amount of sand, after having been screened through a ¼" mesh, is then shoveled into the tank.

While the batching is taking place, connection from the grouting tank to injection pipe should be made so that when the cap has been placed on the tank pressure may be applied immediately and the grout injected. Successive batches are placed in the same injection pipe until its refusal to take more or grout breaks out in the ballast on the shoulder or in the side ditches. When such a break-through occurs, pressure should be released immediately.

It is important that the man controlling the pressure tank be alert to shut off the pressure as soon as the grout has cleared the line after each batch or when a break-through occurs. The Foreman of the crew, who generally stations himself at the point of injection, can readily determine when grout has cleared by pulsations in the grouting hose.

When sufficient grout has been applied, grouting hose should be connected to the next injection pipe and the work continued. It is advisable to leave the last used injection pipe in, as grout very often will force its way up through opening left by pulling pipe. In some instances it is necessary to cap this pipe to prevent grout being forced up through the pipe. There is no method of determining the amount of grout that can be injected into any pipe, so the general practice is to force in grout until its refusal. Quantities injected have varied up to 180 one-sack batches in one pipe.

To date, at 20 locations, cross sections have been dug across the track to make detailed observations of the concrete formations which are produced by injecting grout into the sub-ballast. The resulting concrete is believed to have a compression strength of at least 2500 pounds per square inch.

The sections on pages 7 and 8 are accurate diagrams drawn to scale and show ballast materials and the resulting concrete at the various locations. Solid lines on the sections indicate actual observations and measurements while the dotted lines show where approximate methods were used to determine the lower limits of the concrete.

CONCLUSION

The effectiveness of cement grouting under pressure in the stabilization of roadbed in soft spots which formerly resisted all other methods of stabilization has been proven highly successful and a program of treatment of the numerous soft spots on the System has been undertaken which it is hoped will reduce materially the cost of maintaining the roadbeds and produce a much better riding structure.

The table below summarizes grouting costs and the resulting maintenance savings:

Year	Track Feet	Total Cost	Cost Per L.F.	MAINTENANCE PER MONTH Before Total	Before Per L.F.	After Total	After Per L.F.	Maint. Savings Per Mo.
1941	1.647	$ 1,029.27	$0.625	$ 201.15	$0.122	$ 5.90	$0.004	$ 195.25
1942	4,907	4,334.11	0.883	1.187.10	0.242	73.95	0.015	1.113.15
1943	11,882	16,898.69	1.422	2,308.33	0.194	151.19	0.013	2,157.14
1944	17,943	32,481.61	1.810	4,014.48	0.224	323.29	0.018	3,691.19
1945	21,429	49.432.27	2.307	3.879.45	0.181	290.64	0.013	3,588.81
1946	17,534	42,480.14	2.422	2,009.54	0.115	151.24	0.009	1,858.30

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IX c 8

STABILIZATION WITH CUTBACK ASPHALT OF 42 KILOMETERS OF THE NATURAL SURFACE SOIL OF THE PERIJA HIGHWAY IN VENEZUELA.

EUGENE V. BARRETT
Chief of the Materials Testing Laboratory
Ministry of Public Works of Venezuela Caracas, Venezuela

SYNOPSIS.

An investigation was made of the natural soil of the Perija Highway between La Villa de Rosario and Machiques, and samples of the surface soil were taken from the surface to 20 cm. after grading had been completed. The particle size, specific surface, liquid limit, plastic index, and specific gravity were determined for all soil samples, and each sample was mixed with three percentage of cutback asphalt.

The soil asphalt mixes were compacted and cured, and the density, stability at 60° C, stability after seven days' capillary absorption and the percent absorption was determined.

The cutback asphalt and soil were mixed in the field with road patrols and the mixture was turned over by the patrols until sufficient volatile had been eliminated. After construction was completed, samples of the compacted soil-asphalt mix were taken at the same stations, from which the soil samples had been taken, and the thickness, density and asphalt content of the compacted mix was determined from these samples.

The Perija Highway has a total length of 128 kilometers and connects Maracaibo and Machiques in the State of Zulia, Venezuela. The highway is built through low rolling country; the climate is hot and during the dry season of each year no rain falls for at least four months. However, during the rainy season very heavy rains occur, and the bottom lands of several of the rivers become flooded. The section of highway between Maracaibo and La Villa de Rosario was constructed prior to 1943, and in 1943 construction was started on the 42 kilometer section between La Villa de Rosario and Machiques.

An investigation was made of the undisturbed soil between Villa de Rosario and Machiques, and samples of the surface soil were taken, from the surface to 20 cm., after grading was completed and the surface had been compacted by the construction equipment. The particle size, specific surface, liquid limit, plastic index and specific gravity were determined for these samples, and each sample was mixed with three percentages of RC_2 cutback asphalt. The soil-asphalt mixes were compacted and cured and the density, stability at 60° C, stability after seven days capillary absorption and the percent absorption was determined.

TEST METHOD.

The particle size was determined by the hydrometer method using a specific gravity hydrometer and determining particle size to 1.5 microns.

