.

B.—Consolidation ordinary—fully consolidated without any half metal, but not fully closed on top—grouted with Colas covered with wet screenings and rolled with Steam Roller—11 gals. per square.

C.—Colas method (as described in their pamphlet). Old road scarified, levelled over, and rolled. New metal sufficient to cover the surface spread, rolled, and grouted with Colas covered with wet screenings and rolled—6½ gals. per square.

*Note.*—The wet screenings used were the half metal, taken from the picked up road, washed in a basket, by dipping same into a barrel of water.

In addition to the above, B. and C. still require a seal coat which would practically amount to the same quantity as in A.
DISCUSSION.

7th Paper

The PRESIDENT.—We have here to discuss a subject which should be familiar and of the greatest interest to a very large number of members in the room to-day. I hope Mr. Scott will be rewarded by a very full discussion.

Mr. ROTHWELL.—I am sure we have to thank Mr. Scott for his Paper because he gives not only results, but the troubles that one experiences in carrying out surface painting operations.

Personally I have not done very much surface painting myself, but there are a number of District Engineers here who have done a great deal, and I hope they will not be afraid to get up and give us some of their own experiences. Accurate knowledge of what is the best coating is really very much in the air. We got for instance rival claims of Spramex and Colas, etc., and we get travellers who come round claiming their material to be the best. We have got a great deal yet to gain by experience and from Papers such as Mr. Scott’s. In my own experience I have found the most successful treatment was first coat Road Board Tar followed by Spramex—or Asphaltum second coat.

As far as I can judge, these have given the most successful results. Owing to the recent coal strike by which we have been prevented in Ceylon from getting Road Board Tar, I should estimate the loss to English tar manufacturers at £20,000 to £50,000 and to my mind this is a pity. I am very interested in the arrangements described for improving our quarry systems. As road engineers, I fear that we are rather a conservative lot, and we still stick to the old cubes of metal piled singly on the sides of the road.
Owing to the increasing speed and density of traffic, there is no doubt these isolated piles along the road sides are a confounded nuisance, and I am glad the idea of piling in bulk is brought up. Very often in many districts, there are sufficient small plots of Government land, and where it is not available Government should acquire small plots of land to form these large piling depots. It is perfectly obvious what great improvements there would be in traffic conditions if we have these large piling depots every eighth of a mile; and do away with these single cube piles. The final section of Mr. Scott's Paper I am rather interested to read because he makes the position clear. We hear a lot about being up to date in surface treating our roads with tar and bitumen. It will be forced on the Department in the next few years that the arterial roads outside Colombo and the majority of the mileage of rural roads in Ceylon need greater expenditure. I have no hesitation in saying that if Government would grant sufficient funds for tar surface treatment, the eventual economy in road maintenance would be very great. For example on the main road from Badulla to Bandarawela, a distance of 18 miles—a saving of Rs. 10,000 a year could be effected.

The Annual provision of new metal in large quantities is a heavy recurrent item, but there will eventually be a saving if Government will put down a sufficient vote for the initial cost which admittedly is large for tar surfacing. I think we are all convinced of this—that we should push forward with tar surfacing of roads, and I hope Government will give reasonably large funds in the near future. Let us do twenty, thirty, forty, fifty, sixty or a hundred miles a year and the Colony will eventually benefit very largely in road maintenance estimates.

Mr. VATTWEST.—The point in regard to metal depots is very very essential indeed because in addition to what Mr. Scott has said, the complaint all over the Island is that the roads are too narrow. Our roads are roughly from 16 ft. to 18 ft. in width. These roadside metal depots occupy I should say about 8 ft. very often, because the metal piles are 5 ft. wide and have got to be a little distant away from the edge.
That makes it 7 ft. Then carts and lorries come and roll the metal about spreading it still more so that actually we lose about 8 ft. width of the existing roadway. I think it very essential that these metal deposits should be placed, say an eighth of a mile distant apart, instead of piling metal in single cubes throughout the road.

