PAPER No. 207.

EXPERIMENT ON PREMIX WORK IN MILE 35 G. T. ROAD (DELHI AMBALA) SECTION.

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Kunkar as Road Metal :—Formerly roads in the Punjab used to be constructed of Kunkar of which in those days abundant supplies were available almost everywhere in the country side. Kunkar is a kind of concretionary lime stone and apparently corresponds to the "boulder drift" in England. It produces a good smooth riding surface but has a poor resistance to abrasion. The advent of fast motor traffic soon showed its inability to withstand the thrust and suction of the pneumatic tyre. This resulted in rapid disintegration of the road and the dust nuisance became intolerable.

Kunkar transformed to modern methods :—For some years Kunkar as a motor road material was considered obsolete but Mr. Stubbs and other Engineers refused to lose faith in the possibility of adopting it to suit modern conditions. This problem then lent itself to a number of solutions. Three methods were tried; first, the existing kunkar surface was tar-painted as in mile 19 of the G. T. Road which is still behaving fairly well; secondly, the kunkar surface was scarified, reconsolidated with an additional quantity of stone metal ranging from 9,000 to 12,000 c.ft. per mile of 12 feet width as water-bound macadam and then painted with tar. This process proved to be the cheapest and most practical; the majority of kunkar miles have been reconditioned by this method at any rate in the south of the province.

A third method consisted of using premixed stone aggregate and consolidating it as water-bound macadam. It is this last method which is the subject of this paper and refers to experiments in mile 35 situated on the Grand Trunk Road from Delhi to Lahore.

Experiment :—In February 1933 the representatives of Messrs. Burmah Shell and Co. approached the Superintending Engineer, Ambala Circle, offering him their manufactured preparations such as mexphalte. shelmac and colas, etc., for the purpose of experimenting with those materials on premix work. It was therefore decided to carry out a number of experiments to their specifications slightly modified by the Superintending Engineer and referred to as specifications No. 1, 1A, 2 and 3 (reproduced in Appendix A).

These experiments, 21 in number, were accordingly carried out in mile 35, starting on 15th March 1933 and finishing on 10th April, 1933. Two months later, *i.e.*, in June 1933, a seal coat with shelmac stone and 1500 c.ft. of Delhi stone chips was applied and since then nothing has been done to the surface.

Description of Experiment :—The road appears to be still in good conditions (see photographs) though slight signs of drying out of the binder are now noticable. Before describing the experiment it may be well to define what "Premix" is. The word "Premix" refers to any stone aggregate coarse or fine precoated with a binder such as tar or bitumen. This coating is done in ordinary home made tar drums contrivance vide Fig. 2. The old road crust on which the experiments were to be tried consisted wholly of kunkar. Until then it was considered almost impossible to render the kunkar roads water proof as well as dust proof by grafting on to it a thin skin of water-proofing material but how it has been affected is set forth below.

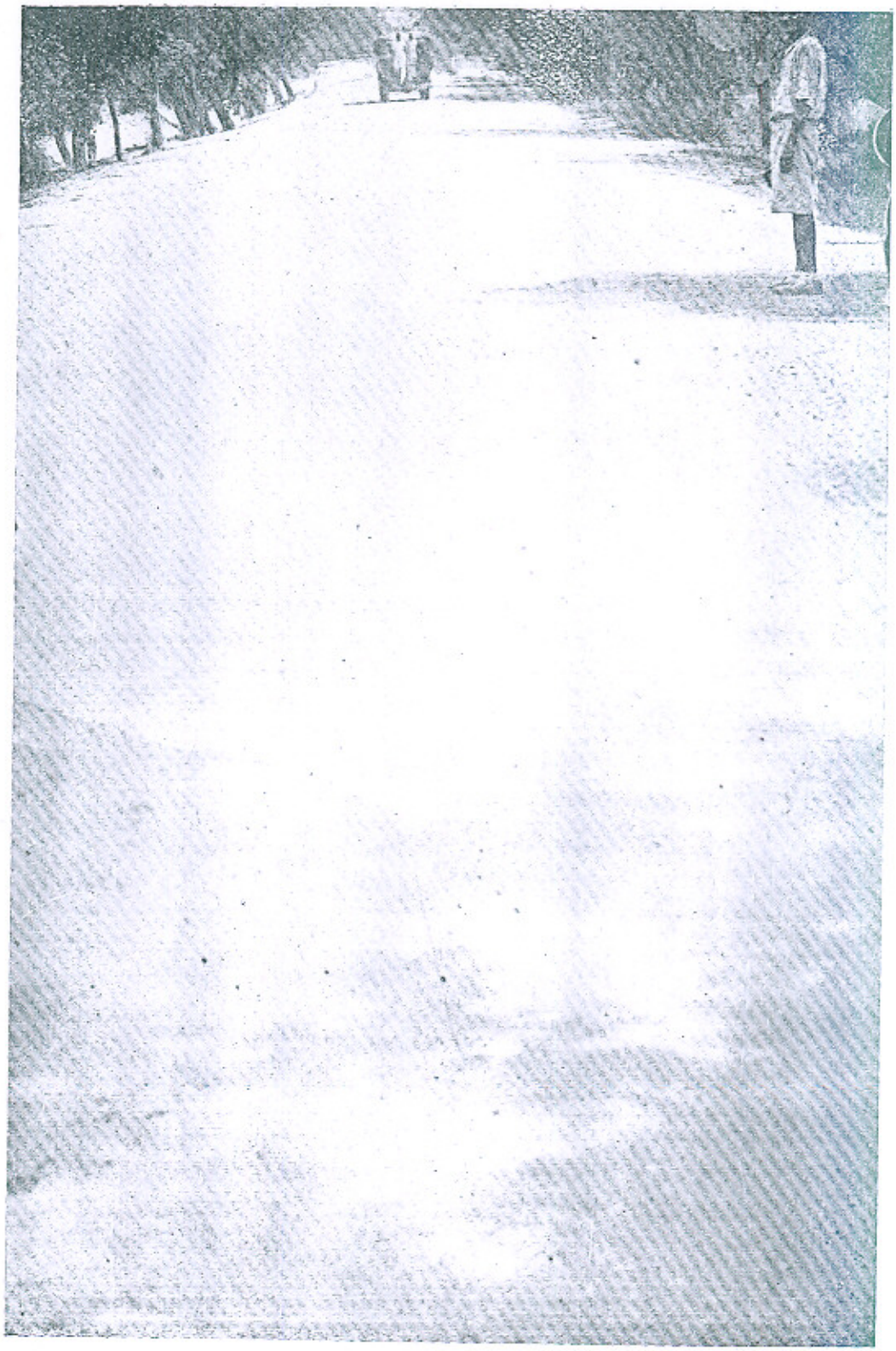
The kunkar surface was scarified by means of pick-axes to $1\frac{1}{2}$ inches depth. The loose kunkar was then removed from the road and screened through $\frac{1}{2}$ inch mesh screen. The bigger stuff which was retained on the screen was put back into the old bed, properly dressed and brought to camber of 1 in 48. It was then rammed with hand rammers using water sparingly during the process.

