SOIL-CEMENT CONSTRUCTION *

By Glenn J. Mirtl, *General Field Engineer — Portland Cement Association*

WHAT is soil-cement? The "book" definition is as follows: "Soil-Cement is a tightly compacted mixture of pulverized soil, Portland cement and water that, as the cement hydrates, forms a hard, durable, low-cost paving material."

Another definition is that soil-cement is a low current factor, mixed-in-place concrete. This definition isn't exactly right, since soil-cement is not like concrete, even though it looks like concrete when it has hardened. The main difference, is that soil-cement does not have a cement paste as such.

Comparing soil-cement to concrete, it has a cement content of about 2.5 sacks per cubic yard and a water cement ratio around 15 gallons per sack.

An important thing to remember about soil-cement, is that it is a base material, not a surface material. Soil-cement must have a wearing surface of some kind when it is used as a part of a pavement structure. This wearing surface can be anything from a bituminous surface treatment to 9" of reinforced concrete.

Now, let's look a little closer at the ingredients that make up soil-cement, that is water, Portland cement and soil.

The water should be reasonably clean and free from harmful amounts of alkalies, acids or organic matter. Water fit to drink is satisfactory. Seawater can also be used.

The Portland cement can be any type that meets the requirements of ASTM or AASHO

Practically all soils can be used for soil-cement, but some would require a prohibitively high cement content. Sandy and gravelly soils with about 10 to 35 per cent silt and clay and at least 55 per cent passing the No. 4 sieve will usually give the lowest cement contents. As you get to the extremes of all silt or clay, or material with no fines such as beach sand, the cement requirements go up.

Now let's talk about the construction procedure. Briefly, it consists of shaping the road bed, spreading the cement, mixing the cement and soil, adding water and blending it in, compacting, and curing.

First, I will briefly discuss the first and last steps, and then I will show you some slides to illustrate the other steps.

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* Presented at the Town Affairs Meeting of The Connecticut Society of Civil Engineers, Inc., Wethersfield, Conn., November 17, 1964.

Before soil-cement construction starts, the roadway should be brought to crown and grade. Since there is little displacement of the soil during processing, the grade at the start of construction will determine the final grade to a major extent.

As with concrete, the soil-cement hardening process is a chemical reaction between the cement and water. In order for the soil-cement to gain strength, water must be available for this chemical reaction. Any curing material that will seal in the water will work. The most common method, is to use a bituminous material. This is applied at the rate of 0.15 to 0.30 gal. per sq. yd.

Now I would like to show you some slides illustrating the steps in soil-cement construction.

First we have the cement spreading operation. The first slide shows bag cement being used. The bags are laid out in a pre-determined pattern depending on the required cement content. The cement is then spread in transverse windrows, and the windrows are then spread longitudinally.

The next slide shows bulk cement being spread directly onto the roadway. The ideal method is to use a specially constructed cement spreader, but when one is not available, this method works well. The longitudinal windrows left by the bulk truck are easily spread with rakes.

It is very important to get the proper amount of cement spread evenly over the roadway.

The next step is the mixing. For mixed-in-place soil-cement, this is done by one of three general types of mixer.

The next slide shows the multi-pass mixer. It is basically a heavy duty roto-tiller, and as the name implies, more than one pass is necessary to thoroughly blend the cement and soil. With the granular type of soil found in Connecticut, three passes are usually needed.

The next slide shows the flat type single pass mixer. This machine is similar to the multi-pass mixer except that it has four sets of tines and the water is added through the machine. The mixing is completed in a single pass.

The third type of mixer is shown in the next slide. This is a windrow machine. The soil is bladed into a windrow, and the cement is deposited in a furrow left in the windrow. The machine picks up the windrow, adds the proper amount of water, mixes soil and cement and deposits it in a windrow. The mixed soil-cement is then bladed back to crown and grade.

The next step is to add the proper amount of water to bring the mix to optimum moisture. With a multi-pass mixer, the water is added after

the first pass of the mixer. With a single pass mixer, the water is added in the mixing chamber.

The next slide shows the type of water wagon used on many soil-cement projects in Connecticut. If the day isn't too hot or windy, and the soil is quite wet at the start of the day, this type of equipment works very well. If conditions aren't ideal however, the watering operation could be quite difficult with this type of equipment. As an example, if you have a moisture content at the start of 4% and a required optimum moisture of 9%, you will need to add 4 gal. of water per sq. yd. With a daily production of 1500 feet of 24-foot wide road, a total of 16,000 gal./day will be required. This could present quite a problem with a small gravity feed water truck.