With regard to tar coating we have done a good deal of that. I have had some experience myself. In Kalutara District, in the heart of the town, I laid a tar coating first with Tarco, then with Asphaltum and for three years I did not touch that road. When I left Kalutara District it was quite good except that it wanted a little patching here and there.

I understand from my friend who succeeded me that that road is still in good order. That will be 4½ years. It cost me Rs. 6,000 for a mile and was well worth it, the road being about 20 ft. wide. The cost of metalling that road was roughly about Rs. 3,000 per mile a year and then it was not satisfactory.

Well Rs. 6,000 expended has stood for over four years. If we add another couple of thousand rupees making it Rs. 8,000, including cost of patching, it works out at less than Rs. 2,000 per mile a year. Probably it will go on for another two years without being picked up. So I say, tar coating is the thing and there is no doubt about it and that it is cheap in the long run.

Mr. Scott has given us one of the finest Papers that we have had in these engineering meetings from their very inception. I think this is one of the best practical papers we have been favoured with. (Applause).

Col. A. C. B. JONKLAAS.—May I just ask one question? On Page 9, I see the covering capacity is given as much as 14 to 15 gallons per square as a first coat, although 24 gallons is more usual. Is it 14 or 15 gallons?

Mr. SCOTT.—Squares to the barrel.

Mr. YOUNG.—Having lately come out from home and spent the best part of the holiday in visiting many kinds of works like road surfacing,
I think Mr. Scott is to be congratulated on keeping us informed of the methods of surfacing roads by painting. At home just now they are not doing much water-bound work at all. There with an expenditure of something between £6,000 and £10,000 a mile for roads I found that road surfacing with metal ordinary water-bound macadam has completely been superseded. This metal depot that Mr. Scott has indicated is indeed very good and I appreciate very much what can be done in a Government Quarry. I don't think any private quarry will admit of, but will it simplify and guarantee the surface of water-bound roads? The trouble is if we adopt this system now, we shall be behind the times and not move with the rapidly increasing traffic problems. I say this, not in disparagement of the water-bound system, for they must be adopted for many years yet, but obviously we must give some attention to quarries, their position and their lay out, with a view to installing much more modern macadam plant such as is done at home. Personally I do not advocate cubes of metal along roads. There is no doubt they are a confounded nuisance. We will always have the problem of transport within a quarter of a mile to tackle and we cannot all find motor lorries or steam waggons. Even now we are alive to the difficulties of loading and unloading which is a point worthy of consideration. We would give a good deal to know exactly whether it really is a benefit in the long run to have twenty-five cubes in one depot which will come in economical later, or to have discovered a cold treatment for surfaces, or whether we can adopt metal or macadam with advantage.

One point I would like to mention in connection with the subordinate staff. You know how little one can do in connection with the supervision of roads when one is bound by so much office work. It is very difficult to keep up to date with the Head Office in Colombo and with one's own work outside. The only solution is to get more subordinates in order to get rid of the drudgery of signing up stock books, etc. I find I have 37 books to post up every other day in my office. You cannot do that and keep your district up to date and supervise all the miles of road. The only way that we could supervise road operations is to be continually on the road, sit on the road side and see work
properly carried out. With regard to the remarks about pot holes I would like to say in addition to the many reasons given, which are very excellent, that in my district I think it is the brand of metal that is principally responsible for the pot holes in many cases. One other thing is, lack of rolling. Sometimes the steam roller does its work totally insufficiently and it is a very important point that rolling must be done from the edge of the road towards the centre. It was mentioned that motor cars run over a newly made semi-consolidated road before the blinding is put. If you do not make that up by re-rolling I find it is a fruitful cause of pot holes. I should like to have Mr. Scott's experience about it. I experienced a series of cars (about a hundred and fifty to two hundred) once or twice over a road and I had to re-roll the disturbed metal throughout rolling from the edge to the centre to make sure I would not have pot holes showing.

Another point is about Colas—I believe a second coat is applied after the first is well rolled. That is the practice, I gather. It never pays to treat a worn road unless pot holes are properly taken up, cut square and chips and Colas applied.

