The bearing capacities (compression strength) can be grouped as follows:

Compression strength of the sedimentated cements, after 28 days, cement - water ratio 1 : 1

Group	Cement no.	Compression strength in kg/cm^2	Remarks
I	10, 12	0	hydr.limes
II	8, 9, 11	13 - 20	
III	1, 2, 7, 14	30 - 40	
IV	3, 4, 5, 6,13	~50	

It appears, from these tests, that cements no. 3 and 7 have distinct properties.

Cement no. 7 of type "agglomerante marino" gave a maximum decantation volume and, at the same time, attained a rather high compression strength (30 - 40 kg/cm^2 after 28 days). Its permeability curve shows a steep reduction for the first six hours after mixing. In this initial period, it has the smallest permeability of all tested cements. It belongs, further, to the slow sedimenting group, with, however, a rather long setting time (70 hours).

Cement No. 3 of type "450 kg/cm^2 special" also has outstanding qualities, like: great rest volume, high compression strength, permeability curve similar to no. 7's, slow sedimentation and medium setting time. Both cements seem to be very suitable for injections.

Aside of these 15 Italian cements, 28 French cements were investigated, though not so extensively. Decantation volume with water flow pressure and permeability of the 28 cements were determined. In the following table we give the decantation volume with water pressure, in per cent of the initial volume and "k" values after 6 hours. It exists, here also, large variations between the different cements.

Investigations of French cements.

Cement No.	Decantation volume with water flow perssure in percent	Permeability values "k" in 10^{-4} cm/min. after 6 hs.
1	47,7	6,6
2	49,3	33,0
3	54,1	12,9
4	53,0	19,2
5	47,1	26,7
6	51,8	16,5
7	61,7	17,4
8	53,0	6,3
9	70,6	6,0
10	82,4	15,0
11	82,5	27,8
12	47,0	22,2
13	43,5	12,3
14	50,0	22,5
15	55,8	36,9
16	50,0	37,5
17	50,6	18,0
18	44,7	9,0
19	48,3	32,1
20	50,0	33,0
21	53,0	48,3
22	51,1	23,4
23	41,2	6,0
24	50,0	25,8
25	61,7	7,8
26	53,0	6,3
27	51,2	13,8
28	52,9	10,5

As a conclusion, all these investigations have shown how a cement in suspension will behave and that important differences exist between the various cement sorts. We obtained, further, information on the permeability of cement sediments; contrarily to the frequent assumption that cement sidiments are impervious from the very beginning, they have, just after the mixing, the permeability of a fine sand and, only after several hours, they become impervious like a clay material.

It is, therefore, advisable, to test cements in view of their suitability as materials for grouting. This is especially important nowadays, because injections are not only used for impermeabilizing soils and pervious masonries, but also in structural constructions.

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IX c 3

AN EXAMPLE OF SOIL-CEMENT CONSTRUCTION DEVELOPMENT

CHRISTOPHER F. ARMSTRONG, A.M.I.C.E.

INTRODUCTION

This paper deals with mix-in-place soil-cement road construction at four sites in southern England. It describes development work carried out by the Ministry of Transport during the period 1944-7 and includes soil survey data, remarks on the use of plant and conclusions.

The object of the work was to apply existing methods of soil-cement construction to certain common British soils containing relatively high proportions of clay or stone and, where desirable, to encourage the extended use of such methods.

Assistance was given both by the highway authorities concerned, and by the Department of Scientific and Industrial Research, in furtherance of the policy of following up laboratory researches by full-scale experiments.The research contribution - part of the programme of the Road Research Board - included improved mechanical methods of testing soil-cement mixtures, chemical methods for the measurement of soil-cement affinity; also compaction tests which afforded a guide to the choice of plant.