The specific surface was determined in accordance with the method described on pages 1363 to 1366 of the 1946 Proceedings of the American Society for Testing Materials (a method of Particle Size Determination of Soils, Cement, etc. by Means of a Chainomatic Specific Gravity Balance - by Eugene V. Barrett).

The liquid limit and the plastic limit were determined in accordance with the standard methods of the A.S.T.M.

The specific gravity was determined using round bottom wine bottles and 50 gm. samples of soil. The soil was placed in the bottle and water was added until it reached almost to the bottom of the neck. The bottle and contents were then immersed up to the neck in boiling water for three hours and allowed to cool to 25° C. The bottle was then filled and suspended in water at 25° C by means of a wire, and the weight of the bottle plus the soil in water was determined. Since the weight in water of the bottle was known, it was possible to compute the specific gravity of the soil.

The soil - RC_2 cutback asphalt mixes were made and tested in accordance with the procedure described in "A Proposed Method of Test for Stabilization of Soils with Emulsified Asphalt" on page 507 of the 1939 Proceedings of the American Society for Testing Materials; with the following exceptions:

1. Samples were mixed with RC_2 cutback asphalt instead of emulsion.
2. Samples were mixed while in an air-dry condition, and immediately tamped into 2" diameter molds. Sufficient mix was used to result in a cylinder 4" high when compacted under a 3000 lb. load for one minute.
3. Specimens of compacted mix were removed from molds and immediately placed in a mechanical convection oven and cured at 60° C for 48 hours.
4. All mixing was done by hand in a basin. The hands were covered with rubber gloves and sufficient mix for three cylinders was made at the same time.
5. One cylinder from each mix was tested hot at 60° C and the other two cylinders were tested after seven days' capillary absorption at room temperature. The values given in tables Nos. 1 and 2 for stability after capillary absorption are the average stability for the two cylinders.

CHARACTERISTICS OF RC_2 CUTBACK ASPHALT.

The characteristics of the RC_2 cutback asphalt used in the construction were as follows:

Specific gravity as received - 0.9543 to 0.9549 at 25° C.
Flash point 46° C to 49° C
Viscosity Saybolt, Furol (60° C) - 145 seconds
Distillation (% of total distillate to 360°C)
At 225° C - 55.6 to 56.4
At 260° C - 76.9 to 78.2
At 315.6° C- 91.4 to 92.6
At 360° C - 100

Residue from the distillation to 360° C, % of volume by difference - 73.8 to 74.2.

Tests on the residue from the distillation:

Penetration 25° C,100 gm, 5 sec -91 to 98
Specific gravity - 1.019 to 1.020
Ductility (25° C) - 110 plus
Solubility in CCl_4 - 99.9

TEST RESULTS.

The results of tests made on the soil samples are given in tables Nos. 1 and 2. The grain size of each soil has been separated, for convenience, in accordance with the M.I.T. grain size scale into gravel sizes, sand sizes, silt sizes and clay sizes. According to this scale, grains larger than 2 mm. are designated as gravel, from 2 mm. to 0,06 mm. as sand, from 0.06 mm. to 0.002 mm. as silt and finer than 0.002 mm. as clay.

RECOMMENDATIONS.

A study of the test results indicated that most of the soil represented by the samples would have sufficient stability, in the presence of water, if the soil were mixed with from 7% to 9% of RC_2 on the basis of the air-dry weight of the soil. Previous work with soil stabilization with cutback asphalt in Venezuela had indicated that a soilasphalt mix having a stability load of 6000 Kg. or more, after capillary absorption, would give satisfactory service in the field.

It was, therefore, recommended that all soil represented by samples with stability loads after capillary absorption of 6000 Kg. or more should be mixed with from 7% to 9% of RC_2 and

Slight cracking observed near top of some small hills

View of first houses on outskirst of Machiques

All curves were built with proper super elevation

Section over low embankment

Long straight section of road

that soils with less than the required stability should be replaced by satisfactory soil.

FIELD STABILIZATION.

The soil was loosened to the required depth by two motor-driven road patrols and a section one kilometer long was mixed as a continuous operation. The RC_2 cutback was heated prior to application and was distributed over the soil by a tank truck with a spray bar. Successive applications of RC_2 were made until the soil contained the required percentage of asphalt; each application being thoroughly mixed with the soil before the next application was made. After the soil contained the required amount of asphalt, the mix was aerated for about a week by the two road patrols. The time the mix had to be aerated depended on the weather and the grain size of tne soil. Other things being equal, the coarser soils required less aerating.

After sufficient of the volatile material in the RC_2 had been eliminated by aeration, the mix was spread in a uniform loose layer with a thickness of about 4 cm, and the excess mix was bladed to the side of the road. The 4 cm layer was then compacted with trucks, starting with empty trucks and finishing compaction with tank trucks with a 3.5 metric ton load. After the first layer was compacted, the road patrols continuously bladed the remaining mix over the surface in thin layers at the same time that the mix was being compacted by the trucks. This operation was continued unitl all of the mix was in place and compacted.

