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USE OF GEOTEXTILES IN CONSTRUCTION OF LOW COST HIGHWAYS: AN EXPERIMENT

EINSATZ VON GEOTEXTILIEN FÜR STRASSEN MIT NIEDRIGER VERKEHRSFREQUENZ: VERSUCHSERGEBNISSE

EMPLOI DES GEOTEXTILES DANS LES CHAUSSEES DE ROUTES ECONOMIQUES: EXPERIMENTATIONS

Some specific problems in availability of raw materials with appropriate geotechnical characteristics or difficulty of aggregate preparation and transport can be resolved by using local resources. The use of textile inclusions in the soil shows a considerable improvements of its mechanical properties.

The paper reports on results of experimental studies on improvement of soil by incorporation of fabrics (fibres and manufactured geotextiles) and its use in pavement base-course.

Differents methods of reinforcing soil are tested.

Some results on the structures behaviour under plate bearing test and traffic load are given and discussed.

The use of geotextiles in road construction offers an attractive solution when good materials are short and difficult to exploit and transport. In the case of low-cost roads, when the determining factors are cost of materials and placement, the use of geotextiles permit the better use of local resources and allow to act upon these two factors.

The present paper gives the results of a research and full scale experiment programme conducted at the Centre d'Experimentations Routières (Laboratoire des Ponts et Chaussées - France) on reinforcing base materials by incorporating textile elements (fibres or geotextiles).

A - EXPERIMENTS

A-1- Schedule

The study consists in investigations of performance of pavement structures using a base-course reinforced by textile elements according to three different processes. For the wearing course it was tested a bitumen course reinforced by a sheet of geotextile. The aim of tests is to compare the deformation characteristics of the various pavement structures and their mechanical behaviour under traffic load. Different test items are shown on figure 1.

An identical sub-base of 0,60 m thick in 0/0,3 mm sand was placed for all test sections. The reinforced base course consists of a ≤ 0,20 m thick layer. For the wearing course, it was use the surface dressing technique improved by a non-woven geotextile. The reinforcement geotextiles were ARMATER, ENKAMAT and TEXSOL processes.

Those three processes are patented. The first two are normally used in control erosion structures.

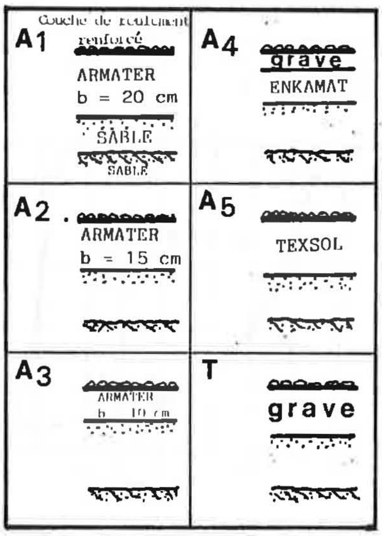

figure 1 : Tested structures

Figure 2 shows the lay-out and dimensions of the realized test sections.

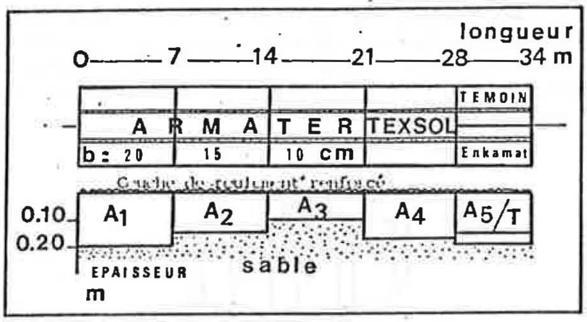

figure 2 : Lay-out and dimensions of test sections (plan and profile)

A-2- Materials and description of test sections

a - Materials

Materials used in this investigation were limited to granular materials (sand and untreated gravel).

* Sand

It is a uniformly-graded sand 0/0,3 mm (Fontainebleau - France) which is regarded as non-trafficable and cannot be used without stabilization.