GENERAL

Conditions common to all experiments were as follows:

1) A soil survey preceded each experiment.
2) Cement bags were spotted on the ground by hand although bulk spreaders, if available, would have been prefered.
3) Proportions of water and cement - based on laboratory tests - were specified by weight, as percentages of the weight of dry soil and

TABLE I

DETAILS OF CONSTRUCTION

Location of Experiment	Date of Construction	Area Treated (Sq.Yds.)	Soil Type (U.S.Engineers' Classification)	Subsoil	Max.Bulk 'Dry' Density Soil-Cement + Stones (lb/cu.ft)	Specified Cement Content % by wt. of dry soil + stones	Specified Moisture Content % by wt. of dry soil + stone	xa) Primer	Surfacing
ABINGDON Berkshire	September 1944	1.400	(a) Sand-Clay (S.P.)	3 ft silt on 7 ft of peat	113	10	12	Tar fuel oil at 13 sq.yds/gal. (0.08 gal/sq. yd.)	3 in. two-coat tarmacadam surface dressed as below
		2,000	(b) Sandy-Clay (CL)	4 ft of gravel - sand - clay on claybound + sandstone	104	10	18		Two coat surface dressing ½ in. and ¼ in. limestone 30° EVT tar at 6 sq.yds/gal. (0.17 gal/sq.yd.)
HATFIELD Hertfordshire	April 1946	4,600	(c) Silty Clay with gravel (M L)	Silty Clay with gravel	115	10	18	None	¼ in. moist sand under concrete slab 8 in. thick doubly reinforced.
DARTFORD Kent	September 1946	14,000	(d) Sandy Gravel (G C)	Thanet sand and upper Chalk	124	7½ x) or 9 or 10	10	Creosote cut-back bitumen (47% Soluble in CS_2 of 25 Engler viscosity at 25° C applied at 5 sq.yds/gal. (0.2 gal/sq.yd.)	3/16 in. gravel and bitumen emulsion at 6 sq.yds/gal (0.17 gal/sq.yd).
			(e) Pebbly Gravel (G P)		136		6.5		
			(f) Silty Clay (C L)		N.T.				
DARTFORD Kent	September 1947	20.000	(g) Sandy Gravel (G C)		135	8	5	As used in 1946, trials with 55% bitumen emulsion were not satisfactory	¼ in. granite and 55% bitumen emulsion at 5 sq.yds/gal. (0.2 gal/sq.yd.)

NOTES x) Rate depending on width and importance of road.
xa) Sprayed after curing for 7-14 days.
N.T. Not tested.

stones in a six-inch compacted layer of soil cement.

4) The gang had no previous experience of soil-cement construction.

Except at Hatfield in 1946, the base, after curing, was primmed and surface dressed.

Tables Nos. 1 2A and 2B show soil classification, compaction and crushing strength data; table No. 3 records the plant used; table No. 4 is a timing diagram used in 1947; table No. 5 gives an indication of costs.

PROGRAMME OF WORK. 1944.

The first experiment, which was undertaken near Abingdon, Berkshire, was the construction of about two-thirds mile of 16ft. road including two soil-cement sections of total area 3,400 square yards. For half this area the soil was used in situ. On the remainder a low embankment of imported soil was used, part of this being founded on peat some seven feet thick. 1).

Except for a motor grader and a sheepsfoot roller, nearly all the plant was either agricultural or improvised. It was quickly confirmed that although reasonably satisfactory experimental work could be done with this equipment, it would be of limited use in continuous operation on a large cheme. The average and maximum daily processing rates were about 900 and 2,000 sq. yds. respectively.

Lack of modern soil mixers resulted in less efficient mixing than was desirable and unduly lengthened the period between wetmixing and rolling. On the area over the peat subsoil the primed soil-cement was immediately surfaced with tarmacadam and surface dressed in Summer, 1945. This length remains in good condition after over three years service, but part of the remaining area proved less durable. Owing to failure of other adjacent experimental sections, the whole area without tarmacadam was resurfaced with concrete after about 15 months service.

PROGRAMME OF WORK 1945.

On completion of the Abingdon experiment, a schedule of required purpose-made plant was drawn up, particularly for soil mixing and the application of water and cement (see Table No. 3). The new plant, which has been referred to elsewhere 2) was not, however, ready nor was any soil-cement experiment carried out during 1945.