Before going home I found that many Engineers treated roads with Road Board Tar and fortnight or month later coated it with Spramex. Since I have been at home I have heard of "Colfix" and "Colas." I have seen many miles treated with them and visited chemical works and I have heard that "Colfix" and "Colas" are the finest for road making. I am sure they are going to be the immediate solution of our surfacing problems.

Mr. ADAM.—In regard to the narrowness of roads due to buildings on either side, mentioned by Mr. Scott, it may be useful to note in connection with the new high level road we intended going along a minor road in one place, but found it cheaper to construct a complete new road as the cost of acquisition of buildings was prohibitive.

The cost to Government is going to be high in case of widening the existing road later unless immediate action is taken to keep a proper building line. There is another thing in connection with pot holes. Small pieces of loose metal are kicked off existing metal heaps and rolled in by bullock carts and thus make pot holes. Another thing
Mr. Scott did not mention is drip off trees—that I consider is probably the cause of pot holes in many districts.

Mr. BRADLEY.—In regard to the covering capacity of Road Board Tar, Mr. Scott mentions that it is eighteen squares per barrel although 14 or 15 is more usual. He says that he tarred with 13 barrels a quarter mile section 20 ft. wide, which works out approximately at 20 squares per barrel. Is that not so? So that there is not very much greater covering capacity by using a sprayer. My experience is that if you get 14 squares to the barrel, allowing for leakage you have done very well. In regard to tar or bituminous materials, my experience of them is that as far as we have been able to see in Ceylon the best form of road—the ideal—is that treated with two coats, the first of Road Board Tar and the second coat of Spramex or Asphaltum. For instance on the Badulla-Bandarawela road, a quarter mile section, which was treated 3 years ago with one coat of Asphaltum has kept in perfectly good order. I don’t think it has had a patch since it has been done. The road carries at this point bullock cart traffic and fast moving rubber tyred vehicles. I was very interested in Mr. Scott’s statement about bleeding after treatment with Spramex. One of the greatest difficulties I have experienced in using Spramex is bleeding. After two or three iron-tyred vehicles had gone over the road, patches stuck to the tyres, spoiling the appearance of the road altogether. I think that Asphaltum causes less bleeding than Spramex. I have been trying liberal applications of sand. Chippings would be better but we have not arrived at the state of having screens in our quarries. It is a very useful method to adopt to screen the metal and lay the chippings on top of Spramex.

Mr. Scott seems to favour the idea of heating bitumen to 350 degrees. I presume he means in Kandy district. My experience is that you can get better results by heating to about 400 degrees. Undoubtedly the whole question of the successful use of Asphaltum is its being applied hot. The hotter it is, up to 400 degrees, the less bleeding you have after it is applied. I think we want to know more about that point. A material like Colas would be the very thing when we cannot, owing to
weather, apply tar on our roads in many instances until they are partly worn out. Mr. Scott has said nothing about the cost. I believe Colas is 80 cents a gallon and figuring 11 gallons to the square it will work out at Rs. 8.80 for material alone. That bring us to the question raised by Mr. Rothwell—the amount of money available. That really is the crux of the whole situation if a road has to be treated thoroughly. It is the want of sufficient money to spend on tar and Spramex, tar and Asphaltum or Colas which delays progress. We know more money is wanted to solve the whole question of modern road making in Ceylon.

Mr. SCOTT.—Mr. President and Gentlemen: “In reply to the various questions, first I think the Contract System was touched upon. It is very essential that we press for this system to be adopted in Ceylon. At home an Engineer seldom employs the labour. He designs, specifies, and supervises the construction of the work carried out by Contractors, such as Highways, Ltd., who are paid when the work has been satisfactorily completed. This method is much cheaper in the end, as the loss for bad work falls upon the Contractor who has to maintain his work for some period agreed upon under the Contract.

I have been impressing upon Spramex, Asphaltum, and Colas representatives the necessity for taking a contract and laying down their own preparations to prove their claims, and I think they are beginning to realise that this will have to be done if they wish to push the sale of their materials.

