Paper No. 498

Trial of sand bitumen mix pavement on Naukot Mithi road

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TRIAL OF SAND BITUMEN MIX PAVEMENT ON NAUKOT MITHI ROAD (Sind)

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Summary

To cut down the construction cost of roads several cheap specifications using native soils/ materials have been evolved and tried.

This paper presents the design, preparation, laying and performance of sand bitumen mix pavement tried in the first mile of a total 30 miles long desert tract joining Naukot Town to Mithi lying in the desert (Thar).

The mix proved successful and also 40% cheaper than conventional roads; as such it was adopted for paving the entire track; same is now expected to be complet by June, 1986.

Introduction

Rising Construction costs of new roads coupled with pressing economic needs for expansion of communication media, especially roads, forced the engineers, back in 1971, to think of cost cutting innovations. Nothing material could, however, be done till 1975 due to lack of institutional arrangements. In the year 1976 the Sind Planning and Development Department created a cell to evaluate and try cheap specifications for roads. This cell could not be manned and no work was done. The author there upon offered to do this job: accepting this, the Sind Communication and Works Department sponsored a scheme titled "Low Cost Experimental Roads in Sind". This was approved for Rs. 5.0 million in fiscal year 1980-81.

This scheme envisaged trial of :-

(a) sand bitumen mix to replace conventional stone metal sub base, base and surfacing.

(b) Lime stabilized soil to replace stone metal sub base, and base.

(c) Cement stabilized soil layer to replace stone metal sub base, and base.

(d) Monitoring the results over a period of 3 years.

All the above specifications have since been tried. This paper presents only the results with sand bitumen mix tried on a desert track running form Naukot to Mithi.

Site & Terrain Description

Site selected, (Fig. I) for trial of sand bitumen mix was the first mile of a 30 mile long track in desert area joining Naukot to Mithi Town.

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The town of Naukot is 90 K.M. to South East of Mirpurkhas; Mithi lies roughly to South East of Naukot at 55 K.M., right in the heart of desert.

The desert begins at 3 miles from Naukot extending upto Great Rann of Katch in South and South-West. Towards North it extends upto Bahawalpur and in East it joins the great Indian desert belt of Rajhistan.

Geologically this desert, which is commonly known as "Thar" in Sind, is formed of older eolian deposits in the shape of longitudinal sand dunes with intervening playa like deposits[1]. The bed rock, about 1000 ft. below is an extension of Kirthar Range: out crops appear at Aravelli - Hills and Nagarparkar.[2]

Design and Materials

For simple sand bitumen mix such as in the instant case no theorotical or empirical design procedure has yet been standardized. This type of mix using sand of specified grading was first tried during IInd World War.[3]

However, in the U.S.A. the design of sand bitumen mix is being done on the methods used for dense bituminous surfacings; the binder content by these methods varies from 5 to 10%[4].

The author, in the instant case, also chose Marshall's method for determining binder content that could give acceptable stability value. For the sake of economy coal tar was first tried as a binder; properties of coal tar used are shown in Table - I, below.

TABLE – I

Tests on Coal Tar from Pak Steel Mills Karachi

Test Method	Test Title	Test Result
ASTM D - 1298	Specific Gravity @ 77°F	1.158
ASTM D - 95	Water by Dean & Stark Vol.%	2.2
IP - 47	Soluble in Carbon Tetrachloride Wt/%	94.85

(Testing by Hydro Carbon Development)
(Institute of Pakistan Karachi).

Samples prepared with 3% (be weight) of coal tar gave adequate stability and flow values as would appear from Table - II. These samples, however, could not withstand 60°C temperature hence, the idea to use coal tar was given up.

TABLE – II

Coal Tar used in Mix 3.0% by Weight of Sand

SPECIMEN WT. GRAMS IN AIR	IN H_2O	BULK VOLUME	BULK DENSITY	STABILITY LBS	FLOW 1/100"
1148.2	557.5	590.7	1.94	470.0	11.0
1027.8	488.0	539.8	1.90	504.0	10.2
1045.0	500.0	545.0	1.92	593.6	9.4

Sand Sample: Mile 3/3 near Naukot Fort. Test specimens with 2% and 2.5% were not stable and, therfore, stability could not be tried.

Testing Done by Soils and Materials Testing Laboratories Karachi.

Bitumen 80-100% pen Grade was then used. Laboratory results were good with both 4 & 5% by weight of bitumen; as shown in Tables - III & IV, below:-

TABLE - III

Asphalt used in Mix 4.0% By Wt. of Sand

SPECIMEN GRAMS:W.T		BULK VOLUME	BULK DENSITY	UNIT WT. LBS.	STABI-LITY LBS.	FLOW 1/100"
IN AIR	IN H_2O					
990.4	426.3	564.1	1.75	109.2	538	13.4
992.5	430.4	562.1	1.76	109.8	570	13.0
986.4	425.2	561.2	1.75	109.2	570	12.4

TABLE - IV

Asphalt Used in Mix 5% by Wt. of Sand

SPECIMEN WT. GRAMS		BULK VOLUME	BULK DENSITY	UNIT WT. LBS.	STABI-LITY LBS.	FLOW 1/100"
IN AIR	IN H_2O					
1189.3	561.6	627.7	1.89	117.9	1602	13.8

SPECIMEN WT. GRAMS		BULK VOLUME	BULK DENSITY	UNIT WT. LBS	STABILITY LBS.	FLOW 1/100"
IN AIR	IN H_2O					
1177.5	545.5	632.0	1.86	116.1	1500	12.6
1177.2	544.5	632.7	1.86	116.1	1668	12.2

Testing Done by Soils and Materials
Testing Laboratories LTD Karachi.