TABLE 1

Soil as received in the Laboratory									Soil mixed with RC_2 Asphalt consolidated and cured at 60°C during 48 hours														Tests of the finished pavement			
									Stability Load in kgs at 60°C				Stability Load in kgs after 7 days capillary Absorption				% at absorption on a dry weight basis				Density in grs/cm³ on a dry weight basis						
									% of RC_2 in the mix				% of RC_2 in the mix				% of RC_2 in the mix				% of RC_2 in the mix						
Station Nº	Gravel	Sand	Silt	Clay	Specific Surface sq/cms. per grms.	Liquid Limit	Plastic Limit	Plastic Index	Specific Gravity	4	6	8	10	4	6	8	10	4	6	8	10	4	6	8	10	Average Thickness	Density gm/cm³	% of Asphalt by extraction	Corresponding computed % of RC_2
04500	4.0	61.0	28.3	6.5	1938	14.5	12.3	2.2	2.63	4750	3470	3420	--	5867	6800	6000	--	1.29	0.97	0.92	--	1.85	1.86	1.90	--	11.4	1.98	4.46	5.58
14000	0.1	67.4	24.5	8.0	2184	15.0	12.6	0.4	2.65	3230	3240	3750	--	6400	7850	6850	--	0.67	0.54	0.36	--	1.84	1.86	1.90	--	10.0	1.92	5.07	6.34
14500	1.0	81.0	14.5	5.5	1089	13.0	--	-	2.65	2910	3120	3590	--	7325	7567	6867	--	0.53	0.37	0.37	--	1.82	1.83	1.88	--	11.2	2.06	5.44	6.80
24000	1.5	69.0	25.0	4.5	1915	13.5	12.0	1.5	2.61	2700	3320	3150	--	7267	7683	6300	--	0.52	0.38	0.37	--	1.81	1.85	1.90	--	11.3	2.02	5.70	7.13
24500	0.5	75.5	19.0	5.0	1524	14.2	--	-	2.66	--	4400	5450	4700	--	8000	7450	5800	--	0.43	0.39	0.21	--	1.80	1.86	1.91	11.0	1.99	5.19	6.49
34000	0.2	84.0	11.0	4.0	1099	16.1	13.8	2.3	2.65	--	4150	5100	4600	--	7675	7583	4350	--	0.48	0.42	0.02	--	1.84	1.88	1.95	15.0	1.79	5.05	6.31
34500	0.8	81.5	12.7	5.3	1447	11.4	10.7	0.7	2.64	--	5900	5700	4700	--	8200	8400	5200	--	0.43	0.27	0.05	--	1.85	1.87	1.96	11.5	2.00	4.46	5.58
44000	0.5	73.5	20.5	5.5	1656	11.1	9.6	1.5	2.62	--	8100	9050	8750	--	7975	8025	10775	--	0.46	0.46	0.02	--	1.95	2.00	2.06	9.7	2.07	7.35	9.19
44500	0.2	77.3	17.3	4.8	1292	15.2	14.2	1.0	2.64	--	6100	5850	5300	--	8550	7950	5875	--	0.54	0.42	0.17	--	1.78	1.86	1.91	9.5	1.99	5.07	6.34
54000	0.5	72.5	20.0	7.0	1913	12.6	11.6	1.0	2.64	--	7100	6400	6100	--	8700	8033	6425	--	0.56	0.24	0.02	--	1.89	1.97	2.03	7.0	2.08	7.04	8.80
54500	1.0	70.0	25.2	3.8	987	12.3	10.4	1.9	2.62	--	5750	5950	4750	--	8050	7000	4650	--	0.40	0.32	0.22	--	1.85	1.88	1.94	11.2	2.03	5.22	6.53
64000	0.0	75.5	20.5	4.0	1277	12.0	11.4	0.6	2.62	--	5900	5300	3800	--	7325	6775	4900	--	0.51	0.24	0.06	--	1.86	1.90	1.96	7.5	2.18	6.94	8.68
64500	0.0	70.5	24.5	5.0	1413	13.-	11.9	1.5	2.63	--	5150	6200	6350	--	9550	9000	5900	--	1.80	0.31	0.13	--	1.86	1.92	1.99	12.0	1.98	6.53	8.16
74000	0.5	59.5	34.5	6.0	1694	12.-	11.0	1.3	2.64	--	7600	7050	6100	--	8275	7750	7750	--	0.75	0.50	0.22	--	1.91	1.95	1.99	13.2	1.94	7.95	9.94
74500	1.0	76.0	19.0	4.0	1268	13.4	11.6	1.8	2.67	--	5500	5950	5350	--	8250	7133	4150	--	0.45	0.41	0.00	--	1.90	1.94	2.05	8.5	2.04	5.71	7.14
84000	1.0	77.5	16.5	4.0	1178	12.0	11.3	0.7	2.63	--	4900	4550	4650	--	7625	7433	8725	--	0.38	0.29	0.27	--	1.85	1.90	1.96	8.0	2.62	7.45	9.31
