USE OF SOIL-CEMENT FOR PATCHING PAVEMENTS IN NORTH CAROLINA

By L. D. Hicks, *Senior Materials and Testing Engineer, North Carolina State Highway and Public Works Commission*

SYNOPSIS

The use of mixtures of soil and portland cement for patching failures in pavements, especially flexible pavements, has proved to be a successful method of pavement repair. Failures in flexible type pavements are in most cases due to inadequate subgrade support and occur in more or less small, isolated areas. Satisfactory repair requires that the unstable subgrade soil be removed to some depth and replaced with more stable material, which generally is granular soil. When properly done, this method is quite satisfactory, but there are many instances where improper workmanship, inadequate design, or the use of unsuitable materials result in a recurrence of the failure.

The labor cost of repairing failures due to unstable subgrade is costly as the excavation is done by hand. Any method that reduces the amount of excavation necessary will reduce the total cost per square yard of the patches. The slab strength possessed by soil-cement mixtures when compacted and allowed to harden serves to reduce considerably the unit pressure applied to the subgrade by surface loads. This allows the removal of much less subgrade material and consequently reduces the cost where much depth of excavation is necessary. This fact together with the dependability of the method has been the cause of much use of soil-cement for patching in North Carolina.

Pavement repair is a maintenance problem of some magnitude and requires a knowledge of pavement design and strength of materials for its successful and economical solution. Patches should be designed with the same care as pavements. Failure to do so often leads to failure of the patch which is a waste of money and materials. This paper is not a treatise on pavement design, although some of the fundamental principles are mentioned that in the opinion of the writer should be given consideration in the design of patches for pavements. The use of soil-cement as a patching material is advocated only as a material which has been found to meet certain requirements in North Carolina.

PATCH DESIGN

Whether repairs are to be made to a flexible or rigid type pavement, the cause of the failure must first be determined before a patch can be properly designed. Inadequate subgrade support is probably the cause of most pavement failures. Patching pavements over such areas requires that the supporting power of the subgrade be increased or that the load transmitted to the subgrade be decreased. The supporting power of the subgrade may be increased by treatment or by removal and replacement with stronger material. The load transmitted to the subgrade may be reduced by increased thickness of the flexible pavement, base or sub-base or by the use of a patch possessing appreciable slab strength which will distribute the applied load over a wide area of the subgrade. Generally rigid pavements are patched with rigid paving materials and flexible pavements with flexible materials.

In designing a rigid pavement patch there are two fundamental facts that must be considered, that the strength of the slab varies with the square of its thickness while the pressure on the subgrade is reduced only by increased area. A small patch may be strong enough to carry the load without breaking but failure of the subgrade could occur due to concentration of pressure over the small area, resulting in settlement of the patch. It is necessary, therefore, in many instances to make the patch larger than the failed area or to increase the supporting power of the subgrade by treatment of the existing soil or by removal and replacement with stronger material. The smallest dimension of a rigid pavement patch should never be less than 4 ft. unless the subgrade has been previously treated to support the concentrated load. Deviation from this rule has caused failure of many rigid patches.

In the design of a patch composed of flexible paving materials, the engineer is concerned with the supporting power of each layer of material and of the subgrade. A flexible pavement generally consists of a surface layer and a base layer. The surface layer is usually a bituminous pavement while the base may consist of selected soil, crushed stone, gravel, sand, or other granular materials bonded with finer soil material or bituminous material. Although layers of these materials may possess some slab or flexural strength, it is small, and is ignored in flexible pavement design. The supporting power of layers of these materials is dependent upon the shear strength of the material of which each layer is composed, and is likely to be different for each material. Pressure applied on the surface of a flexible layer is distributed through the layer in the form of a cone, so that the unit pressure at the bottom of the layer is less than at the top. The thicker the layer, the greater is the reduction of the unit pressure. The exact angle of distribution is a moot question and probably varies with materials, but a design based on an angle of 45 deg. with the vertical is used by many designers.