Side trenches about 9" wide and 2" deep were then dug out in order to provide a greater thickness of premix at the edges than in the rest of the road surface as it is the edges which are subjected to greatest strain due to thrust and lateral pressures. In this way $4\frac{1}{2}$" thickness of premix was provided at the edges while in the centre it varied from $1\frac{1}{2}$" to $2\frac{1}{4}$" thick. About 9000 c.ft. of $1\frac{1}{2}$" gauge stone metal previously coated with $2\frac{1}{2}$% of binder was spread out hot on the road to a template vide Fig. No. 1 and lightly rolled with a ten-ton roller using some water during the consolidation.

Then a mixture of 1250 c.ft. of ($\frac{3}{4}$" to 1") precoated bujree with 500 c.ft. of pre-coated jumna sand or fine siftings from metal was spread and rolled. Just before the final compaction of the premixed metal took place a second instalment of the same quantity of precoated fine aggregate was spread and rolled.

Only sufficient water was added to wash in the screenings so as to fill in the interstices in the coarse premix. But in any case less water was used than in water-bound macadam.

Bujree was precoated with 4% binder and sand with 5% to 10% of binder. Names of the binders are given in the next para.



Traffic was kept off for seven days and the surface kept watered for 14 days after the consolidation.

Physical comparison of various experiments :—Judging from a cursory glance there is not much to choose between the various sections of experiment but careful examination reveals the following.

Number of experiment.	Length in feet.	Binder used.	Conditions of surface.
1	580	Tar No. 2 for premixing coarse aggregate and tar & maxphalt for fine aggregate.	Good.
2	20		,,
3	20		,,
4	20		
5	126		,,
6	330	Coarse aggregate not premixed with tar.	Fair.
7	30		Fair to Poor.
8	186		Bad.
9	20	Shelmac and mexphalt in the proportion to 1 & 2 as binder for both coarse and fine aggregate.	Fair, the coarse premixed aggregate has made its appearance in few places indicating that the fine aggregate has been worn away; binder is drying or losing its viscosity.
10	80		
11	30		
12	30		
13	30		
14	1130		
15	60	Shelmac and mexphalt 1 : 1 for coarse aggregate colas mix for fine aggregate.	Edges of coarse premixed metal are more exposed in this case. Surface is patchy.
16	60		
17	50		
18	995		
19	275	Shelmac and mexphalt 1 : 1.	Fair.
20	1120	Shelmac and mexphalt.	Kunkar premixed surface, rutted and patchy, 1" carpet over kunkar rutted.
21	200	Tar, shelmac and mexphalt.	

Different binders and aggregate compared :—From the foregoing it is possible to form some opinion about the different experiments. It would appear that kunkar as an aggregate is not a good material to be used for premix work. Further the thin water-proof carpet over kunkar does not give good results. We must therefore confine our choice to the experiments involving use of stone metal as an aggregate. The best results seem to have been obtained by using Tar No. 2, for premixing the coarse aggregate and bitumen for fine aggregate in the first five experiments. Again the experiment made without premixing the coarse aggregate and only seal coating the water-bound are not so satisfactory.

Experiment made with Burmah shell products, such as mexphalte, shellmac and colas on the whole do not give such good results as those with tar and bitumen as binder. Both shellmac and colas seem to dry out more quickly.

Economic comparison of experiment with tar painted surface :—From a study of the comparative cost of the different methods of reconditioning a kunkar road, the premix method will appear to be the cheapest and best in the long run. For the sake of brevity we shall take two methods only, one with water-bound macadam with successive tar paints and the other with water bound premixed stuff and subsequent seal coat. The life of a premixed surface with a seal coat under average condition of traffic can be taken as 3 years while during the same period ordinary water bound surface will take 3 coats of tar.

On these assumptions the cost works out as follows :—

Water bound premixed.

	Rs.	a.	p.
Cost per mile as per experiment No. 2 Appendix 2 (in best condition now).	5,050	0	0
Cost of seal coat ..	1,200	0	0
Total	6,250	0	0

Water bound macadam with tar paints.