Geotechnical characteristics

Uniformity coefficient $C_u = 1,7$

Maximum dry density $\gamma_d = 1,60$ at optimum moisture content of 8 % (standard Proctor Test)

CBR without surcharge weight = 2

Mohr's characteristics : $C' = 0$ $\phi' = 36°$

* Untreated aggragate

Maximum size 31,5 mm (Vignats - France)
Maximum dry density $\gamma_d = 2,33$ at optimum moisture content of 4,9 %

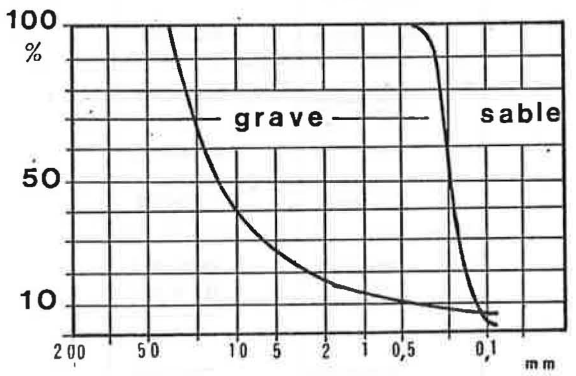

figure 3 : Grain-size distributions of materials used in the trials

b - Materials used for the base-course

* ARMATER structures : Items A_1 to A_4

The reinforced base-course is a sand-filled honeycombed geotextile ARMATER. These 3-D geotextile contained hexagonal - shaped cells that were formed by bonding sheets of fabric. Figure 4 shows the expanded sections of ARMATER.

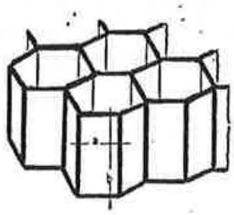

figure 4 : ARMATER
Bottomless hexagonal - shaped cells
side = a - height = b

The basic geotextile used in ARMATER process is a non-woven polyester, needle-punched fabric. The sheets have been impregnated with a resin. That is provided a high mechanical strength (tensile strength (warp) 16,2 kN/m) and a good draining propertie for the geotextile. Three dimensions of Armater cells have been tested. The ratio $\frac{a}{b}$ is kept constant and equal to $\frac{1}{2}$. The height b is equal to 0,20 m (item A_1), 0,15 m (item A_2) and 0,10 (item A_3) (photo 1).

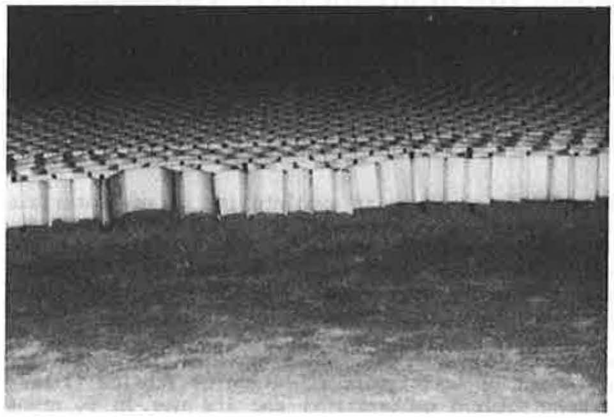

photo 1 : View of expanded ARMATER lap

* ENKAMAT's structure : item A_4

The reinforcement geotextile is a prefabricated sheet, 0,02 m thick, made of a loose tangle of polyamide threads. The reinforced base-course is made of juxtaposed sheets of sand-filled Enkamat, 0,10 m thick altoghether, topped with a 0,06 m layer of unbound aggregate 0/31,5 mm (photo 2).

photo 2 : Enkamat

* TEXSOL'S structure : item A_5

TEXSOL is a 3-D unbound composite fibres-soil obtained by incorporating continuous threads into the sand. It is mised-in-place material.

The incorporation of continuous textile threads into a non-cohesive sand gives the mix a high cohesion. The mechanical properties of TEXSOL depend mainly on the type of sand, the threads characteristics and the amount of threads content in the mix.

photo 3 : Composite fibres-soil : TEXSOL

TEXSOL characteristics

Sand 0/0,3 mm
Thread : Polyester 50 dTex
Thread content (by weight) : 0,3 %
CBR without surcharge weight : 60
Triaxial test characteristics C' = 480 kPa
ϕ' = 37°

* Control structure : item T

Control item was a 0,20 m thick layer of compacted unbound aggregate 0/31,5 mm placed on sand subbase.

c - Reinforced wearing course

The wearing surface consists of a surface dressing placed on a non-woven geotextile sheet. The standard technique is to set on the base surface a mosaïc of stone chippings bound with a bituminous binder.

* Geotextile used

It is a non-woven, slightly needle-punched geotextile (weight = 100 g/m^2) called NADERE.

* Double surface dressing

- chippings sizes 4/6 mm and 6/10 mm
- bituminous binder : 65 % emulsion (cationic)
  . Type : Triple seal with a spread rate of 1 kg/m^2 each (photo 4).

A-3- Realized tests

Before application of the traffic tests, measurements of thickness of layers, in-situ density and modulus of base reaction were realized. The traffic load consisted of 400 passes of a tandem - axle wheel load (80 kN) following by 200 passes of a single-axle wheel load (130 kN).