Knowledge of the bearing capacity or ultimate supporting power of layers of flexible paving materials will enable the engineer to design a flexible pavement or patch with some degree of certainty. The exact value of the bearing capacity is rather difficult to ascertain, but a safe assumption can be made if based on experience and sound judgment. The bearing capacity of the bituminous pavement surface is generally adequate to support the surface loads if it receives adequate support from the base and subgrade. Its stability is controlled by the type and grading of the aggregates and the quality and amount of the bituminous binder. A sufficient thickness of surfacing must be used to reduce the surface pressure to the bearing capacity of the base, while the base must be of sufficient thickness to further reduce the pressure to the bearing capacity of the subgrade. When all of these factors are balanced, an economical and adequate pavement structure is assured.

USE OF SOIL CEMENT

Patching pavements that have failed due to inadequate subgrade support consists of the removal of the old pavement and the subgrade to some depth and their replacement. Since failures generally occur in small isolated areas, much of the work such as removal and replacement of the subgrade is done by hand. Hand excavation is expensive and may be the greatest cost of the operation, so its reduction is economical if it can be accomplished without danger to the replaced pavement. Since the reduction of pressure through flexible layers is a function of their thickness, it is necessary to excavate to a predetermined depth when they are used. A relatively thin rigid layer of sufficient strength and area will also accomplish the same result, so it is possible to effect a saving by the use of a rigid layer, especially if cheap materials may be used in its composition.

Compacted mixtures of soil materials and portland cement produce a hard, rigid mass of appreciable slab strength that is hardly affected by water. They have been used successfully for several years in the construction of bases under the name of "cement stabilization." Soil-cement mixtures may be used to produce the rigid layer referred to as the material cost of this type of work is relatively low when compared to that of concrete. Usually a layer, 6 in. thick, is sufficiently strong to reinforce unstable subgrades, however, greater thicknesses are used in some cases.

PATCHING PROCEDURE

When soil-cement mixtures are to be used for reinforcing unstable subgrades beneath flexible pavement patches, the old pavement and 6 or more inches of the subgrade are first removed. If the base of the old pavement consists of satisfactory material such as topsoil, sand-clay, crushed stone, or gravel, the material is salvaged for use in the patch. The soil-cement mixture at the proper moisture content is then spread over the subgrade in layers not exceeding about 3-in. thick and each layer thoroughly tamped by hand or mechanical tampers. This operation is continued until the total compacted thickness of the soil-cement layer is at least 6 in. This operation should be conducted in such a manner that setting-up or drying out of the individual layers is prevented before the

Figure 1. Removing old pavement and subgrade. The rigid pavement was broken with pneumatic tools, but subgrade was removed by hand.

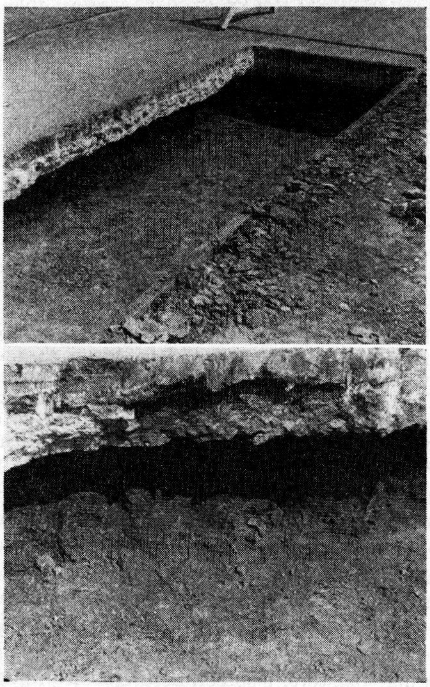

Figure 2. Old pavement and subgrade removed. Slab was under-cut to allow spreading of foundation. Note type of subgrade material—a tough, plastic clay of the Iredell Series.

next layer is spread and compacted. After the soil-cement layer has been completed, the base course material should be spread over it and compacted in the same manner. Light traffic may use the patch immediately, but very heavy traffic should be excluded for about seven days. The surfacing may be placed over the base at any time after complete consolidation has taken place.

The foregoing procedure affords protection to the soil-cement layer from the harmful effects of traffic and at the same time allows the layer to cure under the best possible conditions. The procedure also causes minimum inconvenience to traffic. Another attractive feature is the fact that flexible materials are used throughout, except in the sub-base, and the patch will have all of the characteristics of the adjacent flexible pavement.