For soil mixing, a pair of 'Seaman' motorised rotary-tillers, of six ft. operating width were ordered, (Fig. No. 1). These have the advantage that the tine: forward speed ratio can be varied - an essential feature with British soils. The machines were delivered in December, 1945 and January, 1947 respectively.

For water application, a 1,000 gallon trailer tanker was used (Fig. No. 2) having an 8-h.p. motor pump and twin spray barrels. The

"Seamans" Motorised "Pulvimixer" rotary soil-mixer. (Mixing water into six foot width of soil cement).

FIG.1

TABLE "2A

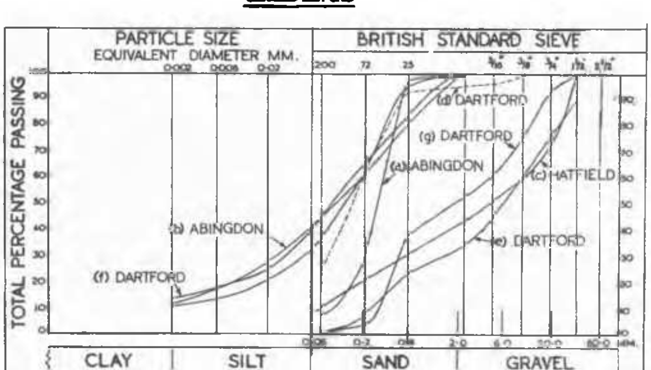
SOIL CLASSIFICATION

Location of Experiment		Abingdon		Hatfield	Dartford 1946			Dartford 1947
Soil Type Reference		(a)	(b)	(c)	(d)	(e)	(f)	(g)
U.S. Engineers' Classification		SC.	CL.	ML.	GC.	GP.	CL.	GC.
British Standard Sieve No. (Cumulative Per Cent Passing) (Typical Gradings)	1½ in.		100	100	100	100		100
	¾ in.		100	72.5	100	100		93.8
	3/8 in.		100	59.8	99.0	61.0		75.7
	3/16 in.	100	100	49.9	96.5	45.0		61.5
	No. 7	99.8	100	44.4	95.5	35.0	100.0	53.5
	No. 25	97.6	82.0	31.0	93.0	24.0	84.0	39.7
	No. 72	31.2	62.0	11.6	65.0	8.0	67.0	3.8
	No. 200	7.7	45.0	8.2	24.0	1,0	45.0	0.8
Silt (0.06 - 0.002 mm)		4.0	30.0	N.T.	N.T.	N.T.	25.0	N.T.
Clay (< 0.002 mm)		3.7	12.0	N.T.	N.T.	N.T.	14.0	N.T.
Liquid Limit		N.P.	29	32	NP	NP	N.T.	NP.
Plastic Limit		-	20	42	-	-	N.T.	NP.
Plasticity Index		-	9	8	-	-	N.T.	-
Average Strength of Soil-Cement Specimens (lb/sq.in.)		421	286	227	615	N.T.	N.T.	260 x
'Dry' Density of Soil-Cement Specimens (lb/cu.ft.)		116	103	108	N.T.	N.T.	N.T.	N.T.

NP - Non-plastic   N.T. - Not Tested.   x Results from tests on soil-cement containing relatively high proportions of clay or chalk.

TABLE "2B

SOIL CEMENT CONSTRUCTION 1944-7 TYPICAL SOIL GRADINGS



latter were superseded in 1946 by a six ft. spray-bar giving a capacity of 160-g.p.m. The machine was fitted with water gauge, and differential pressure gauge calibrated in gallons per minute.

For cement spreading, a commercial firm attempted to modify the gearing of existing

1.000 gallon capacity trailer water sprayer, with 8 H.P. motor pump 6 ft. spraybar piping valves and gauges.

