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Chemical Stabilisation of Sand : Part VII Natural Resins as Dune Sand Stabiliser

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ABSTRACT

The comparative studies on use of a few natural resins as dune sand stabiliser are discussed. Guar-gum – a product of Rajasthan desert, *Terminalia alata* tannins and rosin have proved promising for short-term and emergency use in field, where water, aggregates, skilled manpower and road constructing machines are not available.

Effect of compaction on strength has also been studied in order to optimise the thickness of stabilised surfaces required for construction of roads and helipads in sandy areas. Effect of temperature and bacteria on stabilised specimens have also been discussed.

1. INTRODUCTION

Satisfactory stabilisation of soils in arid areas cannot be accomplished by any one measure used in isolation. All three available means, windbreakers, protective soil covers and stabilisation of soil itself should be used. A number of synthetic resins have been found to improve engineering properties of soils[1]. Phenol-formaldehyde[2], urea-formaldehyde[3,4],aniline-furfural[1,5] and recently furan resins[6] have been reported as promising resins for chemical stabilisation of soil. Vinsol, Copal Damar and rosin[1] have been studied for their soil-waterproofing properties. Alkali rosinates[7,8] and a few other natural resins[9-11] have been used for stabilisation and reducing permeability of soil.

In continuation of our earlier studies on chemical stabilisation of desert sand with urea-formaldehyde[3,4], soluble silicates[12] and guar-gum[13], two natural products, rosin and spray dried powder of water soluble extract of bark of *Terminalia alata* (tannins), have been used for stabilisation of dune sand. In this paper, detailed studies undertaken

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on rosin and *T. alata* tannins are presented. The maximum unconfined compression strength of 135 to 460 kg/cm^2 of the standard specimens (rosin, 9 per cent) found at densities ranging from 1.7 to 2.0 gm/cm^3 is higher than the strengths reported by earlier workers[11,14-16]. The standard guar-gum specimens recorded maximum strength from 40 to 155 kg/cm^2 at densities ranging from 1.6 to 1.7 gm/cm^3, which is much higher than the maximum strength of 1.01 kg/cm^2 at density 1.60 gm/cm^3 reported earlier. *T. alata* tannin specimens, recorded maximum strength of 48 kg/cm^2.

2. EXPERIMENTAL

2.1 Materials and Methods

(i) Sand – Desert sand was collected from a sandy area near Jodhpur and was found to contain silt and clay (less than 0.075 mm), 9.5 per cent; fine sand (0.21–0.075 mm), 85.5 per cent; medium sand (0.60–0.21 mm), 4.7 per cent and coarse sand (2.36–0.60 mm), 0.3 per cent; moisture, 1.1 per cent and water soluble salts, 80 mg/l.

(ii) Rosin – Rosin is a light yellow to brown solid material obtained from pine trees during turpentine extractions. The physico-chemical characteristics of rosin are given in Table 1. It is soluble in many organic solvents and in aqueous solutions of alkali hydroxides. It is widely used as adhesive and water repelling material.

Table 1. Physico-chemical characteristics of natural resins

S.No.	Details	Rosin	Guar-gum	Terminalia alata
	Physical appearance	Pale-yellow, fine powder; mesh 150, 97%	White with pale yellow tinge; mesh 200, 98%	Brown, microcrystalline mesh 150, 98%
2.	Moisture (%)	0.31	10.28	8.43
3.	Solubility	Soluble in organic solvents and aqueous alkalis	Soluble in water	Sparingly soluble in water but more soluble in aqueous alkali
4.	Ash :			
	a) Acid insoluble (%)	0.06	0.72	0.136
	b) Minerals after combustion (%)	0.108	0.85	12.95
5.	pH (1 %) solution)	4.8	6.3	4.5

(iii) T. alata tannins – The bark of *T. alata* has been found to be a potential source for manufacturing oxalic acid. The water-soluble extract of the bark containing around 20 per cent of tannins is thrown away. The spray dried powder of the water-soluble extract recovered amounts to around 15 per cent. The brown colour tannins (Table 1) were obtained from FRI&C, Dehradun.

(iv) Guar-gum – Guar-gum (galactomannan), a product specially available in Rajasthan was procured from a local factory. The powdered gum (mesh 200, 98.30

per cent) and its derivatives are commonly used in the oil and gas, food, paper, textile, explosive and mining industries at concentration below one per cent.

(v) Preparation of specimen – Powdered rosin was dissolved in absolute alcohol at different concentrations (Fig. 1) and the solution was homogeneously mixed with 750 gm of sand. Mixing was generally continued till colour of entire sand mixture became uniform. The standard specimens dia, 79 mm and height, 60 mm were prepared in Jodhpur–Mini Compactor[17]. In case of *T. alata* tannin and guar-gum specimens were prepared[13] by taking respective solid mixtures of resin and sand and mixing them homogeneously with aliquot amount of water before giving standard compaction. These specimens (Fig. 1) have been referred in the text as standard specimens.

Compaction was varied to study the relationship between density and strength as shown in Fig. 2 for different natural resins. All specimens were cured at 45°C for 48 hours (Table 2).