In the field, however, 4 & 4½ by weight of bitumen could not give adequate coating; the quantity was therefore, increased to 5% by weight of sand, this was found satisfactory and adopted.

The sand used was local, dug after removing about 6" top layer to eliminate foreign matter. Grading of few samples is shown in Fig.II .

For determining the thickness of pavement an equivalency factor of two i.e. one inch of sand bitumen mix equivalent to two inches of granular dry bound base was adopted on the analogy of asphaltic concrete. Equivalent thickness is lieu of 9" granular material, which is commonly used, thus worked out to 4¼ inches and same was adopted.

Sub Grade Preparation:

For testing the first specification of sand with 5% bitumen by weight, 50 ft long 22 ft wide stretch was selected. This was lightly watered with the idea that sand in moist condition would permit compaction by road roller; the sandy subgrade however could not bear even the lightest roller of 2½ T. wt. The subgrade was therefore brought to shape manually by rakes and a tack coat of 80 - 100 Pen. butumen was applied at the rate of 15 lbs per 100 Sq. ft.

Sand-Bitumen Mix Preparation & Laying:

Sand was quarried from area adjoining the site, after removing top six inches layer to eliminate foreign matter, and brought near the mixer.

For mixing, a drum type concrete mixer with heating arrangement was used. First, measured quantity of sand was fed into the drum and heated to about 275°F the heating time in the drum varied from 1½ to 3 min. depending on burner working and sand dampness.

Bitumen separately heated to about 300°F was then poured into the mixer and drum revolved for 1 to 1½ minutes to achieve complete coating.

Laying was done manually in single layer of 4½ inches thickness. (In further construction laying is now being done in two layers of equal thickness i.e. 2¼" each).

The mix-after laying, when atmosphinc temperature was 104°F (40°C) remained in jelly state for 48 hours, it then was hard enough to bear the load of a light car with driver only but with deep tyre imprints. The edges also opened up in 'V' shape on the third day.

To accelerate the hardening time addition of cement 1% by wt. of sand was tried on another 50 ft. long stretch. This mix was hard enough to bear car load in 24 hours; opening of edges was also very much reduced.

For further rapid hardening addition of stone chips (natural bajri) at 3% by wt. of sand together with 1% cement was tried, on another 50 ft stretch.

This mix was hard enough to bear car load in only six hours and edges did not open up.

All these three types of stretches were then opened to casual light traffic on the fifth day after laying. Mix number one was still being imprinted by vehicle tyres yet rutting was not noticed. Other two mixes were behaving well. ON sixth day after laying the test stretches were closed to traffic and the stiffness of mix number one was tested daily by driving a car around noon time and look for tyre impressions. On fifteenth day tyre prints were feable and on twentieth day no impressions were formed. The mix was allowed another four days to stiffen and then opened to full traffic. The behaviour of all the three mixes was observed for one year to cover all the different seasons. Mix number one softened during summer noons; yet rutting; undue cracking, undulations, corrugations etc were not noticed. Performances of mixes number '2' and '3' were found to be very good.

Discussion:

(a) There was an apprehension, since the begining, about the use of 80-100 Pen. grade bitumen in desert area. This very much delayed the stiffening period of the mix. Bitumen 50-60 Pen would have been more suitable but unfortunately grades other than 80-100 Pen. are still not being produced in the Country.

(b) Mixing device used in the experiment was not very satisfactory; greatest draw-backs were direct heating of bitumen and no temperature control. The best way would be to use asphalt emulsion; this would do away with heating and shall result in further cost reduction. At the time of experiment emulsions were not produced in the Country; now National Petro Carbon Ltd; are ready to produce on order. Same may be used with advantage in future work.

(c) Due to abnormally long hardening time the field mix could not be compacted; consequenty no relationship between field mix stability and density values and those of laboratory specimen could be determined, to help in quality control.

Laboratory testing therefore has simply provided the order of stability that is possible for the mix to attain.

The stability value of the field mix has also yet not been determined by core or other tests. Since the pavement has behaved well during past five years it would be reasonable to believe that it's stability is sufficient to bear tyre pressures of 100 lbs. p.s.i. For this value of tyre pressure and adverage flow equal to 12.9 as determined by the laboratory the stability works out to about 1500 lbs.

Thickness of mix adopted is not backed by proper correlation between strength and loads. However, arrangements to evaluate the strength by Core penetration method and relate the same to traffic are underway.