FIG.2

TABLE 3

PLANT USED FOR PROCESSING

OPERATION	EXPERIMENT: Abingdon 1944	Hatfield 1946	Dartford 1946	Dartford 1947
Towing (Crawler tractors)	1. No. D.6 Caterpillar 1 No. Cletrac	1 No. D.6 Caterpillar 1 No. Cletrac	1 No. D.4 Caterpillar 1 No. Ransome (Midget)	1 No.D.6 Caterpillar 1 No.D.4 Caterpillar 1 No.D.2 Caterpillar
Towing (Pneumatic-tyred tractors)	2 No. Fordson		1 No. Fordson Major	1 No. Fordson Major 1 No. Muir-Hill dumper
Pulverising soil; mixing cement and water	1 No. set of disc harrows 1 No. Set spike-harrows. 1 No. Cultivator (tined) 1 No. Ripper 1 No. Plough (four-furrow)	1 No. Ripper 1 No. Cultivator (tined)	1 No. Seamans Motorised soil-mixer 1 No. Rotary hoe (hand steered) 1 No. Plough (single-furrow) x) 1 No. set of Disc Harrows.	1 No. Seamans Motorised soil-mixer 1 No. Seamans Motorised soil-mixer x) 1 No. Ripper 1 No. Plough (two furrow)
Spreading and levelling cement	(hand)	(hand)	(hand)	(hand) xa)
Water-spraying	1 No. Tank sprayer Self propelled 1,000 gallons capacity. motor pump delivering 80 g.p.m. 1 No. auxiliary motor pump for filling tanksprayer at 100 g.p.m.	1 No.Trailer sprayer 1,000 gallons capacity motor pump delivering 200 g.p.m.	1 No. Gulley-emptier 750 gallons capacity motor pump delivering 35 g.p.m. (hand sprayed)	1 No. Trailer sprayer 1,000 gallons capacity motor pump delivering 160 g.p.m. 1 No. Gulley-emptier as 1946
Grading	1 No. Caterpillar motor grader	1 No. Towed grader 1 No. Fordson Major grader x)	None	1 No. Towed grader
Water storage on site	None	1 No. Canvas water dam 1,000 gallons capacity.	(None)	4 No. Canvas water dams each of 1,000 gallons capacity.
Rolling	1 No. Sheepsfoot Tamping roller (club feet)6 tons 150 lb/sq. in Foot pressure. 1 No. pneumatic-tyred roller 6 tons laden 1 No. Smooth-wheeled towed roller 6 tons.	1 No. Sheepsfoot tamping roller (pyramidal feet) 6 tons 180 lb/sq. in. Foot pressure. 1 No. Pneumatic-tyred roller 8 tons laden. 1 No. Power roller 2½ tons.	1 No. three-wheeled power roller 2½ tons. 1 No. three-wheeled power roller 8 tons 2 No. Agricultural ribbed-towed roller	1 No. Pneumatic-tyred roller. 8 tons laden 1 No. three-wheeled power roller 8 tons.
Curing	Water-sprayer	Water-sprayer	Water-sprayer	Water-sprayer
Sweeping before priming	Towed mechanical sweeper (horse-drawn type)	Towed-mechanical broom sweeper	Hand-sweeping	Towed mechanical broom sweeper.
Priming	1 No. Self-propelled tank-sprayer.	None	Brushing by hand from barrels	Brushing by hand from barrels.
Surface dressing	1 No. Bucket loader 1 No Gritter 1 No. Self-propelled tank-sprayer.	None	Hand-spreading Hand-spraying	

Note. Plant shown in italics owned by Ministry of Transport.
x)Used only during part of experiment xa)Mechanical spreader demonstrated on one day.

lime-spreading lorries. These are bulk tankers with longitudinal and transverse conveyor worms, mounted on six wheeled chassis having a capacity of about four tons of cement. Such a machine was demonstrated in 1947, but it is still in the development stage for cement spreading. (Fig. No. 3).

Lime - spreading lorry spreading 4 tons of cement using one main longitudinal worm and two co-axial transverse worms.

FIG.3

PROGRAMME OF WORK, 1946 (a) HATFIELD.

In April, the new plant was used in the formation of 4,800 sq. yds. of base for a concrete carriageway for a trunk road at Hatfield, Herthfordshire. The soil consisted of a silty-clay-gravel with occasional pockets of heavy clay. Attempts to pulverise the soil showed at once that thorough preliminary breaking-up by rippers was necessary if excessive damage to the soil mixer tines was to be avoided. It was also found that wheeled tractors, although sufficiently powerful, could not be run slowly enough for the soil mixer to be drawn over the ground without some loss of tines (Fig. No. 4) This was overcome by substituting a crawler tractor - albeit a less economical arrangement.