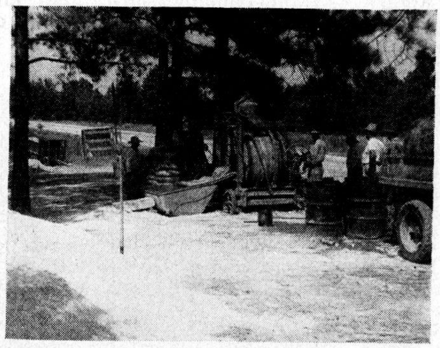

Figure 3. Mixing soil and cement. Soil stockpile in left foreground is disintegrated sandstone.

It is not necessary to confine the use of soil-cement mixtures to the sub-base portion of a flexible pavement patch. An old flexible pavement that has been well consolidated by traffic can be patched using soil-cement mixtures as the base material. It is advisable, however, to increase the thickness of the bituminous surfacing to compensate for the rigidity of the soil-cement base. It may be advisable to increase the minimum thickness of the base from 6 to 8 in. in some cases. The same procedure is used in constructing the soil-cement layer, except that it should be surfaced with a thin bituminous mat before traffic is allowed on the patched area. This prevents damage to the base due to abrasion and prevents excessive drying out.

Old rigid pavements that are to be resurfaced with a bituminous wearing course cost was $5.55 per cu. yd. or $0.46 per sq. yd., making the total cost of the rigid patch, less excavation, $2.75 per sq. yd.

CONCLUSION

Soil-cement mixtures have not been used in patching pavements over the entire State, although their use would have proved more economical in several instances. The availability of excellent sand, sand-clay, and gravel in certain localities, together with fair subgrade conditions, makes their use more economical than soil-cement mixtures. In certain cases, however, it has been necessary to reinforce the worst subgrades in these localities with soil-cement mixtures before the patches would hold. Weight and volume of traffic has also been a governing factor. In areas where the traffic is light, the use of good granular materials has been quite successful and economical.

The use of soil-cement mixtures in patching is advocated only when their use is more economical than other materials or when a very dependable material is desired. In areas subjected to traffic which consists of some heavy vehicles and where subgrade conditions are bad, its use will be found to be quite satisfactory and economical.

SOME WARTIME SOIL-CEMENT CONSTRUCTION EXPERIENCES

By Miles D. Catton, *Manager, Soil-Cement Bureau, Portland Cement Association, Chicago, Illinois*

SYNOPSIS

The application of soil-cement to war projects on the North American Continent began in the summer of 1940 with the construction of 330,000 sq. yd. of taxiway and runway widening at Camp Borden, Canada. It was followed with an increasing number of military projects in the United States, the largest of which consisted of a landing mat 355 acres in area built by the Navy in the fall of 1942. Included in military activities were training schools and demonstration field projects for substantial numbers of U. S. Army Aviation and Airborne Aviation Engineer units, Seabee Battalions and Marine Aviation Engineer units.

At the request of the Office of Chief of Engineers, U. S. Army; Bureau of Yards and Docks, U. S. Navy and of individual officers of the Army and Navy responsible for the construction of individual projects and the training of troops, the Portland Cement Association cooperated on the work undertaken in the United States. This cooperation included laboratory testing work, construction supervision assistance, the preparation of special tests and training manuals for military use and assistance in conducting training schools. This close association with the laboratory and field work has given the Portland Cement Association first hand information on the accomplishments and developments in the use of soil-cement by the Army and Navy in the United States.

As would be expected, the Army and Navy successfully built projects under soil and weather conditions never attempted previously. They built paving projects of a magnitude that pleased even the pre-war dreamer. They developed construction procedures and equipment in a matter of days that would have required months or even years under previous peacetime conditions. Most important of all, it was demonstrated repeatedly that the simplicity of soil-cement construction operations permitted construction to proceed at speeds unheard of in previous paving experience. Daily construction of 20,000 to 30,000 sq. yd. of soil-cement became commonplace.

A brief review of the highlights of the Army and Navy experiences with soil-cement construction is of value to the paving engineer in planning and executing his work. In the following summary, details are given of construction procedures, equipment and accomplishments on some of the more important projects. Also, some of the unusual weather and subgrade conditions encountered on some jobs are described together with results obtained.