Visual observations and cross-section level readings were recorded at intervals throughout the traffic test period. In the case of ARMATER's structures, measurements of the transient vertical stress induced by the traffic load were achieved.

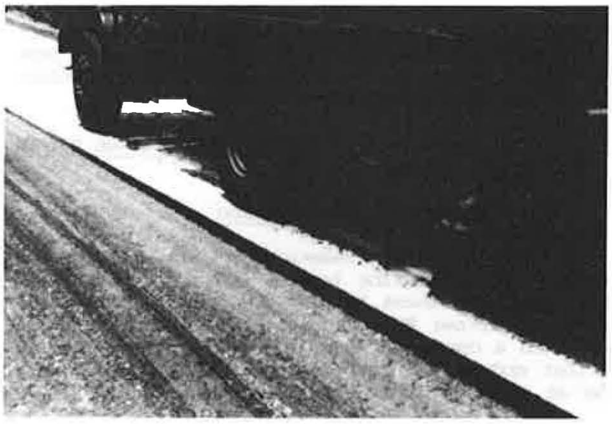

photo 4 : Reinforced surface dressing : Binder spreading over geotextile sheet

B - RESULTS AND DISCUSSION

B-1- Construction technique

The improvement of granular material characteristics based upon confinement and membrane reinforcement concepts shows its considerable trafficability enhancement. It makes the choice of construction techniques and equipment easier. In the case of AMATER's structures, the dimensions of hexagonal-shaped cells determine the type of the filling soil, its moisture content and its compactability. For the ENKAMAT's structures, the choice of the filling soil was limited to sand of maximum grain size of 5 mm and at very weak moisture content.

Texsol is a case in point since its mixing and its placement require a specific equipment. Table 1 gives results of construction data.

Table 1 : Test sections : Construction data

STRUCTURE	EPAISSEUR COUCHE RENFORCEE (cm)	POIDS GEOTEXTILE / POIDS SABLE SEC (%)	DENSITE SECHE
A_1 ARMATER b = 20 cm	20	0,3 %	1,56
A_2 ARMATER b = 15 cm	15	0,4 %	1,60
A_3 ARMATER b = 10 cm	10	0,6 %	1,57
A_4 TEXSOL	18	0,3 %	1,68
A_5 ENKAMAT	16	2 %	1,77
T TEMOIN	15	----	2,00

As for as construction and placement are concerned, ARMATER's structures is easier to realize. The compaction of base materials did not raise any specific problems, although the density level reached are comparatively low. A rubber-tyred compactor was used.

B-2- Structural performances of test section before traffic tests

a - Modulus of base reaction

The modulus measurements after the second cycle EV2 (plate bearing test ∅ 600 mm) indicate no significant differences between the tested structures. Table 2 summarizes EV2 values, together with measures obtained on a compacted sand full depth. Those results show that moduli EV2 of reinforced sand layers hardly differ at all from that of the basic sand.

b - Deflectograph's measurements

The measures of the LCPC deflectograph give the radius of curvature of the deformation and the total surface deflection under standard axle-load of 130 kN. That method is normally used to characterize the behaviour of a pavement base course. The results (table 2) show improvements of performance of reinforced structures (decrease of total deflection and increase of curvature radius). The improvement is marked in the case of TEXSOL's structure (item A_4), while it is slightly significant in the case of ARMATER's structure item A_1.

Table 2 : Performance characteristics of test sections before traffic tests

STRUCTURE	MODULE EV2 (MPa)	DEFLECTOMETRIE	
		DEFLEXION (1/100 mm)	RAYON DE COURBURE (m)
A_1 ARMATER b = 20 cm	54	119	7
A_2 ARMATER b = 15 cm	52	171	5
A_3 ARMATER b = 10 cm	41	182	6
A_4 TEXSOL	64	128	10
A_5 ENKAMAT	66	185	4
T TEMOIN	87	149	10
SABLE	65	114	5

B-3- Performance of test sections under traffic load

a - Rutting

The graphs (figure 5) show the increase of the rut depth in wheel paths in function of the number of passes of traffic. The average rut depths were not exceeded 0,05 m for every test section. The best performing structure was observed in the case of control structure (item T).

The results shows also that in the cases of TEXSOL's structure, ENKAMAT's structure and control structure, the additional rutting was developed very slow for the later 200 passes of traffic while it had increased, in the case of ARMATER's structure, by amount of 30 per cent to 50 per cent of total deformation. The maximum rut depth was observed for ARMATER's structure b=0,20 m (item A_1).The trenches excavated across the wheel path and cross-section show that in this case most of rutting resulted was due to lateral shifting of the surface sand out of the wheel paths probably caused by increasing of cells sizes of ARMATER (figure 5). The permanent surface depression was observed to be lower than the measured rut depth.

