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Chemical Stabilisation of Sand : Part* II Construction and Studies of 50m × 4m Road

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Abstract. An experimental track (50m × 4m) was constructed on a loose sand bed by using two chemical-sand compositions containing either 9 per cent urea formaldehyde (UF) resin or 11 per cent sodium silicate binder (on solid content basis). The trafficability studies on 5-6 cm thick stabilised track were carried out after 6 hr setting time. The load bearing capacity of the stabilised track was found to vary from 1625 to 1700 psi in UF stabilised track and from 1340 to 1460 psi in silicate stabilised track. The effect of rain, desert environmental conditions and trafficability studies showed cumulative loss of load bearing capacity from 1625–1700 to 645–1125 psi.

1. Introduction

The Rajasthan desert covering an area of 1.96 lakh sq km poses problems for movement of vehicles and landing of helicopters due to loose, cohesionless and dry sand. The armed forces operating in this region advance by laying duck-boards. This paper discusses the construction of an experimental 50m × 4m track by a novel technique[1] requiring 9–11 per cent chemicals (solid content basis) and 6 hr setting time. The details of trafficability and environmental studies conducted on the track have also been discussed.

2. Experimental

(a) *Preparation of experimental site* — A loose sand bed was made by ripping the soil using bulldozers on a sandy area about 10 km away from Jodhpur. The gravels and vegetable matter were removed and an area of 50m × 4m was levelled.

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(b) *Chemicals used*

(i) Urea-formaldehyde (U.F.) resin[1] (sp gr, 1.2 and viscosity 13.0 cp at 30°C) prepared by refluxing 1 : 2 molar ratio of urea and formaldehyde for 30–40 min.

(ii) Calcium dihydrogen phosphate monohydrate (catalyst) prepared from calcium hydroxide or calcium oxide and phosphoric acid by the standard method[2].

(iii) Sodium silicate binder having Na_2O, SiO_2, and H_2O in the ratio of 18, 37 and 45 and sp gr, 1.6 at 20°C.

(c) *Construction of track* — A homogeneous mixture of UF resin (9% solid content), aqueous catalyst solution of calcium dihydrogen phosphate (0.3%) and desert sand (90.7%) was dried for about 20–30 min by spreading it on the ground till the required sticking property developed. The mixture was then evenly spread on the levelled sand bed and compacted to 5–6 cm thickness using hand rammers. Sodium silicate stabilised portions were similarly constructed taking sodium silicate binder (11%) and sand (89%). The 50m × 4m track was constructed by stabilising 2m × 1m block alternately (using wooden frames) in the manner identical to cement concrete laying.

(d) *Trafficability studies* — The trafficability studies were undertaken by running 3-ton and water bouzer vehicles for two weeks at the rate of 200 passes per day. The average speed was maintained at 30 km p.h. and occassionally brakes were applied. The studies were continued for one year under ambient conditions.

(e) *Environmental studies* — A meteorological observatory was established at a distance of 15m from the experimental site. The maximum and minimum temperatures, humidity, wind velocity and average rainfall were recorded. Effects of rain and heat were studied on the stabilised surface.

(f) *Load bearing capacity (LBC)* — The unconfined test apparatus (AIMIL make) was used for determining LBC. The 3-ton vehicle for application of load and a field set up[3] using a calibrated proving ring and dial gauge for determining LBC were used. The plunger was seated at the test site of the stabilized surface and the proving ring was held between the plunger and rear axle of 3 ton vehicle. The uniform load of the vehicle was applied by lowering both the jacks simultaneously (at the rate of approximately 0.05 inch/min). The LBC in psi was calculated using the standard proving ring graph.

The LBC was determined before and after trafficability studies and rains as well as after exposure of road, for one year, to the extreme climatic conditions of Jodhpur.

3. Results and Discussions

General characteristics — Out of the total 200 sq m area, 168 sq m were constructed using UF resin — sand mixture and rest 32 sq m area stabilised with sodium silicate-sand mixture.

The particle size of the sand used for the construction of road varied from coarse sand to silt and clay as per composition given in Table 1. The laid track appears

sturdy and intact having fine lines demarcating 2m × 1m rectangular blocks. The thickness of the track after setting varies from 5.5 to 6.2 cm. The colour of the track matches with sand colour.

Table 1. Particle size distribution of soil sample used for the construction of 50m × 4m road.