12000 c.ft. of stone metal c 20 of c.ft. ..	2,400	0	0
Consolidation of metal	600	0	0
Tar stone at 125 per ton	1,000	0	0
Delhi stone chips 2000 c.ft. at 25% c.ft. ..	500	0	0
Labour for one mile 0-4-0 s.ft.	160	0	0
Subsequent coat of tar at 850	1,700	0	0
Patch work for 3 years	150	0	0
Total ..	6,510	0	0



Advantage of premix work :—It will, therefore, be seen that the premixed method is slightly cheaper than the other method; moreover in the latter case yearly programmes of tarring have to be worked out entailing expenditure of time and energy of officers and subordinates; obstruction to traffic is caused and also inconvenience to travellers; while in the former case, nothing requires to be done for 3 years. The draw back in the extensive use of this method is its inadaptability to working in the cold and rainy season. To overcome this cold emulsions such as bitumals W. R. M. may be found to be a better substitute. The great advantage of premixed stuff lies in its cohesion due to each particle being covered with a film of binder—a feature which is absent in ordinary water-bound macadam. Thus premix provides a more durable and elastic base for the future coat of paint than the water-bound crust which depends or its strength on the mechanical inter-locking of its aggregate, suffers less from attrition than in water-bound whilst it has more resilience against the impact of fast traffic and the crushing of the iron tyred cart.

Comments.—The writer is of opinion that hot premixed stuff should not be rolled immediately but should be mixed with dry sand, allowed to weather for about a week and then spread out on the road and consolidated; the object of adding sand to premix is that by its addition as a filler the sand will render the premix very much more compact and less liable to crushing under heavy iron tyred traffic. This will also obviate the necessity of using much water during consolidation as the tendency of particles to slip one over the other will be greatly minimized—a very marked fault in the case of material applied hot—to overcome which water is added. Another purpose of using water seems to be to wash in the screenings so as to fill in the interstices in the coarse aggregate. This could be achieved by having a well graded aggregate and bujree in the first instance;

Metal 60% $\frac{3}{4}$" to 1" gauge.	Bujree 60% $\frac{3}{8}$" to $\frac{1}{2}$".
40% $\frac{1}{2}$" to $\frac{3}{4}$" ,,	40% $\frac{1}{8}$" to $\frac{3}{8}$".

The advantage of having to use water only in small quantities during consolidation will render the process eminently suitable for the sandy tracts of Rajputana and Sind where water is so scarce.

Some suggestions :—In order that premix work may be employed in an extensive scale it is recommended that precoating of stone should be done at the quarry where a suitable mixing plant could be installed and supervision centralized.

The premixed metal could then be transported to the road side by rail or cart. This will do away with hand mixing, and supervision at site of work. Delays will not occur through bad or wet weather. In fact the work could proceed during the full twelve months of the year.

Conclusion :—As a result of surfacing the roads in the Punjab the annual maintenance budget has been reduced considerably. The G. T. road in Rohtak district has had its annual expenditure reduced from Rs. 1062 in the year 1925-26 to Rs. 395 per mile in the year 1935-36. This is rather an abnormal figure as very little work was done during the year but on the average the annual maintenance has been reduced by 50 p.c. and come down to Rs. 900. In conclusion the methods indicated bid fair to solve to some extent the problem of rehabilitating the old kunkar roads to meet modern conditions, Kunkar is readily available in many parts of the country where the cost of stone metal is prohibitive and the need of metalled roads is urgent.

If it is possible to recondition an old kunkar road and provide a water-proof surface which adheres to the metal below, is it not equally possible to design and construct new roads on the same principles *ab initio* ?



APPENDIX "A".

General specification for premix work with tar as binder on kunkar roads.

1. *Scarifying.*—Scarify by means of pickaxes to a minimum depth possible say 1 to 2 inches. As the main object of scarifying is to obtain a proper binding between the new layer and the original, it is not desirable to disturb the original surface more than necessary and thus weaken the foundations on which the new coat will be laid.

2. *Removing and Screening the loosened stuff.*—The loosened stuff is removed from the road and screened through a $\frac{1}{4}$ inch screen. The bigger stuff which has been retained on the screen is put back into the old bed.

3. *Sectioning the old metal.*—The old metal is now brought to proper camber of 1 in 48, watered and rammed with hand rammers. As the edges are the weakest spot in a road, these are dug about 2 inches deeper than the cambered surface so as to provide a total thickness at the edges of about $4\frac{1}{2}$ inches, which when compacted under a roller reduces to $3\frac{1}{2}$". This is done by means of a special template as per figure No. 1 which is made to conform to the section of road. The side trenches are made about 9" wide. Care is taken that no fine stuff is left in them before the premixed stuff is put in.

4. *Spreading premixed metal.*—From 8000 to 12000 of $1\frac{1}{2}$" gauge metal previously coated with $2\frac{1}{2}$lb. No. 1 or No. 2 Shalimar tar per c.ft. is spread on the surface and brought to the required camber. The metal should be spread while it is hot. It requires a battery of five home made premixers to premix 500 c.ft. of metal a day and 150 c.ft. of fine aggregate.