Conclusion:

Mix number '1' i.e. native sand with 5% bitumen 80-100 Pen. by weight, despite its softening during Summer hot hours, is quite fit for desert roads carrying about 50 commercial vehicles a day, as has been proved by its five years performance.

Mixes number '2' and '3' are still better but cost wise these are 15 to 20% more expensive than mix number '1'.

Mix number '1' affords 40% saving over conventional design using stone metal sub base and base; also water and road making machinery, except a mixer are not needed; even the mixer can be dispensed with emulsion is used instead of bitumen. This elimination of machinery and water is the biggest advantage in desert areas. Paving with mix number '1' is also very speedy.

Life of mix number '1' in relation to traffic is, however, yet not known; further observations and tests of the pavement are necessary to evaluate it.

References

1. Geology of India, Third Edition (Revised) — By D.N. Wadia
2. Ground Water in Hyderabad and Khairpur Divisions. — By M.H. Panhwar
3. Wet Sand Mix — Shell International Publication.
4. Highways — By C.A. O'Flaherty.

Fig. I

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ROAD MAP OF SIND

SHOWING PROJECT ROAD

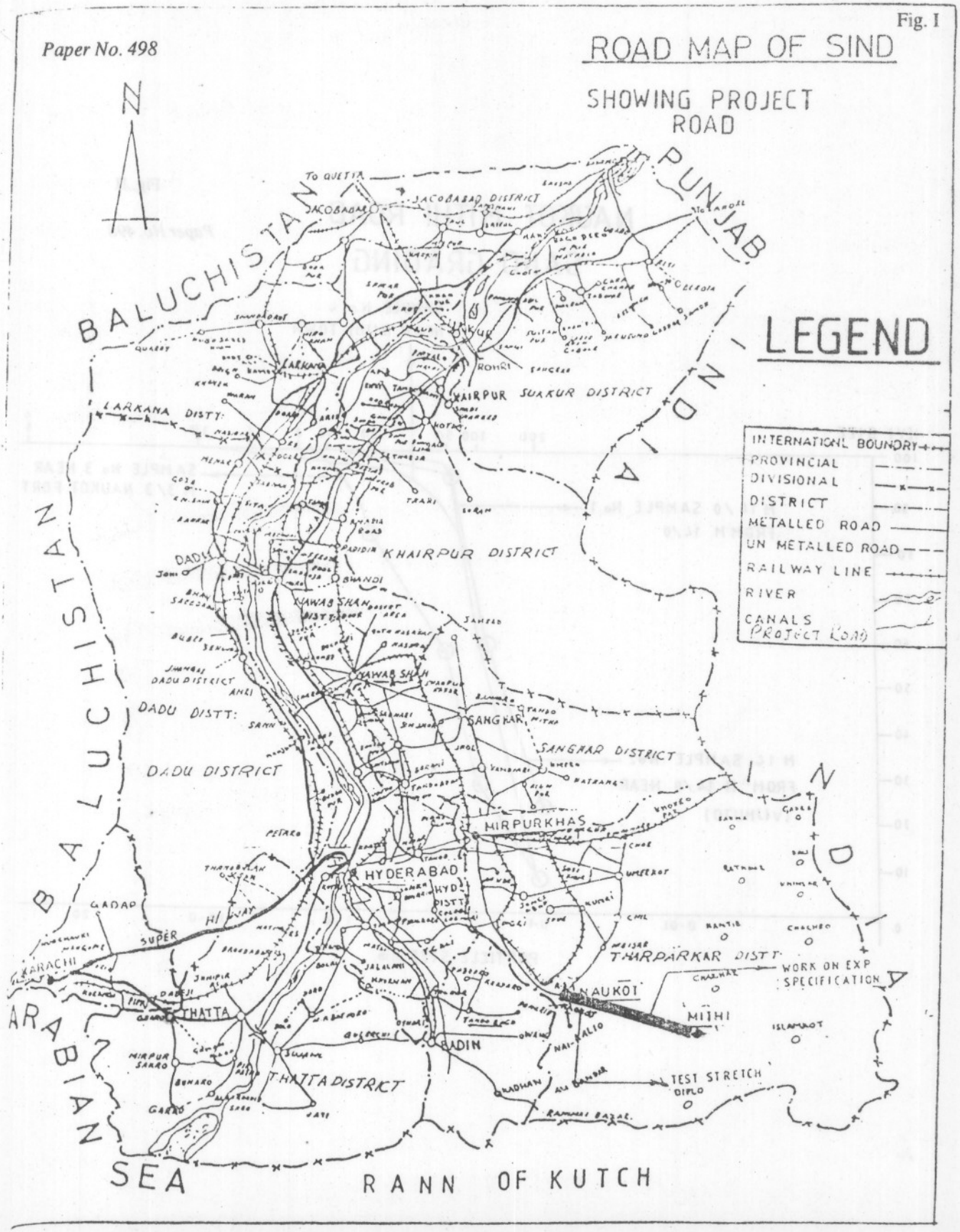

Fig. II

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NAUKOT MITHI ROAD
SAND GRADING