(vi) Unconfined compression strength – For every strength determination three identical samples were made and cured under identical conditions. The strength was determined using PR-20, Load Frame 9B, 200 KN, AIMIL make. The data for strength reported in different figures and tables is the average of these three readings.

(vii) Effect of temperature on UCS – The standard specimens were exposed to temperatures ranging from 0 to 200°C for 24 hours, cooled and then subjected to strength determination. The data for strength given in Fig. 3 are also the average of three readings.

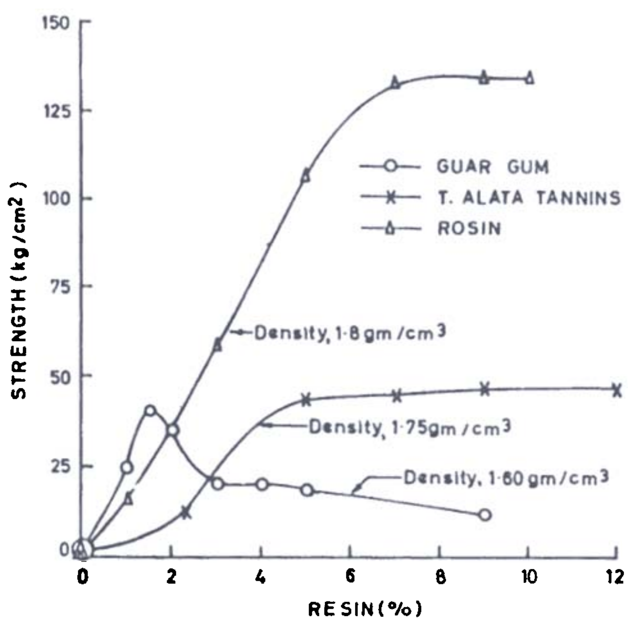

Figure 1 Strength of standard specimens at different concentrations of guar-gum, *T. alata tannins* and rosin, cured at 45°C for 48 hr.

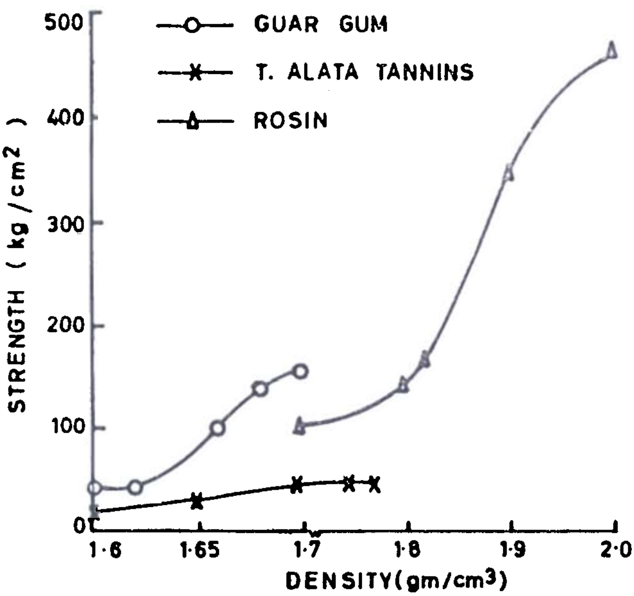

Figure 2. Variation in strength of standard specimens of guar-gum, *T. alata tannins* and rosin at different densities.

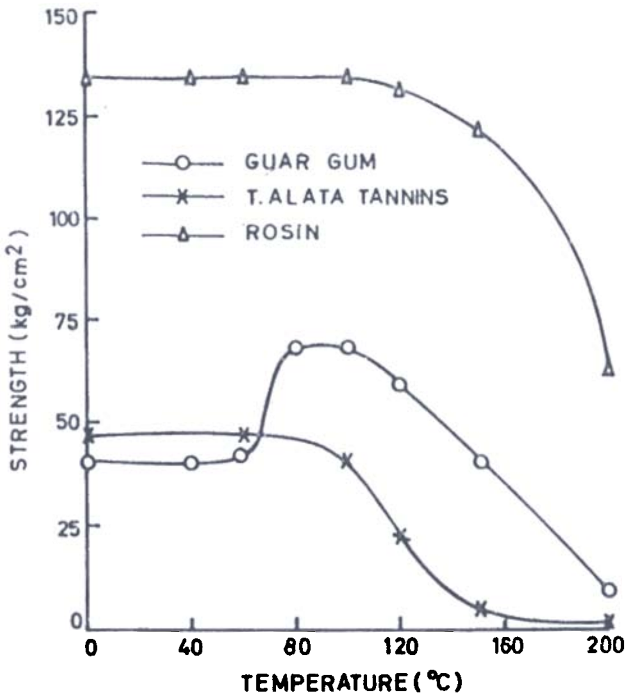

Figure 3. Effect of temperature on strength of standard specimens of guar-gum, *T. alata tannins* and rosin (exposure, 24 hr).

2.2 Exposure Trials

The standard specimens made from fresh *T. alata* tannins and a portion of tannins were exposed for a period of four months. Another set of specimens were made out of exposed resin and strength determined (Table 3).