5. *Rolling.*—The premixed metal should then be lightly rolled with a 6-ton roller. Then precoated bajri $\frac{1}{8}$" to $\frac{3}{8}$" gauge hot at the rate of 2500 to 3000 c.ft. for a (12 feet wide) mile and precoated Jumna sand at the rate of 1000 c.ft. per mile spread in two instalments during the consolidation, half the quantity may be spread just after the light rolling with a 6 ton roller and the remaining half just before final compaction takes place, care being taken to see that the surface is completely covered with the precoated stuff. 3 lb. per c.ft. of Shalimar Tar No. 2 will be used for precoated bajri and $4\frac{1}{2}$ to 5 lb. per c.ft. for sand. The rolling is started from the edges towards the centre and is continued till no movement of particles takes place. Sufficient water is used during consolidation on the surface as well as on the wheels of the roller so that the fine screenings are washed in and well worked into the voids of the metal. The object of watering on the wheels is that no particles stick to the wheels. To facilitate entry into the voids, water is freely used while brushing the fine stuff just before final rolling. Too

much water should not be used as it will oversaturate the sub-grade and produce unevenness in the wearing surface. In any case much less water is used than in water bound macadam. Too much fine stuff should also not be used as when voids are overfilled, interlocking of stone pieces will not take place and their movement is likely until tar hardens.

General.—Traffic should be kept off for seven days and surface kept watered for 14 days.

HEATING AND PREMIXING.

Use the home made tar drum contrivance vide Fig. 2 on which the method of operation is clearly shown. Mixing should be done in hot dry weather when the sun's temperature is 100 degrees F. or over and under such conditions there is no need of heating the aggregate. The temperature of the aggregate is raised much more rapidly by laying it on iron sheets of any kind. Old drums flattened out will serve the purpose. No. 2 Shalimar Tar should be heated to a temperature of 250°F. In the hottest weather of the year (May to June) this temperature can be lowered by about 5° F, but under no circumstances should this temperature be exceeded. Recently the temperature to which tar ought to be heated has been reduced to 200°.

SPECIFICATION No. 1.

(As Referred to in Table of Experiments).

I. Scarify the old kunkar surface to about an inch depth by pick-axes, reshape, bring into camber and partially compact (with a roller in the case of stone and hand ramming in the case of kunkar), then dig the side trenches as described in the general specification for tar premix.

II. Spread 9000 c.ft. of 1½" gauge metal previously coated with 2½ per cent. of binder and lightly roll with water.

III. Spread a mixture of 1250 c.ft. of (⅛" to ½") precoated bajri with 500 c. ft. of precoated sand (Jamna) or fine siftings from metal and again roll. Spread a second instalment of the same quantity of precoated fine aggregate and complete rolling. The bajri should be coated with 3 per cent. and sand with 5 per cent of binder. The binder should consist of two parts of maxphalts (20—30) penetration bitumen and one part shelmac. The maxphalt should be heated to a temperature of 350° F. and allowed to cool to 275° F. At this stage the shelmac should be added and the mixture thoroughly stirred and allowed to cool to 250° F. when it is ready for precoating the metal. Mixing should be done in an ordinary tar drum with a slit cut out of its side and a lid provided and fitted with two revolving handles and mounted on a wooden frame work. See Fig. No. 2.

SPECIFICATION No. 1 (A).

Instead of scarifying and rolling, merely fill up ruts and pot-holes with ordinary metal and bring the surface roughly to camber; then follow the rest of the specification No. 1 above. Mixing can either be done by means of adapted tar drums or by means of a road drag broom; when the latter is used it is called "Mix-in-place": this specification, *i.e.*, I (A), might also be adapted for a previously tarred surface in order to strengthen it.

SPECIFICATION No. 3.

Same as specification 1 above except that 9000 c.ft. of washed Bitchwa kunkar shall be used instead of stone metal and 5% binder for precoating the kunkar. The binder shall consist of a mixture of fuel oil and bitumen and shall be used for precoating the kunkar. The percentage and ingredients of the binder for coating the fine aggregate shall be excatly the same as for specification I above.

APPENDIX "C".

Tools & Plants Required for Premix Work.

1.	Battery of five home made premixers	
2.	Pickaxes	.. 12
3.	Phowras	.. 10
4.	Iron screens $\frac{1}{4}$"	3
5.	Screen $\frac{1}{4}$" to $\frac{1}{8}$" gauge for screening fine aggregate.	
6.	Iron rakes large	.. 4
7.	Do. small	.. 4
8.	Iron rammers	.. 4
9.	Baskets	.. 20
10.	String 100' long	.. 2
11.	Bamboo 12' long	.. 2
12.	Bamboos small	.. 2
13.	Country made tar boiler with chulahs	8
14.	Small Khurpas	.. 4
15.	Measuring pots with handles	.. 4
16.	Galvanized iron bucket	.. 6
17.	Measuring box 2×1×1	.. 4
18.	Bags gunny	.. 12
19.	Iron sheet made of tar drums flattened out for spreading out for aggregation.	.. 4
20.	Scale & Weights 1 Chhataak to 5 seers	.. 1 set.
21.	Thermometer to read temperature to 100° F.	.. 2
22.	Do. 400° F.	.. 2
23.	Steam road roller (6 ton)	.. 1

APPENDIX "B".

XPERIMENTS IN MILES 34 & 35 G. T. ROAD, ROHTAK DISTRICT.

PERIMENT. No. 1. 580' No. 2. No. 3. No. 4.
120 × 100 × 20' × 20' × 20'
Mics 34.