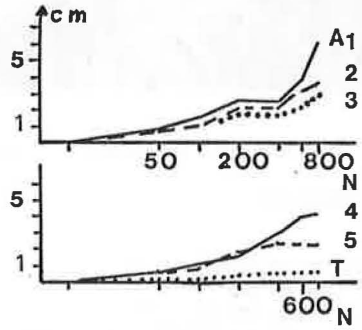

figure 5 : Rut depths versus the number of passes of traffic

b - Deformability characteristics of test sections

Table 3 gives values of modulus EV2, radius of curvature and total deflection at the completion of the traffic tests. It can be seen a high decrease of the deflection for all items and an increase of radius of curvature in the case of ARMATER's structure (item A_2) and in the case of TEXSOL's structure. It has been suggested a "slab effect" behaviour of these structures. The measures of the transient vertical stress recorded at the bottom of base course indicate an effective decrease of about 50 % of the vertical surface pressure.

Table 3 : Deformability characteristics of test sections after the traffic tests

STRUCTURE	MODULE EV2 (MPa)	DEFLECTOMETRIE	
		DEFLEXION (1/100 mm)	RAYON DE COURBURE (m)
A_1 ARMATER b = 20 cm	56	118	27
A_2 ARMATER b = 15 cm	47	77	18
A_3 ARMATER b = 10 cm	43	105	22
A_4 TEXSOL	66	101	31
A_5 ENKAMAT	64	135	4
T TEMOIN	87	103	4

c - Reinforced wearing course

Surface dressing on unbound gravel pavement layer often deteriorate rapidly due to the development of cracks and potholes. The incorporation of a non-woven geotextile in surface dressing gives it traction resistance and improves its adhesion on the gravel layer. This technique is relatively simple and cheap in comparison with other surfacing treatments particularly in the case of the sand-base pavement.
After traffic tests, the reinforced-wearing course appeared to be in good condition.

The additional improvement of the wearing course consists of placing a thin layer of unbound gravel between the former and the reinforced base course.

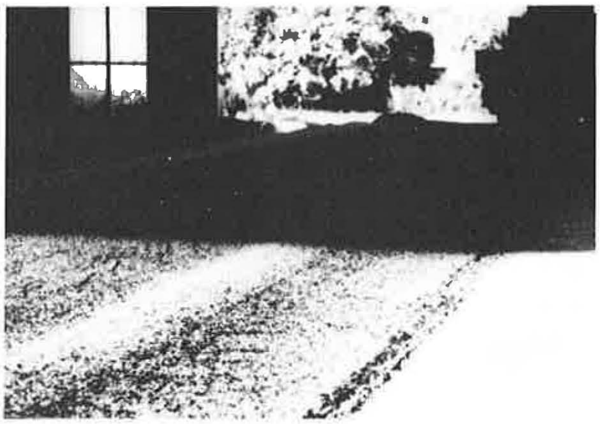

photo 5

C - CONCLUSIONS

The process based upon the granular material confinement concept is shown as an interesting construction technique for pavement. The performance structural contribution of reinforcement geotextiles concerned with the bearing capacity, the material trafficability enhancement and the dynamic behaviour of the structure (photo 6). The modulus EV2 was not found to be increased with reinforcement. In the case of ARMATER's structure, type of geotextile and cells sizes were all related to traffic performance. The studied processes can be a cost- effective alternative to other techniques in the low cost road construction. Further more study of this on going research programme will be carried out in order to provide design criteria of reinforced pavement structure. A cooperation with the Centre d'Etude du Machinisme Agricole, du Génie Rural, des Eaux et Forêts (CEMAGREF) allow to extensive field tests under the actual traffic.

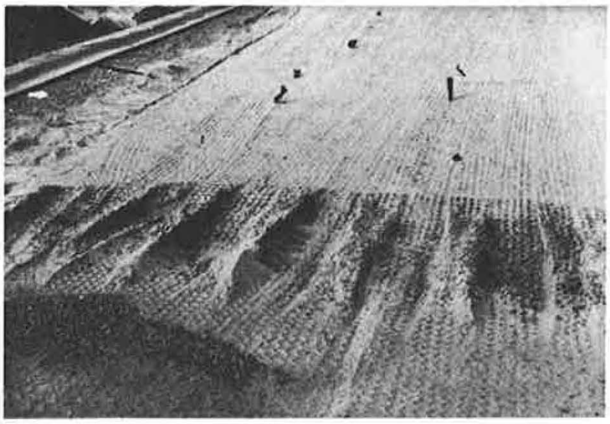

photo 6

D - ACKNOWLEDGMENTS

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