84940	0.0	30.0	30.0	40.0	7577	23.8	12.2	11.6	2.60	--	--	--	7800	--	--	--	300	--	--	--	3.43	--	--	--	1.97	(A) 9.2	(A) 1.94	(A) 8.56	(A) 8.20
94500	0.0	72.0	24.0	4.0	1334	13.3	10.2	3.1	2.62	--	7050	6700	7650	--	8275	7061	7425	--	0.42	0.19	0.00	--	1.95	2.01	2.08	8.2	2.09	8.12	10.15
104000	8.0	68.0	22.0	4.0	1139	13.4	13.2	0.2	2.66	--	5500	7050	7600	--	8400	7667	7375	--	0.44	0.43	0.16	--	1.91	1.94	1.99	9.1	1.90	6.55	8.19
104500	4.5	73.5	13.5	8.5	1719	14.1	11.6	2.5	2.61	--	8900	8100	6700	--	9825	8450	6700	--	0.57	0.46	0.00	--	1.93	1.95	2.02	11.9	2.09	6.16	7.70
114000	1.0	69.0	18.3	11.3	2641	13.5	9.9	3.6	2.62	--	9900	8950	7650	--	7450	7175	5875	--	0.76	0.55	0.07	--	1.99	2.02	2.05	8.9	1.83	6.76	8.45
11-500	0.8	68.2	15.5	15.5	3775	13.9	12.2	1.7	2.66	--	8300	5600	2950	--	8875	7375	4950	--	0.47	0.37	0.09	--	1.84	1.90	1.95	10.0	1.68	7.71	9.64
124000	0.2	77.8	17.0	5.0	1461	13.9	12.0	0.9	2.60	--	6000	5750	3850	--	9000	7833	5765	--	0.59	0.35	0.12	--	1.88	1.92	1.98	8.3	1.99	6.77	8.46
124500	4.2	66.8	19.0	11.0	2745	13.9	12.3	1.6	2.66	--	8100	7500	5850	--	8400	7925	6883	--	1.12	0.49	0.21	--	1.91	1.95	1.99	7.4	1.97	7.64	9.55
134000	2.0	68.0	21.5	8.5	2346	14.1	10.2	3.9	2.61	--	10400	18900	10400	--	9250	16250	7500	--	0.86	0.00	0.00	--	1.97	2.15	2.13	8.6	1.98	7.00	8.75
134500	0.2	79.8	16.0	4.0	1190	10.1	10.0	0.1	2.62	--	5150	5000	4300	--	8550	7916	7200	--	0.47	0.26	0.00	--	1.87	1.94	1.99	10.8	1.85	6.32	7.90
144000	0.0	78.0	18.0	4.0	1325	16.1	12.7	3.4	2.64	--	4800	5200	4900	--	9125	8125	7100	--	0.43	0.25	0.10	--	1.81	1.85	1.90	10.7	1.93	6.65	7.06
144500	0.1	71.9	23.5	4.5	1442	15.6	11.8	0.8	2.62	--	3800	6100	5800	--	8000	8350	7550	--	0.43	0.33	0.00	--	1.90	1.93	1.99	9.8	2.00	7.96	9.95
154000	0.0	65.0	29.0	6.0	1878	15.6	13.5	2.1	2.62	--	2500	4500	4150	--	7800	7167	6700	--	0.44	0.31	0.31	--	1.78	1.86	1.87	11.6	2.01	6.91	8.64
154500	0.2	71.3	22.0	6.5	1791	14.4	--	-	2.61	--	4000	5450	5200	--	8650	7465	6850	--	0.48	0.39	0.13	--	1.88	1.93	2.00	9.3	1.97	6.45	8.06
164000	0.0	72.0	22.0	6.0	1806	15.9	14.1	1.8	2.58	--	4000	4500	4000	--	6525	6000	5850	--	0.36	0.25	0.22	--	1.82	1.84	1.88	7.8	1.93	5.76	7.20
164500	0.1	67.0	27.0	5.0	1882	15.3	12.7	2.6	2.57	--	4600	5300	5650	--	8150	8600	6475	--	0.52	0.41	0.21	--	1.80	1.85	1.90	8.7	1.95	6.14	7.68
174000	0.0	75.5	21.0	3.5	1709	13.6	11.9	1.7	2.61	--	7400	9550	7800	--	9300	9400	7550	--	0.58	0.35	0.06	--	1.98	2.03	2.09	8.1	1.92	6.61	8.26
174500	0.1	75.4	16.5	8.0	2095	13.5	11.9	1.6	2.64	--	10400	11600	8300	--	8750	8750	8300	--	0.75	0.54	0.17	--	1.99	2.01	2.01	9.8	2.03	7.08	8.85
184000	0.0	70.0	20.5	9.5	2556	14.4	10.7	3.7	2.62	--	10500	11500	10500	--	9625	12525	4400	--	0.66	0.40	0.11	--	2.05	2.07	2.10	9.0	1.94	7.72	9.65
184500	5.0	60.0	28.0	7.0	1924	14.8	12.3	1.5	2.63	--	5450	6950	5500	--	8050	8825	5750	--	0.77	0.58	0.19	--	1.92	1.98	2.01	8.8	1.99	4.75	5.94
194000	1.0	72.5	22.0	4.5	1539	14.6	10.6	4.2	2.67	--	8250	7900	8000	--	8700	8483	8100	--	0.54	0.39	0.08	--	1.96	2.01	2.08	9.0	1.93	8.51	10.04