1. Premix Work with Tar and Bitumen.	Premix Work with Tar and Bitumen.	Premix Work with Tar and Bitumen.	Premix Work with Tar and I

1. Coarse Aggregate.
1½" Delhi Stone metal 9000 c.ft. per mile.
2. Fine Aggregate.
Delhi Stone chips ½" to ⅜" 2000 c.ft. per mile.
3. Binder for No. 1.
2½ p. c. (by weight) Tar No. 2.
4. Binder for No. 2.
4 p.c. (by weight) 1 Bitumen & 2 Tar No. 2.
	1. Coarse Aggregate.
	As per No. 1.
	2. Fine Aggregate.
	(a) Delhi Stone chips ½" to ⅜" 2000 c.ft. per mile.
	(b) Jamna sand 1000 c.ft. per mile.
	3. Binder for No. 1.
	2½ p. c. Tar No. 2.
	4. Binder for No. 2.
	For (a) 4 p.c. (by weight) 1 Bitumen and 2 Tar No. 2.
	For (b) 10 p.c. (by weight) 1 Bitumen and 2 Tar No. 2.
		1. Coarse Aggregate.
		As per No. 1.
		2. Fine Aggregate.
		(a) Delhi Stone chips ½" to ⅜" 2000 c.ft. per mile.
		(b) Jamna sand 2000 c.ft. per mile.
		3. Binder for No. 1.
		2½ p. c. (by weight) Tar No. 2.
		4. Binder For No. 2.
		For (a & b) 5 p.c. (by weight) 1 Bitumen and 2 Tar No. 2.
			1. Coarse Aggregate.
			As per No. 1.
			2. Fine Aggregate.
			(a) Delhi stone chips ½" to per mile.
			(b) Stone screenings bel 1000 c.ft. per mile.
			3. Binder for No. 1.
			2½ p. c. (by weight) Tar N
			4. Binder for No. 2.
			For (a & b) 5 p.c. (by w men and 2 Tar No. 2

Cost per mile Rs. 4850.	Cost per mile Rs. 5050.	Cost per mile Rs. 5700.	Cost per mile Rs. 5650.

No. 14. No. 15. No. 16.
1130' × 50' × 50' ×

Specification No. 1-A.	Specification No. 1-A.	Specification No. 1-A.	Water
1. Coarse Aggregate. Delhi Stone 1½" gauge 9000 c.ft. per mile. 2. Fine Aggregate. Delhi Stone Chips ½" to ⅜" gauge 2000 c.ft. per mile. 3. Binder for No. 1. 2½ p. c. (by weight) 1 shelmac and 2 Mexphalt. 4. Binder for No. 2. 4 p. c. (by weight) 1 shelmac and 1 mexphalt.	1. Coarse Aggregate. Same as No. 14. 2. Fine Aggregate. Delhi Stone Chips ½" to ⅜" gauge 2000 c.ft. per mile. 3. Binder for No. 1. 2½ p. c. (by weight) 1 shelmac and 1 mexphalt. 4. Binder for No. 2. *Nil.* After Rolling dry chips the surface was grouted with colasmex at ¼th. gallon a square yard.	1. Coarse Aggregate. (a) Delhi Stone Metal 1½" gauge 7000 c. ft. per mile. (b) Screening of kankar 2000 c.ft. per mile. 2. Fine Aggregate. Delhi Stone Chips ½" to ⅜" gauge 2000 c.ft. per mile. 3. Binder for No. 1. 3 p. c. (by weight) 1 Mexphalt and 1 Shelmac. 4. Binder for No. 2. *Nil.* After spreading and Rolling Dry Chips the surface was grouted with Columix at ¼th. gallon a square yard.	1. Cha D 2. Fin D 3. Bin At
Cost per mile Rs. 5400.	Cost per mile Rs. 6350.	Cost per mile Rs. 6600.	

APPENDIX "B".

No. 4.	No. 5.	No. 6.	No. 7.
20'	120'	330'	50'
and Bitumen.	Premix Work with Tar and Bitumen.	Premix Work with Tar and Bitumen.	Water Bound Macadam, Interstices Filled with Precoated Bajri and Surface sealed with Bitumen.	Water Bound Macadam, Subgrade Primed with Molasses and Surface Grouted with Molasses and Blinded with Chips & Sealed with Bitumen.	W
	1. COARSE AGGREGATE. As per No. 1. 2. FINE AGGREGATE. (a) Delhi stone chips ¾" to ⅜" 2500 c.ft. per mile. (b) Stone screenings below ¾" Gauge 1000 c.ft. per mile. 3. BINDER FOR No. 1. 2½ p. c. (by weight) Tar No. 2. 4. BINDER FOR No. 2. For (a & b) 5 p.c. (by weight) 1 Bitumen and 2 Tar No. 2.	SAME AS No. 1. 1000 c.ft. screenings below ¾" added to Fine Aggregate.	COARSE AGGREGATE. 1. 1½" Delhi Stone metal 12000 c.ft. per mile. 2. FINE AGGREGATE. Delhi Stone chips ¾" to ⅜" 2000 c.ft. per mile. 3. BINDER FOR 1. *Nil.* 4. BINDER FOR 2. 4 p.c. (by weight) 1 Bitumen & 2 Tar No. 2. 5. SEAL COAT. Spramex at 5 Tons per mile.	1. COARSE AGGREGATE. 1½" Delhi Stone metal 12000 c.ft. per mile. 2. FINE AGGREGATE. ¾" to ⅜" Delhi Stone Chips 2000 c.ft. per mile. 4. Subgrade prepared and primed with molasses of 1 gallon per 15 s.ft., coarse aggregate spread and Rolled and then grouted with molasses at 30 s.ft. per gallon and Blinded with Delhi Stone chips at 2000 c.ft. per mile. 5. SEAL COAT. Spramex at 5 Tons per mile.	Sa
¾" to ¾" 2000 c.ft. c.ft. per mile. Tar No. 2. weight) 1 Bitumen 2.					
700.	Cost per mile Rs. 5650.	Cost per mile Rs. 5400.	Cost per mile Rs. 5100.	Cost per mile Rs. 5300.	