Mr. van Twest appears to have experienced the same difficulty as myself regarding metal depôts, but I fear we may still have to pile on the road for a short period immediately before consolidation. My proposal is to store the metal in bulk depôts, one or two per mile the fewer the better. If there is difficulty about sufficient transport, when consolidation is actually taking place, then it would be necessary to commence transport, say a month ahead, from the depôt to the road-side. The metal would then lie there a very short time compared with what happens at present.
If, however, we get a local Highways, Ltd., they will be able to organise, transport and use the metal straight from the depots and move from one district to another when required.

With regard to development of quarries and screens (a model of which is shewn), I find that the trouble and expense incurred have been fully justified. Coolies like to work in a clean quarry. They can get stone easily, and where there are breaking sheds, they can break under cover and get a larger out-turn per head and therefore better wages.

A single screen was first designed by me with the object of getting all the quarry dust out of the metal before transporting, and the idea was developed, when I came to require chips for tar concrete, and patching. The model on the table, is what I have been making as standard with $\frac{1}{2}$ in. round holes on top perforated plate, and $\frac{1}{3}$ in. round holes on lower perforated plate.

Sufficient chips for covering miles of carpet could not be obtained in this manner unless the metal was broken smaller which I now intend doing, but with ordinary 2 in. metal from 5 to 10% passes through the screen, which is found to be sufficient for levelling up the hollows when painting and for patching. Not only is the 2 in. metal better for water bound consolidation by being freed from dust, but I get the chips for nothing.

Chips simplify patching of pot holes. You can either make tar concrete and store it ready for use, or you can simply sweep out the depression thoroughly clean, paint a little hot tar, and cover with clean dry chips. I have been 3 years in Kandy, and have not picked up a road which has been surface painted. It has been patched, re-coated, and kept in order. Surface painting has been the means of reducing the cost of remetalling and I have been gradually widening out the metalled surface on either side with the savings effected. My experience has been that you must not allow the surface to break up. It requires a lot of driving force to get it.
patched properly and in time. The greatest difficulty is to get the surface clean, and the material hot enough. I have ordered large wire brushes similar to those on the table which I find very good.

If tar is not hot enough it will not dry up for days, and will not stick to the road, but will creep and come off some months later. I am inclined to think that most of the bleeding is due to insufficient heating. Mr. Bradley mentioned this trouble, and I found that with the small tar boiler it was very difficult getting the temperature above 350°F. owing to the small fuel capacity. With the Sprayer it is simple, as you have a far better fire box, and a thermometer fixed to the tank, and I agree with him that the higher the temperature the better.

With regard to his question about covering capacity with a Sprayer, it all depends on what thickness you want to lay down. If you move Sprayer slowly, you cover a small area with a thick coat, and if you move it faster, you cover a greater area with a thin coat. You can also pump fast or slow as required.

I presume, the traffic on the Bandarawela road is mostly rubber tyred, and this is the reason why it is lasting so well. It is the same in Kandy Town. My predecessor laid down Ward Street with Asphaltum, and the portion from Brownrigg Street to the Queen’s Hotel, has never been touched—not a single patch has been required. At either end of this section however there is a greater proportion of concentrated iron tyred traffic, and it has to be coated fairly frequently. I notice, however, that this is lasting longer as the bullock carts get fewer in proportion to the Motor Vehicles.

The Analyses of spramex and Asphaltum are said to be practically the same, but I agree with Mr. Bradley that in actual practice, there is a difference—Spramex seems to bleed more. If you have a sufficient supply of chips, you can stop that bleeding, but when you have to rely on sand, unless it is very hard and coarse, it is rather difficult.
We have no Stone Crushers suitable for our small quarries. I have tried to use Stone Crushers in Koslande and Colombo districts, and there were so many difficulties, I could not make them pay. This was of course some years ago.

My Paper deals with surface treatment. I do not go into the question of hot mix. I consider it will take years before our rural roads require this, as stated in my concluding paragraph.

Mr. Young asked what can be done about fast moving Motor Vehicles disturbing the metal during consolidation. The only thing which can be done, until such time as the road has been widened to double width to allow half the road to be repaired at one time, is for a man with a rake to level it, as the Steam Roller goes over it. If it has been disturbed over night, it must be raked level in the morning.