GRAVEL.- Larger than 2 mm.
SAND.- 2.0 mm. to 0.06 mm.
SILT.- 0.06 mm. to 0.002 mm.
CLAY.- Finer than 0.002 mm.

(A) The soil used in this mix came from station 8400

Construction was started about June 1943 and finished in November 1944, so that the time of construction included two rainly seasons and one dry season. The rains caused a great deal of difficulty with the soil stabilization, since the mix had to be aerated to eliminate the water. In a number of cases the mix was repeatedly wet by rain and re-aerated, with the result that too much of the volatile was eliminated. It was, therefore, necessary to re-temper the mix by adding more cutback, and as a result of this re-tempering, the final asphalt content was higher than was recommended. The difficulty of obtaining materials, equipment and repair parts resulted in a considerable delay of the work.

FINISHED SURFACE.

The compacted soil asphalt mix was smooth and resulted in an attractive non-skid surface. The writer has ridden over this road at various speeds up to 120 kilometers per hour, and the surface smoothness is comparable to that of a first-calss road in the U.S.A.

After construction was completed, samples of the compacted soil asphalt mix were taken at the same stations from which the soil samples had been taken, and the thickness, density and asphalt content of the compacted mix was determined by means of continuous extraction of a sample for eight hours in a Soxhlet apparatus, using carbon tetrachloride as the solvent. The corresponding original content of RC_2 was computed by means of a factor obtained by mixing the soil with RC_2 and curing at 60° C to determine the percent of volatile that was lost. The results of tests of the compacted mix are given in tables 1 and 2.

MAINTENANCE OF STABILIZED SOIL SURFACE AND PRESENT CONDITION.

In November, 1947, the stabilized surface was three years old, and the writer made a careful inspection of the 42 kilometers of stabilized surface to determine its present condition. The surface in the intervening three years has not been subjected to a heavy intensity of traffic, but it has been subjected to very heavy loads, consisting of logging trucks, oil well equipment and trucks loaded with farm produce. Most of the trucks, passenger cars and buses using the road travel at high speed.

The surface was given a RC_2 sand seal one and one-half years after construction was completed and has not had another seal since that time. However, three sections of the road were re-surfaced in 1947 with 4 cm. of soil asphalt