No. 16.	No. 17.	No. 18.	No. 19.	No. 2
50'	50'	995'	275'	1120'
Specification No. 1-A.	Water Bound Macadam Subgrade primed with Molasses.	Specification No. 2.	Specification No. 1.	Specification No. 3 B
COARSE AGGREGATE. (a) Delhi Stone Metal 1½" gauge 7000 c. ft. per mile. (b) Screening of kunkar 2000 c.ft. per mile. FINE AGGREGATE. Delhi Stone Chips ¾" to ¼" gauge 2000 c.ft. per mile. BINDER FOR No. 1. 3 p. c. (by weight) 1 Mexphalt and 1 Shelmac. BINDER FOR No. 2. *Nil.* After spreading and Rolling Dry Chips the surface was grouted with Colasmix at ⅓th. gallon a square yard.	1. COARSE AGGREGATE. Delhi Stone Metal 1½" gauge 9000 c.ft. per mile. 2. FINE AGGREGATE. Delhi Stone Chips ½" to ¼" gauge 2000 c. ft. per mile. 3. BINDER FOR No. 1 & No. 2. *Nil.* After Spreading and Rolling the Bajri surface was grouted with colasmix at ⅓th. gallon a square yard.	1. COARSE AGGREGATE. Delhi Stone Metal 1½" gauge 9000 c.ft. per mile. 2. FINE AGGREGATE. Delhi Stone Chips ½" to ¼" gauge 2500 c.ft. per mile. 3. BINDER FOR No. 1. 2½ p. c. (by weight) colasmix. 4. BINDER FOR No. 2. 4 p.c. (by weight) colasmix.	1. COARSE AGGREGATE. Delhi Stone Metal 1½" gauge 9000 c.ft. per mile. 2. FINE AGGREGATE. Delhi Stone Chips ½" to ¼" gauge 2500 c.ft. per mile. 3. BINDER FOR No. 1. 2½ p. c. (by weight) 1 shelmac and 1 Mexphalt. 4. BINDER FOR No. 2. 4½ p. c. (by weight) 1 shelmac and 1 Mexphalt. After rolling fine aggregate the surface was covered with stone screenings below ¾" gauge at 3000 c.ft. per mile.	1. COARSE AGGREGATE. 1½" gauge washed per mile. 2. FINE AGGREGATE. Delhi Stone Chips c.ft. per mile 3. BINDER FOR No. 1. 5 p.c. (by weight) and 70 p.c. Me 4. BINDER FOR No. 2. 4 p.c. (by weight) Shelmac.
Cost per mile Rs. 6600.	Cost per mile Rs. 4700.	Cost per mile Rs. 5600.	Cost per mile Rs. 5550.	Cost per mile Rs. 550

Specification No. 1 & 1A Using Burmah Shell materials.

No. 7.	No. 8.	No. 9.	No. 10, 11, 12, & 13.
50′	180′	20′	160′

erstices Filled Surface sealed n.	Water Bound Macadam, Subgrade Primed with Molasses and Surface Grouted with Molasses and Blinded with Chips & Sealed with Bitumen.	Water Bound Macadam, Subgrade primed with Molasses Surface Blinded with Bajri and Sealed with Bitumen.	Premix Work with Bitumen Specification No. 1.	Premix Work with Bitumen Specification No. 1-A.
0 c.ft. per mile.	1. Coarse Aggregate. 1½″ Delhi Stone metal 12000 c.ft. per mile.	Same as No. 7 with the exception that the grouting with molasses was not done.	1. Coarse Aggregate. 1½″ Delhi Stone metal 9000 c.ft. per mile.	1. Coarse Aggregate. Same as No.9.
o ¾″ 2000 c.ft.	2. Fine Aggregate. ¾″ to ⅜″ Delhi Stone Chips 2000 c.ft. per mile.		2. Fine Aggregate. (a) Delhi Stone chips ¾″ to ⅜″ 2500 c.ft. per mile. (b) Jumna Sand 1000 c.ft. per mile.	2. Fine Aggregate. Stone chips ½″ to ¼″ 2500 c.ft. per mile.
	4. Subgrade prepared and primed with molasses @ 1 gallon per 15 s.ft., coarse aggregate spread and Rolled and then grouted with molasses at 30 s.ft. per gallon and Blinded with Delhi Stone chips at 2000 c.ft. per mile.		3. Binder for No. 1. 2½ p.c. (by weight) 2 mexphalt and 1 shelmac.	3. Binder. For 10·4 p. c. (by weight) 2 mexphalt and 1 shelmac, length 60 ft. For 11·4 p. c. (by weight) 1 mexphalt and 1 shelmac, length 30 ft. For 12·4 p. c. (by weight) 1 mexphalt and 2 shelmac, length 30 ft. For 13·4 p. c. (by weight) shelmac.

urmen & 2 Tar	5. Seal Coat.
	Spramex at 5 Tons per mile.
			4. Binder for No. 2.
			For (a) 4 p.c. (by Weight) 2 mexphalt and 1 shelmac.
			For (b) 10 p.c. (by weight) 2 mexphalt and 1 shelmac.	

mile.				
	Cost per mile Rs. 6300.	Cost per mile Rs. 5100.	Cost per mile Rs. 6100.	Cost per mile Rs. 5800.