The next slide shows a far better piece of equipment. This is a standard asphalt distributor. With this type of equipment, water is not a problem even under the worst possible conditions.

In addition to mixed-in-place soil-cement, we also have plant mixed soil-cement. This is often the most economical method when the project is 100% borrow. It also works very well for city streets with concrete gutter strips and many manholes and catch basins. The next few slides show a plant mixed job in Maryland.

The soil is fed on to a conveyor belt which carries it to a continuous pug mill mixer. Cement is metered on to the soil on the conveyor belt, and water is added by a spray bar in the mixer. The blended soil-cement mixture is fed into dump trucks which take it to the site, and it is spread with a stone box.

The next operation is compaction. The soil-cement mixture must be compacted at least to 95% of Standard Proctor Density. This is rarely a problem in Connecticut, with densities normally running about 100%. I have seen them as high as 120% of Proctor.

With the stony soils generally encountered in Connecticut, at least the first pass should be made with a steel wheel roller. This will drive the stones down and give a smoother finish.

The following slides show some of the rollers that have been used in Connecticut.

First we have the 12-ton three-wheel roller. This is my favorite type of roller for soil-cement, but it is showing signs of becoming extinct.

Next, we have the tandem steel wheel roller, which is more easily obtainable. This will do a good job, but tends to get stuck in loose material on steep grades.

The third type that has been used in Connecticut is the pneumatic tired roller. This will give good compaction quite rapidly, but as I mentioned earlier, with many soils a first pass with a steel wheel roller is needed for a smooth finish.

Another type of roller used for soil-cement, is the sheeps-foot. This is very useful with heavy soils, but would be of doubtful value with most soils used in Connecticut.

Plate vibratory compactors are also used on soil-cement. These work very well with clean sands.

After compaction is completed, any minor grading that is needed is done, and the soil-cement is ready for curing. The cure coat should be applied as soon as practical, since the road must be kept wet until it is applied. The usual practice is to apply the cure coat after completing two or three days' work.

In closing, I would like to make a few general comments about soil-cement.

First, I wish to remind you that soil-cement is a base material, and must have a wearing surface applied.

A question I am often asked, is when may the road be opened to traffic. Light traffic may use the road as soon as compaction is completed. Heavy truck traffic should be avoided for a week if possible. Light traffic can be maintained all through construction, and usually is.

Another question often asked is what do you do if it starts raining during construction. I usually let it rain. Light rain causes no harm, except that you may feel a little foolish running the water truck with it raining. Heavy rain usually causes a little excitement, but rarely hurts the soil-cement. If a heavy rain starts while cement is being spread, it should be mixed in immediately. If its starts just as optimum moisture is reached, it should be rolled with all available equipment, including trucks. After compaction, rain will do no harm.

The first question I am usually asked about soil-cement, is how much does it cost. This is a hard question to give a specific answer to, since the cost depends on many things. Since the cement is the most costly item, the required cement content will have a big effect on the cost. Another factor, is whether the work will be done by Town Forces or by a contractor. Other items affecting cost are the size of the job, whether or not the existing soil is to be used, water requirements and available equipment.

To give you some idea of cost, I have the costs for four of the projects done in Connecticut by Town Forces. They varied from $0.71 to $0.96 per sq. yd. These costs do not include the soil, but do include all materials,

equipment and labor for the 6″ soil-cement, including the bituminous seal coat.

The only job done in Connecticut by a contractor, was Leroy Avenue in Darien which was done in 1962. There were eight bidders, with prices ranging from $1.25 to $2.14 per sq. yd. These costs include all of the soil as well as the seal coat with stone chips applied. The contractor that got the job, bid $1.66 per sq. yd.

I also have cost figures for several projects done in Maine between 1940 and 1961. The average cost of 5 projects done by Town Forces is $0.81 per sq. yd. These were all quite small, ranging from 1650 sy to 2100 sy. The average cost of 4 projects done by contractors is $0.91 per sq. yd. These were larger projects, ranging from 7000 to 48,000 sq. yd.

If any of you in Eastern Connecticut have a specific project in mind for soil-cement, I would be very happy to sit down with you and make a cost estimate. For those of you in Western Connecticut, I am sure that Dick Hansen will be willing to do the same thing.

I would like to leave you with this thought; soil-cement will give you a high quality long lasting rigid base for low cost, using sub-standard local materials.

I thank you.