Table 2. Comparative studies of different natural resins used as dune sand stabilisers (curing temperature, 45°C and curing time, 48 hrs)

S.No.	Natural resin (solid content in %)	Type of soil (%)	Strength (kg/cm²)
		Desert sand • (100)	.4*
2		Silt and clay (100)	24.6*
3	Rosin (9)	Desert sand (91)	135
4	*Terminalia alata* tannins (9)	Desert sand (91)	48
5	Guar-gum (1.5)	Desert sand (98.5)	40
6	Guar-gum (1)	Desert sand (99)	25

* Specimens were prepared using aliquot amount of water

Table 3. Effect of exposure on the strength of *Terminalia alata* tannin specimens made from exposed resin

S.No.	Resin concentration	Strength (kg/cm²)	
		Fresh resin	After degradation*
1	2.3	11.3	3.9
2	5	45.3	14.2
3	7	46.5	14.5
4	9	48.2	15.0
5	12	48	14.8

* After 4 months

3. RESULTS AND DISCUSSION

(i) Rosin – Standard specimens were made at different concentrations of rosin (Fig. 1). Steady increase in strength was recorded with increase in resin percentage and maximum UCS of 135 kg/cm² at optimum 9 per cent rosin (density, 1.80 gm/cm³) was found, which is much higher than the value reported by Tosher[15] (19.5 kg/cm²), Singh[17], *et. al.* (78.8 kg/cm²) and other workers[1]. The high value is due to the novel technique[3] developed by this laboratory. At different compaction the UCS of rosin specimens was found to give steady increase in strength from 105 to 460 kg/cm² at relative densities 1.70 to 2.0 gm/cm³ (Fig. 2).

(ii) T. alata tannins – The relationship between resin percentage and UCS was also studied. It indicates that after increase in its concentration up to 5 per cent the UCS is practically constant at 45 kg/cm^2. The marginal increase in strength at concentrations from 6 to 9 per cent attains the steady value of 48 kg/cm^2 at 9 per cent concentration. Further increase in resin content does not affect the strength and at 10 per cent concentration the strength remains constant at 48 kg/cm^2. Higher compaction did not show increase in strength (Fig. 2), recording maximum UCS of 48 kg/cm^2.

Bhatia, *et al.*[10] have studied stabilisation of soil using 5 per cent resin and clay. The briquettes and bricks made by them were studied for soil stabilisation and water resistance. Stabilised specimens were exposed to rain (210 mm). Strengths have not been reported before or after the study.

(iii) Guar-gum – Standard guar-gum specimens recorded maximum UCS of 40 kg/cm^2 at 1.5 per cent of gum concentration (Fig. 1). However the strength drops to 12 kg/cm^2 at 9 per cent of gum. Effect of compaction on strength of guar- gum specimens is presented in Fig. 2. It is found that UCS shows steady increase from 40 kg/cm^2 to 44, 100, 140 and 155 kg/cm^2 at respective density of 1.60, 1.62, 1.66, 1.68 and 1.70 gm/cm^3. Development of hydrogen bonding and high viscosity of gum suspension in water is responsible for higher strength values.

(iv) Effect of temperature on stabilised specimens – Effect of temperature (24 hours exposure) on standard specimens made from rosin, *T. alata* tannins and guar-gum after curing at 45°C for 48 hours was studied (Fig. 3). It is found that strength of rosin specimens is not affected up to 100°C and thereafter it falls due to charring of resin to 62.5 kg/cm^2 at 200°C. In case of *T. alata* tannins specimens the strength remains constant up to 60°C and then drops to 1.0 kg/cm^2 at 200°C. The behaviour of guar-gum specimens was altogether different.

After 24 hours exposure the strength remained constant up to 60°C and then recorded steady increase from 40 to 68 kg/cm^2 up to temperature 100°C. It then gradually drops to 9 kg/cm^2 at 200°C.

(v) Microbial attack – Degradation of natural resins by bacteria is well known. In our studies it is found that rosin, *T. alata* tannins and guar-gum are also attacked by aerobic bacteria. Degradation of rosin and guar-gum by bacteria has been reported[1,18]. *T. alata* tannins were studied and it is found that the tannins start degrading after a few months. A random check after 4 months showed that the strength of specimens made at different concentrations of exposed tannins drops one-third to one-fourth (Table 3). The colour of resin becomes darker and its viscosity in aqueous phase abruptly dropped. The specimens after exposure for 4 months, however, recorded strength, 10–20 per cent less than that of initial reading. All the three natural products when kept in air-tight containers did not show loss in properties and strength. Stabilised specimens of rosin and guar-gum when exposed in shade for 2 months did not show appreciable loss in strength, the conditions being unaerobic. This suggests that unaerobic conditions are more suited for these stabilised specimens. A suitable coating on resin stabilised surfaces would make them more durable.

For short-term and emergency use the natural resins may be suitable for stabilisation of desert sand, particularly in areas where water, skilled manpower, aggregates and road constructing machinery are not within reach.

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