TABLE 2

Station	Soil as received in the Laboratory: % Gravel	% Sand	% Silt	% Clay	Specific Surface sq/cm. per gm.	Liquid Limit	Plastic Limit	Plastic Index	Specific Gravity	Soil mixed with RC_2 Asphalt consolidated and cured at 60°C during 48 hours: Stability Load in kgs at 60°C, % of RC_2 in the mix: 6½	7½	8½	Stability Load in kgs after 7 days capillary absorption, % of RC_2 in the mix: 6½	7½	8½	% Absorption on a dry weight basis, % of RC_2 in the mix: 6½	7½	8½	Density in grs/cm³ on a dry weight basis, % of RC_2 in the mix: 6½	7½	8½	Tests of the finished pavement: Average Thickness	Density gm/cm³	% of Asphalt by extraction	Corresponding computed % of RC_2
194+500	30.0	47.0	15.0	7.5	1937	14.0	12.5	1.5	2.68	6100	6500	6250	8975	9450	9325	0.99	0.77	0.56	2.00	2.04	2.05	9.1	1.88	5.89	7.49
204+000	0.0	70.0	22.2	7.8	2096	12.4	—	-	2.68	3550	3750	3450	9075	7775	7500	0.65	0.64	0.46	1.93	1.98	2.03	11.2	1.86	5.95	7.44
204+500	0.1	47.0	32.1	19.9	5867	16.0	11.3	4.7	2.64	7550	9700	10500	6900	7500	7250	1.57	1.33	1.18	2.07	2.05	2.05	7.9	1.84	9.08	11.38
214+000	0.0	71.0	21.0	8.0	2202	12.8	—	-	2.62	5100	4300	5800	9900	8250	7400	0.88	1.00	0.90	1.96	1.97	2.02	7.0	2.06	8.41	10.51
214+500	0.0	12.0	54.0	34.0	9149	28.2	17.1	11.1	2.80	7350	9150	9150	4585	4625	4075	3.09	2.75	2.63	1.89	1.90	1.93	(B)8.0	(B)1.97	(B)8.08	(B)10.10
224+000	0.1	39.9	46.5	13.5	4059	21.5	17.0	4.5	2.62	7750	10200	8600	5925	6050	5950	1.93	1.93	1.80	1.86	1.86	1.89	8.6	1.89	7.23	9.04
224+500	0.2	36.8	41.3	21.5	5499	24.6	16.0	8.6	2.64	7000	7750	7950	*DESINTEGRATED*			3.89	3.44	3.02	1.96	1.99	2.00	(B)9.2	(B)1.88	(B)5.25	(B) 7.44
234+000	0.0	22.0	48.0	30.0	8166	33.8	18.2	15.6	2.65	9400	8250	8900	*DESINTEGRATED*			4.09	4.58	3.98	2.00	1.99	1.96	(B)9.1	(B) 2.00	(B)9.19	(B)11.49
234+500	0.2	7.8	58.0	34.0	9185	36.8	18.3	18.5	2.66	7700	6700	8100	*DESINTEGRATED*			7.34	5.72	4.87	1.95	1.95	1.97	(B)10.3	(B) 1.74	(B) 9.37	(B) 11.71
244+000	0.0	19.5	57.5	23.0	7906	28.4	12.6	15.8	2.67	9750	8650	9100	*DESINTEGRATED*			4.00	3.22	3.58	1.99	1.97	1.98	9.1	(B) 1.77	(B)6.52	(B) 8.15
264+500	1.0	68*0	23.0	8.0	2255	12.5	—	—	2.66	7+00	6000	6000	7200	7600	5725	0.70	0.59	0.54	1.98	2.04	2.05	10.9	1.76	5.54	6.93
284+000	1.2	68.8	22.2	7.8	2091	14.0	10.2	3.8	2.62	7050	9500	6300	9250	7675	9875	0.80	0.68	0.42	1.95	1.98	2.02	15.1	1.96	9.19	11.49
284+500	6.0	30.0	30.0	34.0	9368	24.0	14.5	9.5	2.68	9150	9900	7050	575	1425	1250	9.52	5.87	3.54	1.91	1.89	1.92	(C) 7.2	(C)1.86	(C)6.54	(C) 8.18
294+000	4.0	61.0	25.0	10.0	2763	17.0	12.5	4.5	2.63	13350	11150	11500	9125	7650	8775	1.53	0.93	0.97	1.98	2.03	2.02	9.4	1.91	8.00	10.00
294+500	1.0	77.0	15.5	6.5	1705	17.0	13.3	3.7	2.62	6800	7200	5900	7550	7975	8100	0.88	0.91	0.57	1.90	1.94	1.96	10.2	1.87	7.27	9.09
274+000	0.5	82.0	7.5	10.0	1844	15.0	14.5	0.5	2.61	3050	3450	4000	7400	7650	7775	1.99	1.41	1.27	1.81	1.84	1.86	11.7	1.94	6.51	8.14
274+500	4.0	64.0	20.0	12.0	2966	16.0	13.3	2.7	2.73	9700	7400	8400	7975	7875	7925	2.26	2.05	1.80	1.95	1.96	2.00	8.8	1.87	6.45	8.06
284+000	0.8	73.4	20.0	6.0	1744	18.0	12.7	1.3	2.62	5000	4300	5400	9250	9300	8400	1.02	0.99	0.18	1.92	1.93	1.95	8.7	1.89	7.02	8.78
284+500	2.0	70.5	21.5	6.0	1534	18.0	13.5	1.5	2.64	5800	3400	3900	8300	9125	8150	1.38	1.37	1.17	1.84	1.87	1.90	9.1	1.90	5.31	6.64
294+000	20.0	62.0	14.0	4.0	1025	17.0	14.0	3.0	2.67	5050	3150	4550	9550	8850	9475	0.95	1.04	1.05	1.97	1.96	1.98	9.3	1.93	7.21	9.01
294+500	22.0	55.5	14.5	8.0	2039	20.0	18.6	1.4	2.70	8400	8450	8650	6050	6275	7575	2.64	2.46	1.97	2.01	1.96	2.03	11.2	1.78	5.62	7.03
304+000	1.0	70.0	25.5	3.5	1067	15.0	12.1	2.9	2.68	5000	5700	5950	7850	8150	7925	2.04	1.45	1.26	1.85	1.90	1.89	11.7	1.76	6.76	8.46
304+500	8.4	68.1	18.6	14.0	3193	17.0	13.5	3.5	2.77	7800	8200	7700	8250	7150	8325	1.55	1.31	1.38	1.90	1.92	1.95	10.3	1.78	8.13	10.16