No. 19.	No. 20.	No. 21.
275′	1120′	200′

Specification No. 1.	Specification No. 3 Burmah Shell.	Reshaping old kunkar surface and then laying 2 layers of precoated Bajri.
arse Aggregate. Delhi Stone Metal 1½″ gauge 9000 c.ft. per mile. ne Aggregate. Delhi Stone Chips ¾″ to ⅜″ gauge 2500 c.ft. per mile. nder for No. 1. ½ p. c. (by weight) 1 shelmac and 1 Mexphalt. nder for No. 2. ½ p. c. (by weight) 1 shelmac and 1 Mexphalt. After rolling fine aggregate the surface was covered with stone screenings below ⅜″ gauge at 3000 c.ft. per mile.	1. Coarse Aggregate. 1½″ gauge washed kunkar 9000 c.ft. per mile. 2. Fine Aggregate. Delhi Stone Chips ¾″ to ⅜″ gauge 2000 c.ft. per mile. 3. Binder for No. 1. 5 p.c. (by weight) (30 p.c. Diesel Oil and 70 p.c. Mexphalt). 4. Binder for No. 2. 4 p.c. (by weight) 1 Mexphalt and 1 Shelmac.	1. Fine Aggregate. (a) Delhi Stone Chips ⅜″ to ¼″ gauge 2600 c.ft. per mile. (b) Delhi Stone Chips ¾″ to ⅜″ gauge 2700 c.ft. per mile. 2. Binder for (a). 4 p.c. Tar No. 2. Binder For (b). 4 p.c. (by weight) 1 Shelmac and 1 Mexphalt. At edges 1½″ stone premixed with Bitumen laid 2″ thick and 9″ wide.
ost per mile Rs. 5550.	Cost per mile Rs. 5500.	Cost per mile Rs. 4500.

KIDAR NATH,
Assistant Engineer,
Gurgaon Provincial Sub Division.
8th April, 1933.

FIG. 1.
Paper No. 207.

TEMPLATE FOR SECTIONING THE SUBGRADE
SCALE 1" = 2'.

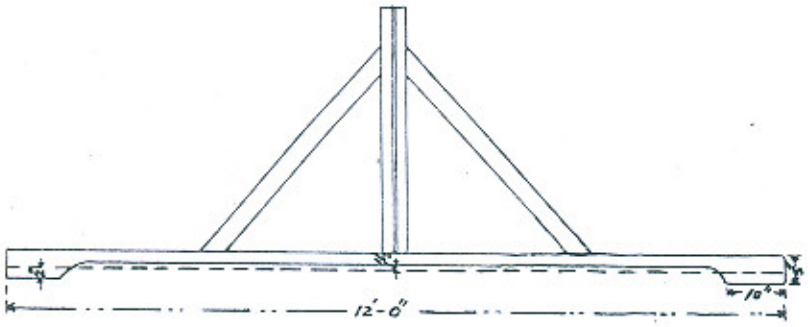
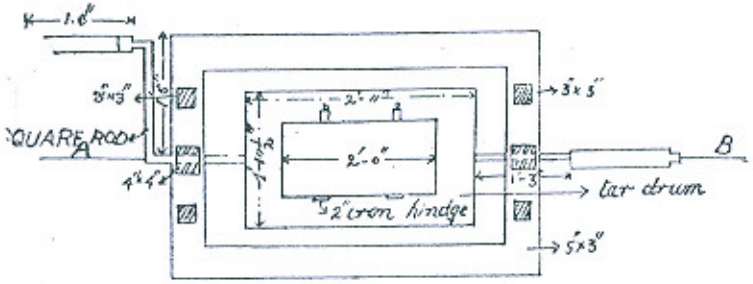
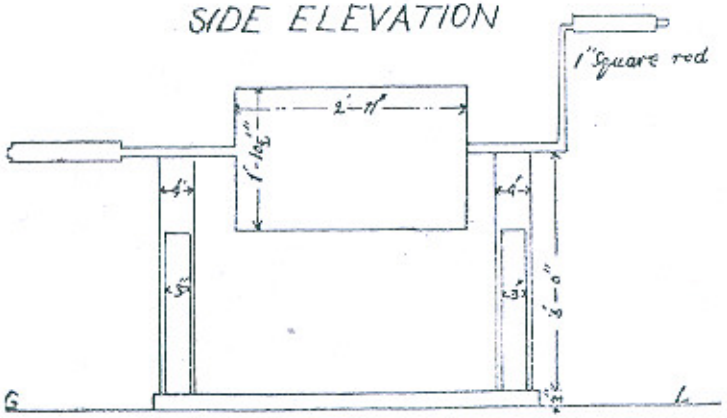


FIG. 2.
Paper No. 207.

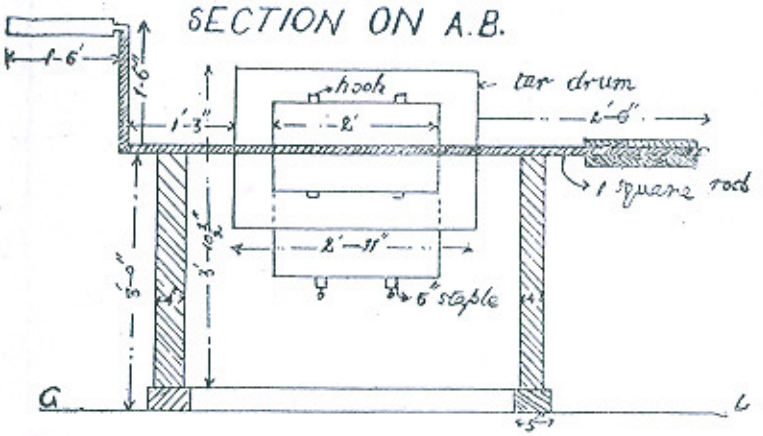
PLAN OF MIXER
Scale ½" = 1'



SIDE ELEVATION



SECTION ON A.B.