Sl. No.	Type of soil	Particle size (mm)	Composition (%)
1.	Coarse Sand	0.36–0.6	0.3
2.	Medium Sand	0.6 –0.21	4.5
3.	Fine Sand	0.21–0.07	84.5
4.	Silt and Clay	< 0.07	10.7

During the construction, trafficability and environmental studies (28 May to 26 June, 1979), the temperature varied form 19.5 to 46°C, average wind velocity from 4.4 to 16 km ph, and average rainfall was 76 mm. However total rainfall upto 30 Sept 1979 was 630 mm.

Trafficability studies — The trafficability studies were conducted by running 3-ton and water bouzer vehicles for 2 weeks at the rate of 200 passes per day. Physical apprearance of the track, initial LBC and LBC recorded after 600 and 2000 passes are given in Table 2. It is seen that there is no appreciable variation in the LBC after 600 passes but it is noticeable after 2000 passes as shown in Table 2.

Table 2. Comparative LBC after trafficability studies

Patch No.	Physical Appearance			LBC (psi)			Remarks
	Initial	After 600 passes	After 2000 passes	Initial	After 600 passes	After 2000 passes	
2, 5, 6, 7, 9 43, 46	Uniformly compacted smooth surface	Hair line cracks	Very fine cracks developed	1600–1770	1560–1670	1560–1640	
1, 3, 4, 8, 10, 11–30 39–42, 44, 45, 47, 48, 49, 50	Uniformly compacted plane surface with hair line cracks	Developed very fine cracks	Fine cracks developed	1625–1670	1560–1670	560–1125	
31–38	Uniformly compacted smooth surface	Smooth surface, no cracks	Fine cracks developed	1340–1490	1310–1460	645–1125	

Environmental studies — The environmental studies on the track were continued for a period of one year. The comparative LBC of three types of the test patches,

Table 3. Comparative LBC of test patches after 2000 passes and 630 mm rain

Sl. No.	Patch	Patch Nos.	Comparative LBC after 2000 passes and 630 mm rain			Comparative LBC after expiry of one year		
			Physical apprearance	Thickness (cm)	LBCs (psi)	Physical apprearance	Thickness (cm)	LBCs (psi)
1.	Unaffected patches	4, 37–43 45–48	Uniform, few minor cracks	5.5–6.2	1450–1560*	Fine cracks, unaffected by rain	5.5–6.2	1400–1500
2.	Moderately affected patches	2, 9, 24 31–36, 49, 50	Upper layer affected uniformly up to 1cm	4.5–5.5	1000–1310*	Upper layer uniformly affected by 1 to 1.5 cm	4.5–5.2	1000-1300
3.	Affected patches	1, 3–8 10–23 25–30, 44	Affected Uniformly up to 2cm	3.5–4.5	560–830*	Affected uniformly by 2 to 2.2 cm	3.5–4.0	560–800
4.	Loose sand	—	Loose sand	—	12	Loose sand	—	12
5.	Laboratory specimen of 5–6 cm thickness	—	Intact, smooth	5	915**	Intact smooth	5	890
6.	Laboratory specimen kept/ exposed to ambient conditions	—	Intact, smooth	5	815**	Intact smooth	5	775
7.	Laboratory specimen exposed to environment and 630mm rain	—	Upper layer was affected by rain	5	400**	2 mm upper layer affected	4.8	350

*Confined, **Unconfined

selected on the basis of their physical appearance, loose sand and laboratory specimens are given in Table 3. It is seen that the LBC in unaffected patches varied from 1560–1640 (before rain) to 1450–1560 psi (after rains). The LBC of the moderately affected patches was found in the range of 1000 to 1310 psi, while affected patches gave strength between 560–830 psi. The comparative study of these patches after rains and also after exposure for one year period, indicate that the LBC of unaffected patches varied from 1450–1550 to 1400–1500 psi, moderately affected patches from 1000–1310 to 1000–1300 psi, and affected patches from 560–830 to 560–800 psi (Table 3).

The findings clearly show that ambient conditions other than rains do not appreciably affect the strength of the chemically stabilised surfaces while heavy rains (630 mm) considerably affect the strength as shown in Table 3.

Fine cracks 4–6 mm wide were noticed in a few patches. These were filled up by seeping the required amount of resin and sand mixture. No other maintenance was required for the road during the period of study.

4. Conclusion

1. The technique, requiring only indigeneous chemicals 9–11% (solid content) and sand could be useful for construction of roads, helipads and tracks similar to duck-boards during emergency.
2. Stabilised layer 5.5 to 6 cm thick, after 6 hr of setting can withstand the movement of caravan of 3 ton vehicles and does not require maintenance.
3. The technique does not require camouflaging, skilled manpower, conventional road materials equipments, and water, etc.

References

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