In the limited space available for turn-arounds, the fully swivelling front axles of the towed grader and the rubber tyred roller showed to advantage except where reversing was necessary. Largescale site water-storage was not provided as mains were available nearby but one canvas water-dam was tried out. However, with only one sprayer, the time occupied in water carrying and spraying was undesirably long, so that, as at Abingdon, the moisture content tended to be under, rather than over optimum, at times when application and mixing of further water would not have left time for adequate rolling.

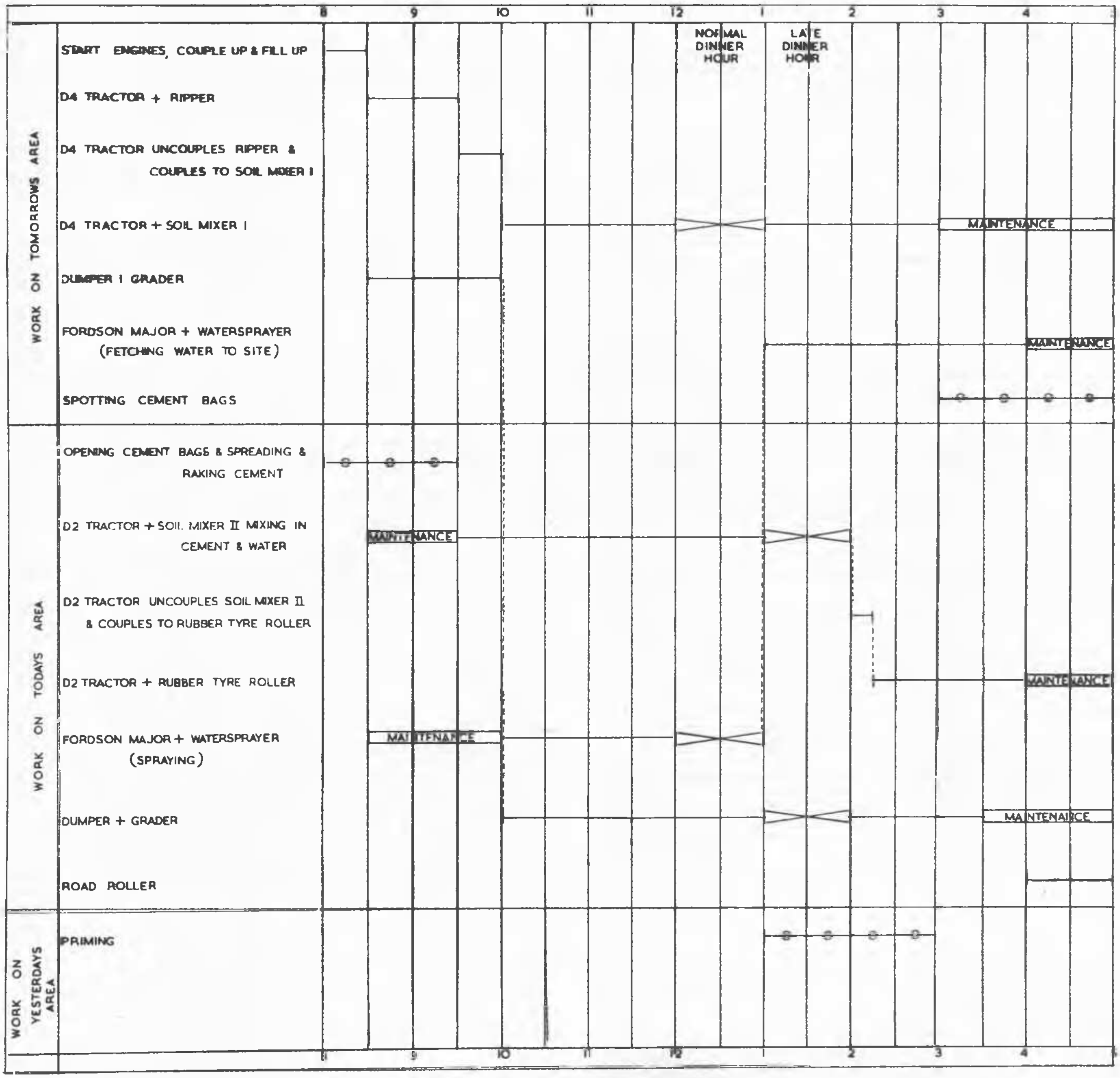
To prevent the sheepsfoot roller from

TABLE 4

BOROUGH OF DARTFORD

TEMPLE HILL NEIGHBOURHOOD UNIT

Soil Cement Stabilised Roads Site No 2 Suggested Time Table of Work



— USE OF TRACTORS (HOURS) —

TRACTORS	FILLING UP	MAINTENANCE	WORKING	DINNER HOUR	COUPLING UP
FORDSON MAJOR	½	2½	5	1	–
DUMPER	½	1½	6	1	–
D4 TRACTOR	½	2	5	1	½
D2 TRACTOR	½	2	5½	1	½

— TEA BREAKS —

TO ENABLE THE NORMAL TEA BREAKS OF

9.0–9.15 & 3.0–3.15 TO BE CONTINUED

TABLE 5

ANALYSIS OF COSTS

(excluding priming and surface dressing)

Scheme x	Abindgon 1944		Dartford 1947		Remarks. (Regarding work at Dartford).
Type of Expenditure	Cost per sq.yd. (shillings and pence)	Percentage of Total	Cost per sq. yd. (shillings and pence)	Percentage of Total	Based on total cost of job at 1,000 sq. yds. per day as against specimen day's cost at 2,000 sq. yds per day.
Labour	1.4d	5.5	3.75	10.4	Larger force and higher rates of pay than at Abingdon.
Plant Hire	7.2d	28.3	1s-5.75d.	49.4	More expensive types of plant used.
Cement and Bags	1s. -4.9d.	66.2	1s-2.5d.	40.2	8% content at 67/-per ton (1947) as against 10% content at 50/- per ton.
Total	2s.-1.5d.	100.0	3s .	100.0	The totals include overhead costs of 23½% as against 13% for Abingdon

x Cost Analyses for the work at Hatfield and at Dartford in 1946 are not available.

Note. These costs, being in respect of experimental work, should be regarded as approximate, when considered in relation to the cost of soil-cement construction on a large scale.