END ELEVATION

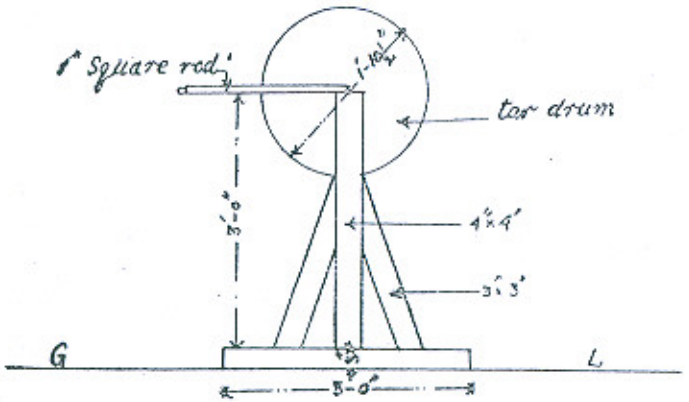


FIG.3
PAPER NO 207

PROGRESS OF SURFACING & EXPENTURE ON G.T. ROAD IN ROHTAK SUB DIVISION FRM 1935-36.



DISCUSSION.

The **Author** of this Paper, MR. MURARI LAL, Assistant Engineer having proceeded on long leave, Mr. **Brij Mohan Lal** in introducing the Paper said that the experiment described was, as a matter of fact, carried out under the supervision of Lala Kidar Nath, Sub-Divisional Officer in March 1933. Mr. Murari Lal did not personally see the experiment being carried out, as he took over charge of that road in 1935, two years later. The main object in carrying out the experiment was to find out the best material—bitumen or tar—for premixing the coarse aggregate which formed the foundation of the wearing coat and the fine aggregate which filled in the voids of the coarse aggregate and acted as a covering to protect the aggregate from abrasion.

In the first five experiments, only tar No. 2 was used for premixing the coarse aggregate and mixtures of Road Tar No. 2 and Mexphalt (30—40 penetration) in various proportions for premixing the fine aggregate. In the remaining experiments, various other products of the Burmah Shell Company were used in mixtures of various proportions to premix the coarse as well as fine aggregates. While the coarse aggregate was 1½" Delhi Stone in all cases, the fine aggregate varied. Delhi Stone chips, Chandigarh bajri, fine stone screenings and Jumna sand were all tried. While most of the experiments had been a success, the best results were achieved in experiment No. 1, in which road Tar No. 2 was used for premixing the coarse aggregate and a mixture of Mexphalt and tar in the proportions of 1 and 2 was used for premixing the fine aggregate. This was also the cheapest, costing Rs. 4,850 per mile.

The second paragraph on page 182 of the Paper was a bit confusing. The Author had stated therein that experiments made with Burmah Shell products, such as Mexphalt, etc., did not give good results. The Author appeared to forget that bitumen used for premixing for fine aggregate in experiment No. 1 was nothing but Mexphalt—a Burmah Shell product.

The advantage in using pre-mixed coarse aggregate was that it provided a store of tar or bitumen in the base of the road, but it was evidently more costly than tar painting on water bound macadam where stone cost less than Rs. 25 per cent. cubic feet. As the cost of stone moved higher than Rs. 25, premix became economical to use. It was also of benefit where water for consolidation of water bound macadam was not readily available.

A seal coat of some soft bitumen (83—100 penetration) however had to be laid over the premix within three months, otherwise it was likely to break up. In some miles laid with premix in Hissar District, where the seal coat could not be applied soon after the premix difficulties were experienced in subsequent maintenance. In mile 35, a seal coat of

premix was laid in June 1933, three months after the premix, and as far as the speaker knew it had not yet been repeated. The traffic in this mile was, however, much lighter than in other sections of the Grand Trunk Road and there was very little traffic of heavy loaded bullock carts with iron tyred wheels, which were the cause of real damage to the painted roads.

MR. **Trevor Jones** remarked that these experiments on the Delhi-Ambala Section were of interest in view of our efforts to adopt local materials to present traffic requirements.

Mr. Murari Lal had not stated the possibility of treating an ordinary kankar road with a tar surface but this was dealt with last year by Mr. Brij Mohan Lal. He shewed there that such application was not a success where bullock cart traffic was to be accommodated.

Mr. Brij Mohan Lal also dealt with the second method mentioned in Mr. Murari Lal's Paper and said that we had learnt that it was possible to combine stone with kankar. It was two coats of tar for Rs. 5,600 against Rs. 8,200 for ordinary waterbound tar specification.

Mr. Murari Lal had ended his Paper on a note of interrogation. The answer was that we had sufficient faith in these methods to specify them on our new roads in the Road Programme that was under consideration of Government. The core of the road was to be brick ballast or kankar to a depth of 6" with a 2¼" stone skin.

When imported stone cost more than approximately 25 per cent. such a specification could be used with economy and as much as Rs. 4,000 could be saved in initial costs.

MR. **L. A. Freak** requested that the Author should complete his Paper by giving details of the traffic at the site so that this item should be considered when reviewing the merits and economics of the experimental work.

The Author sent his thanks to Mr. Brij Mohan Lal for introducing the Paper in his absence on leave.

Purely Burmah Shell products did not give as good a result as a mixture of tar and Mexphalt—a product of Burmah Shell.

The reply to Mr. Trevor Jones' remarks about the possibility of treating a kankar surface with tar was that a sufficient number of experiments had been made in the past and they had all proved this method to be a failure. Hence, simple tar painting on a kankar surface was never to be tried where heavy traffic was to be dealt with and it was therefore not mentioned in the Paper.

In the Author's opinion it was premix alone that could stand the heavy strain of cart and motor traffic.

As suggested by Mr. Freak, a Census of traffic on the Grand Trunk Road in the vicinity of mile 35 would be sent when received from Sub-Divisional Officer, Rohtak.