314+000	14.0	63.5	16.0	6.5	1725	15.0	13.4	1.6	2.65	6450	7800	7950	8600	8225	8750	1.22	1.08	0.82	1.99	2.01	2.05	9.8	1.87	7.70	9.63
314+500	4.0	82.0	12.0	6.0	1769	15.0	14.3	0.7	2.67	7050	7750	7500	7500	7800	7325	1.18	0.96	0.92	1.97	1.98	2.02	11.1	1.78	5.58	6.94
324+000	9.5	61.5	15.0	14.0	3437	18.0	13.1	4.9	2.69	7400	8650	8500	6075	6975	7125	2.49	1.89	1.46	2.02	2.04	2.09	11.9	1.80	5.37	6.71
324+500	8.6	70.0	13.5	8.0	2226	15.0	13.7	1.3	2.72	6350	7050	7000	7175	6900	7625	1.11	1.16	1.06	1.98	2.00	2.01	8.0	1.06	6.77	8.46
334+000	1.0	78.0	17.0	4.0	1152	15.0	13.4	1.6	2.63	5650	6850	5700	6925	7025	7225	1.26	1.08	0.96	0.86	1.88	1.91	10.7	1.94	5.31	6.64
334+500	4.0	78.0	17.0	7.0	1436	14.0	12.8	1.2	2.67	5200	5700	5900	7675	8425	7725	0.89	0.80	0.71	1.87	1.92	1.94	11.4	1.90	6.23	7.79
344+775	1.0	34.0	39.0	26.0	6566	22.0	12.0	10.0	2.65	10050	8650	8100	700	950	700	5.97	6.20	5.93	2.00	1.99	1.98	(d) 8.7	(d) 2.06	(d) 6.33	(d) 7.91
344+000	0.5	37.5	47.0	15.0	4184	21.0	17.2	3.8	2.62	8850	9200	8600	5050	6100	6250	3.51	2.80	2.30	1.91	1.90	1.93	(d) 9.2	(d) 1.97	(d) 7.04	(d 8.80
344+250	1.2	24.8	65.0	10.0	5482	26.0	18.5	7.5	2.69	8450	9350	8250	3850	5050	3100	3.43	3.84	3.39	1.88	1.87	1.88	(d) 8.2	(d) 1.97	(d) 5.79	(d) 7.23
344+500	3.0	48.0	41.5	10.5	3070	18.0	13.4	2.6	2.68	9750	8650	7350	6025	6325	6725	2.47	2.10	2.07	1.96	1.96	1.98	(d) 11.3	(d) 1.94	(d) 9.10	(d)11.37
344+750	1.0	39.4	44.0	16.0	4230	23.0	17.0	6.0	2.67	10700	9000	8450	5550	5875	5850	2.53	2.19	2.09	2.00	2.00	1.98	(d 7.3	(d 2.00	(d)8.22	(d)10.27
354+000	2.0	37.0	49.0	12.0	376	20.0	16.2	3.8	2.63	9000	8900	9100	6625	6650	7900	2.31	1.71	1.49	1.87	1.87	1.91	(e) 9.3	(e)1.97	(e)7.09	(e) 8.86
354+250	1.5	38.5	46.0	14.0	4172	31.0	25.4	5.6	2.67	7600	7150	7100	3300	4650	4650	4.84	3.23	2.25	1.80	1.80	1.81	(e) 14.8	(e)1.83	(e)6.46	(e) 8.08
354+750	1.5	29.0	52.0	18.0	5377	30.0	19.9	10.1	2.68	9250	9200	8850	625	975	825	8.47	5.33	5.72	1.88	1.89	1.87	(e)11.2	(e)1.86	(e)6.09	(e) 7.61
364+250	6.0	78.0	12.0	4.0	1103	14.0	13.7	0.3	2.64	7900	6100	3900	7750	7982	8550	0.62	0.62	0.47	1.88	1.93	1.97	10.0	1.78	6.71	8.39
364+500	1.0	81.0	14.0	4.0	1134	16.0	14.1	1.9	2.63	3650	2150	2400	9375	9275	7800	1.05	0.76	0.73	1.91	1.96	1.95	9.1	2.00	6.44	8.06
374+000	6.0	65.0	18.0	11.0	2809	20.0	14.0	6.0	2.63	2900	4050	6350	9300	9400	10100	1.24	1.14	0.81	1.88	1.91	1.97	7.4	1.89	7.38	9.23
374+500	2.0	78.0	20.0	6.0	1716	18.0	14.4	3.6	2.63	6900	7100	7100	8250	8500	9225	1.32	0.90	0.90	1.93	1.96	1.97	8.8	1.89	9.30	11.62
384+000	3.0	73.0	20.0	4.0	1187	16.0	13.8	2.2	2.67	5000	4000	6800	8875	9200	9650	1.21	0.89	0.67	1.95	1.99	2.04	9.1	1.82	7.08	8.77
384+500	2.7	52.0	36.0	11.0	3822	19.0	15.0	4.0	2.59	6400	5550	4900	8700	8650	7900	1.56	1.33	1.17	1.93	1.97	2.09	14.3	1.89	5.44	6.80
394+000	1.2	70.0	24.0	4.0	1227	15.0	13.1	1.9	2.62	7150	7000	6150	8775	8450	9225	2.89	2.07	1.75	2.00	2.04	2.08	6.8	2.06	9.42	11.78
394+500	2.0	80.0	14.5	3.5	946	16.0	14.1	1.9	2.64	4900	5400	5500	7975	7725	7275	7.30	3.52	3.38	1.89	1.91	1.98	5.8	1.98	5.81	7.26
404+000	1.0	77.0	18.0	4.0	1383	16.0	11.5	4.5	2.61	8450	6550	8000	8825	8550	9200	0.65	0.52	0.41	1.97	2.02	2.09	8.3	1.90	7.55	9.44
404+250	2.0	78.5	18.0	6.5	1881	21.0	18.0	3.0	2.58	5700	5000	5750	7400	7900	6925	1.04	0.73	0.59	1.84	1.85	1.89	—	—	4.87	6.09
414+250	0.0	34.0	57.0	8.5	2633	17.0	15.2	1.8	2.64	6300	5800	5600	8125	7975	7575	1.25	0.77	0.72	1.96	1.99	1.91	—	—	5.46	6.82
414+250	3.5	30.0	42.0	24.5	6264	20.0	14.4	5.6	2.64	7150	7400	8100	5150	6275	8375	0.80	0.53	0.37	1.92	1.94	1.97	8.8	1.91	6.28	7.86
424+000	2.0	28.0	47.5	22.5	5475	22.0	15.5	6.5	2.66	7000	6900	7450	225	2800	1625	2.15	1.04	2.91	1.84	1.91	1.94	(f)7.7	(f)1.96	(f)6.89	(f)8.61