picking up soil between its feet, one initial pass with the rubber-tyred roller was found effective. This difficulty led to the development of a special sheepsfoot roller with variable foot pressures up to 300 lb. per sq. in. It was nine inch pyramidal feet, and a comb to prevent picking up of soil between them. The two drums have an operating width of six ft. to match the soil mixers and water sprayer.

PROGRAMME OF WORK, 1946 (b) DARTFORD.

In the Autumn, an opportunity occurred to demonstrate the Ministry's soil-mixer during the construction of soil-cement roads for a new housing site since constructed at Dartford, Kent. This work has been described in detail by Robertson 3).

The aim was to complete the roads immediately on clearance of the site so as to haul and accumulate building materials throughout the winter. On completion of building, kerbs were to be laid and the levels made up with bituminous surfacing, surface treatment meanwhile being confined to priming and surface dressing.

Tines of soil - mixer showing central level gear and depth control shoe.

FIG.4

Though the soil was sandy, with occasional patches of gravel and over-wet loam, a crawler tractor had to be used for towing the soil mixer slowly enough to prevent shedding of tines, particularly on the gravelly areas.

Largely by use of the 'Seaman' mixer, the average and maximum daily processing rates were 1,000 and 2,300 sq. yds. respectively. Originally, a set of disc-harrows and a small hand-steered soil-mixer with a much lower rate of progress were to have been used. The small mixer was, however, useful for processing at corners which otherwise could not easily be reached.

The 'Seaman' mixer was loaned at short notice and it was not then possible to offer other plant. By its own screeding action it assisted considerably in providing a reasonable surface finish. No grader was available and the correction of longwave irregularities had to be done by hand-raking and a straight edge. Consequently, the final profile was such that the use of a thin bituminous surfacing alone was precluded.