I have tried also to make traffic reduce speed by placing a double row of barrels at either end of the consolidation, leaving a narrow passage only. I have also got a Policeman to stand and warn traffic to proceed slowly. The method adopted in America, is to raise a ridge or cut a shallow trench about 2 in. deep across the road. I have tried this and it is most effective in reducing speed over temporary bridges, where warning signs are entirely ignored.

Mr. Adam mentioned the drip from shade trees. This nuisance will entirely disappear when the surface has been painted.

The best surface painting is first Road Board Tar and after 6 months a second coat of Asphalt whether Spramex or Asphaltum. It takes some time to find out whether the tar is adhering to the road and it is better to allow traffic for 6 months to show up the weak spots and have them repaired before putting down the Asphalt carpet.

It is waste of money to surface paint a badly consolidated road, as the surface painting will crack and give way if there is any movement below. Should the first coat break up badly before the end of 6 months, it must either be due
to bad work, or failure of this class of road to withstand the weight, in which case grouting would have to be undertaken before surface painting.

I did not go into the question of costs, because it is a very controversial subject. Districts vary greatly, and so must cost of labour, transport, and materials.

I think, I have answered all the questions asked, and I thank you Gentlemen for the kind way you have received my Paper.

THE PRESIDENT commenting on Messrs. Scott’s and Worth’s papers, said: On the question of allowing buildings to be erected too close to other existing reservations a proposed amendment to the ‘Thoroughfares Ordinance’ to prevent building within 25 feet of the centre of existing reservation has been published in the ‘Gazette’ and is no doubt under consideration.

As to the quality of metal, selection will undoubtedly pay. For Colombo use, the rubble is selected when it is distributed to the breakers. Pieces unsuitable for breaking into metal are put aside for use as rubble. Evenness of size is also an essential and screening is necessary if this cannot otherwise be obtained.

The picking up of an old road surface to a sufficient depth will always be difficult and will never be obtained with any regularity by hand picking in these days. Scarifiers are now indispensable.

The result of experience in Colombo suggests that the sweeping off of all dust and fine material from the old surface after scarifying is most necessary but equally so is the scarifying to an even depth. Hollows below the general surface should be reduced to a minimum. No matter what the material used to form a new road crust, thorough consolidation without crushing the material is absolutely necessary, if it is to stand up to present day traffic. The consolidation must be complete before any grit, blinding, water or surface painting are applied.
It has also been found that no matter what painting material is used it is essential that each coating should be applied as thinly as possible and two separate coats given where required. It is suggested by Mr. Scott that by the use of baffle plates on pouring cans brushing hot tar can be done away with. No doubt it can be, but as a general practice it would seem advisable not to run the risk.

The use of pressure sprayers is inclined to be extravagant in material since their effect is something in the nature of grouting. Where mere surface painting is sufficient very good results are obtained in Colombo by hand work and at less cost. Pressure sprayers may however be very essential at higher elevations.

As to the respective merits of various preparations for surface painting it is clear that these must vary with the climate, traffic and other circumstances and that there cannot be one panacea to suit all the varying conditions. Tar, emulsified bitumens, bitumens and Asphalts all have their uses. The two former have more limited uses and life and for Colombo conditions but still have their uses—frequently as a preliminary protection.

Mr. Scott enquires about bullock drawn rotary sweeping brushes. Such machines are still regularly in use in Colombo and do very good work.

Mr. Worth's remarks when speaking of surface painting that the "heavy cost of other methods has been found to be unwarranted on any but the heavily trafficked roads," appear rather optimistic. Such treatment may serve a very large proportion of Ceylon roads, but the lengths which will require to be dealt with by other methods will not be inconsiderable. Mr. Worth's classification of asphalt does not appear to tally with the Standard Specification. The term "bitumen" therein includes Asphalts, but asphalt is a particular form of bitumen and does not apparently include the products from oil fields.
There is so much excellent detail in these Papers and so much that tallies with the results of many years' experience in Colombo that I would venture to commend them very strongly to all who are engaged on Road Maintenance work.