GRAVEL .- Larger than 2 mm.

SAND .- 2.0 mm. to 0.05 mm.

SILT .- 0.05 mm. to 0.002 mm.

CLAY .- Finer than 0.002 mm.

(B). The soil in these samples came from station 194 00

(C). The soil in these samples came from station 284 00

(d). The soil in these samples came from station 334 500

(e). The soil in these samples came from station 364 250

(f). The soil in these samples came from station 414 600

mix. Re-surfacing was required due, in each case, to a base failure that caused the surface to become badly cracked and uneven. In each section that was re-surfaced, our tests had shown that the soil was of bad quality and had little or no stability in the presence of water even when mixed with RC_2. The sections that were re-surfaced were:

Station 33 + 750 to 33 + 850

Station 35 + 650 to 35 + 800

In addition, there has been considerable cracking of the surface of the section of road over the embankment from Station 8 + 500 to 9 + 100. This section is in the bottom lands of the San Juan River, and the fill for the embankment was taken from the bottom lands on each side of the road. Our tests showed that this soil was of bad quality and cracking of the surface is due entirely to cracking of the embankment. This section has had several seal coats during the last three years.

In the opinion of the writer, the stabilized surface between La Villa de Rosario and Machiques, with the exception of the sections mentioned above, is in excellent condition, and as smooth as at the time construction was completed.

The slight amount of cracking that was noticed occurs in most cases at the tops of small hills and the cracks in the surface correspond to cracks in the base soil.

In addition, some map cracking was noticed in sections where the RC_2 content was above 10%, but this cracking did not appear to affect ei-

ther the stability or the smoothness of the surface.

CONCLUSIONS.

1. Mixes of soil - RC_2 cutback asphalt that have a stability load of 6000 Kg. or more, after seven days of capillary absorption, will give satisfactory service in the field if they are properly aerated previous to being placed, and provided that the soil under the stabilized mix has sufficient stability in the presence of water.
2. The suitability of a given soil for stabilization with cutback asphalt can be predicted on the basis of an area-plasticity index, and all soils having an index of 19.0 or less will have a stability load after capillary absorption of 6000 Kg or more when mixed with the proper percentage of RC_2. This area plasticity index is computed by multiplying the specific surface by the plastic index and divinding by 1000. The area-plasticity indexes of the soils tested in this investigation varied from 0.0 to 169.9.
3. Soil should not be stabilized with cutback asphalt during a time of the year when frequent rains are liable to occur. In the tropics all soil stabilization should be done during the dry season.
4. Close control of the RC_2 content of a mix is not possible when the soil is mixed in place with road patrols. It appears that the RC_2 content cannot be specified closer than plus or minus 2%.
5. Close control of the compacted thickness of stabilized soil is not possible when mixing and placing is done with road patrols. It appears that the thickness cannot be specified closer than plus or minus 2 cm.
6. Soil stabilized with cutback asphalt is capable of supporting very heavy loads, and the maintenance cost of such a surface is low.
7. The density of the compacted Laboratory samples of the soil asphalt mixes closely approximated the density of the corresponding field mixes.

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IX c 9

AN INTERESTING BELGIAN REALIZATION OF "CLAY CONCRETE"

Paper presented in the name of the
"Société SOLVAY"
by Marcel THUILLEAUX
Ingénieur des Arts et Manufactures

INTRODUCTION

As a result of the war, many roads remain devasted by belligerent armies, and the resources of state and Communes are exhausted; hence the special interest presently conferred to processes for restoring viability to these roads at as low a cost as possible.

One of these processes was first called "stabilized gravel", but is now better known under the name of "clay concrete", it consists of a coarse aggregate (or skeleton) with a granular composition following a well determined law and of a binder clay, the properties of which are stabilized by an hygroscopic salt. It was born in the United States and is used on a large scale in the Northern countries of Europe, especially in Sweden, but it remains nearly unknown in Western Europe.

For a few years however, Belgium has already realised some applications of it; the town of Tournay deserves a special mention as, in 1942-43, it rebuilt in this way about 2 Km of bicycle track; never had the builders considered its utilization by others than bicycles; now it admirably resisted the severe, unexpected ordeal to which it was submitted by the Liberation Armies; parkings for vehicles of any kind and weight were established there which literally dug and deeply cut the approaches : however no repair at all was needed to the track itself, except removing the materials of any kind, unconsiderately thrown about upon the surface by the unexpected users x)

A hauling road had also been established in the same region following a similar formula, and the same kind of observations as those made in Tournay could be registered there.

ORGANIZATION AND GENERAL CONDITIONS OF ATHUS EXPERIMENT.

As they had been informed of these results, a delegation of the provincial and technical authorities of the Province of Luxemburg came there to make observations on the spot. This delegation gained such a good impression, that they decided to subsidize a wide experiment on roads. In order that technicians may form a good judgment about the value of the process, the most difficult place in the Province was intentionally chosen; the city of Athus, situ-

x) A bicycle track of 6 Km long, built in France ir 1939 between Douai and Valenciennes behaved equally well under military traffics of invasion and liberation.