Water was carried in a self-propelled gulley-emptier of 750 gallons capacity spraying being done by hand-operated hose. The rate was controlled on a time-per-area basis, the pump output being about 35 g.p.m. This low output, inadequate even on a sandy soil, was fortunately supplemented by appreciable falls of rain.

As no sheepsfoot roller was used, it was possible to reduce the time allotted for rolling. This enabled the time for completion of mixing to be fixed later in the day than would otherwise have been necessary. Consequently the area which it was possible to process in a day was also increased. A light agricultural roller was used first, then a 2½ ton power roller and finally an 8 ton smooth wheeled roller.

A sound base for constructional traffic was thus obtained allowing building materials to be brought in without interruption even during the severe winter weather conditions. Thereafter, nothing was seen to suggest that the soil-cement was not in as sound condition as when laid, except for an area of 500 square yards where an attempt had been made to stabilise a pocket of sandy loam of high moisture content without gravel admixture. This area failed during the winter and was replaced by lean-mix concrete. By the end of 1947 about 70 % of the building work will be completed and about 40 % of the houses on the estate occupied.

PROGRAMME OF WORK, 1947.

The success of the 1946 experiment prompted Dartford to use the process on two further extensions of the housing site, and a total of 20,000 square yards was prepared for roads in September, 1947, the width to be stabilised being three feet greater than that between kerbs. This time nearly all the Ministry's equipment was demonstrated.

The soil on these extensions was roughly similar to that met the previous year, except for occasional areas of very large gravel and a few pockets of chalky soil or sandy-loam. After several weeks without rain the soil had so dried that water spraying was necessary before the ripper could work efficiently. Subsequently, a plough was substituted and was better able to penetrate the hardened surface layer.

Water from mains was used and, in addition, the gulley-emptier employed the previous year was used every morning. First, it lightly sprayed the area processed the previous day and then kept filled four 1,000 gallon canvas water dams (Fig. No. 5). These were moved along the site every two days, enabling the Ministry's trailer sprayer to draw from them without idle time in travelling. This also obviated uncoupling the crawler tractor as would otherwise have been necessary, as the main could only be reached via a public road. The bags of cement were spaced at the proper longitudinal intervals alongside the area to be processed and stacked according to the number of lanes to be covered. Some pulverising and spraying were done before spotting the cement the next morning, to cut down the time interval between starting to wet-mix the cement and completion of rolling. The bags were then spotted, opened and the cement raked to a uniform depth, empty bags being collected by lorry meantime.

Gulley - emptier shown filling canvas water dams.

FIG.5

With the possession of a pair of soil mixers, the operations were so planned that whilst some plant was occupied on processing, the remainder would be preparing the ground for the next day, to increase the daily output. Unfortunately this proved impossible owing to damage to the bevel gear of one of the mixers before a full progress rate had been built up, but the advantage was demonstrated of not relying on a single mixer, as, even so, a daily output of 1,000 square yards was achieved.

CONCLUSIONS.

The following conclusions are drawn; some in confirmation of those from earlier work elsewhere.

1) The normal methods of mix-in place soil-cement construction are applicable to British soils, but, because of the prevalence of stony and clayey soils, wear on available types of soil mixer is heavy and a larger and more robust machine with more positive control needs to be designed.
2) The number and location of cement works makes soil-cement a potentially economical form of construction in Britain.
3) Spotting cement bags by hand is a reliable method of application, but needs about a dozen labourers per team of plant, especially if the cement has to be double-handed.
4) There is urgent need for the development of efficient cement-spreading devices, capable of spreading 10 % of cement by weight of dry soil in not more than two passes. The vehicle should be served by bulk-supply lorries using hoppers or ramps.
5) When processing involves the use of cement, break-down of plant has a more serious effect on moisture control than when other stabilisers are used. Drying out is more rapid and there may not be sufficient time to spray and mix additional water before rolling must start.
6) Lack of sufficient water at critical times of the day is the most frequent and serious cause of dislocation of the processing sequence.
7) As water supply is a more important factor with soil-cement than with other stabilisers, every possible time-saving device. e.g. instantaneous hose couplings, should be provided in the design of all supply and spraying plant.
8) Formation of junctions between successive days' work needs particular care in soil-cement construction, as correction of mixing faults is not so easy as when stabilisers without a cementing action are used.
9) Except during the period November-February, rainfall is not such a material consideration in drawing up a programme of construction in Britain as had been supposed.
10) For dry-mixing or wet-mixing cement, the soil mixers produced satisfactory mixtures, except with overwet soils, in no more than two passes. Often this was done in a single pass, which would have been quite impossible with disc harrows.
11) Observation has shown that the longer the period during which moist soil-cement is left uncompacted the more difficult does effective rolling become.
12) If sheepsfoot rollers are not used, wet-mixing of soil-cement can be deferred. This shortens the time between spraying and rolling, thus facilitating the latter operation and increasing the area which can be treated per day.
13) As the top surface of sandy soils tends to dry out rapidly, the levels should be kept slightly proud so that the surface material

can be graded to the sides after the first pass of the roller.

14) It is now recognised that bases to be surfaced with bituminous materials must be primed. Thus if the cost of the primer at the site cannot be kept low, cement stabilisation may be uneconomical even though the actual stabiliser is readily available.

15) Soil-cement construction cannot be developed extensively in Britain until an adequate supply of suitable plant is available. This is not the case at present, and, in the absence of existing American plant, the British plant will have to be developed. This involves encouragement of manufacturers which in turn necessitates an increased interest on the part of users. To achieve this, further experiments and demonstrations on the lines described herein will be required.

FUTURE WORK.

Further lines of development include:

1) Demonstrations of the economic value of soil-cement construction.
2) Encouragement of the design of suitable British plant, particularly better soil-mixers with improved control of working depth for dealing with soils having relatively high clay or stone content; also mechanical methods of spreading cement.
3) Use of travel-mixers (when available).
4) Use of the plant-mix method.

SUMMARY.

Given suitable equipment, satisfactory results should be obtainable with all soils of the types used except that for the heavy clay and large gravel without soil binder, found in patches on two sites, it would be necessary either to balance the grading with suitable granular or clayey soil respectively, or to excavate and replace by suitable soil. The four experiments indicate that the use of soil-cement mixtures in Britain promises to provide an economical form of road construction.

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ACKNOWLEDGEMENTS

Acknowledgement is due to Mr.H.E. Aldington, C.B. M.I.C.E. Chief Engineer, Ministry of Transport for permission to submit the paper, and to Mr. H.L. Kerr B.Sc. A.M.I.C.E. Borough Engineer, Dartford for the use of the photographs.

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IX c 4

SOIL STABILIZATION TESTS USED IN GREAT BRITAIN

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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Road Research Laboratory

SUMMARY

In Great Britain a crushing test has found wide acceptance both for determining the suitability of a soil for stabilization with cement and for checking the quality of the processed soil in the field. The reasons for adopting this test are discussed, and its application to the construction to two experimental stabilized roads is described.

The crushing test is made on 4-in. (10.2 cm) cubes compacted to a bulk density and at a moisture content generally determined by a laboratory compaction test. The cubes are cured in a damp atmosphere for 7 days before being crushed.

The data obtained from the experimental roads support general experience that a crushing strength of 250 lb./sq.in. (17.6 Kg./sq.cm) is a suitable criterion for soil-cement in Great Britain. A comparison of the crushing strength of field and laboratory processed soil from one of the experiments using mix-in-place work showed that the efficiency of modern rotary tillers in processing soil-cement may exceed 75% of that of laboratory mixing.

For the waterproofing stabilization of soil the Rapid Water Absorption test and the Capillary Water Absorption test have been developed by the Road Research Laboratory to determine the suitability of soils for stabilization and to check the quality of field processing. In the former test samples are completely immersed and the weight of water absorbed after 16 hours' immersion determined. In the other test the weight of water absorbed by capillarity is determined for periods up to 28 days.