UNTREATED SURFACES OF SAND CLAY, CHERT AND GRAVEL

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At the request of the Chairman of the Committee on Low Cost Improved Roads, the writer attempts to present herein a brief summary as to the experience of Georgia in the construction, maintenance, serviceability, and salvage of sand clay, chert, and gravel surfaces.

The subject given me is quite a broad one, but I will undertake to discuss each of the three classes of surfacing material under the following topics:

Materials
Methods of construction.
Costs of construction and maintenance.
Serviceability, and salvage value.

SAND CLAY SURFACES

1. *Materials.* In the construction of sand-clay and top-soil surface courses, it is necessary that carefully selected materials be used in order to insure a smooth, well compacted and easily maintained surface These materials must have a proper grading of the small aggregates with the correct amount of adhesive clay. They are classed as a mixture of loose aggregates wherein the larger sizes and particles (sand and gravel) have a stability due chiefly to mechanical interlocking, or bond, and wherein the finer particles (silt and clay) increase that mechanical stability by filling voids, and by greater or less adhesion, usually with the aid of moisture, to the larger particles.

Sand clay and top soil should conform to the following specifications:

	Percentage
Clay	12-25
Silt	0-30
Total sand	60-80
Sand above No 60 sieve ..	45-60

The detailed classification, percentage limits, and methods of laboratory analysis are to be found in the United States Department of Agriculture Bulletin, No. 559, and University of Georgia Bulletin, Volume 22, No. 5-a.

Coarse material above a No. 10 sieve in amounts greater than 10 per cent distinctly increases the stability and durability of the sur-

face. This coarse material is most effective when present in graded sizes from one inch downwards

2. *Methods of Construction* The methods of construction of this type of road have so frequently been discussed that I will touch on them only very briefly

The sand clay or top soil is placed on the prepared subgrade in one layer 18 to 24 feet wide, and varying in depth from 12 to 14 inches, depending upon the desired compacted depth. At the present time we are building in most cases a 30 foot road which contains a compacted depth of material of 9 inches in the center, 7½ inches at a point 9 feet from the center, and then sloping down to approximately 1-inch at the edge. This gives a crown of 1/6 of an inch per foot, which has proved satisfactory

The loose material is spread on the subgrade and thoroughly mixed by harrowing, and then shaped up with the aid of a road machine, so as to conform as nearly as possible to the finished cross section when compacted Consolidation is effected by the construction teams and trucks, and by traffic. This should proceed from the bottom toward the top if a dense slab is to be secured Wet weather and a puddled mass of fresh surfacing material usually results in a dense and well compacted slab The process of compacting and shaping requires frequent use of a heavy road machine The work of the road machine is carried from one ditch to the other and establishes the final shape and crown.

3 *Costs of Construction and Maintenance* The average cost per mile for a sand-clay or top-soil surface is approximately $1650. This is based on an average price of 50 cents per cubic yard, compacted measurement, and the typical cross section as given above. Variations in this price are usually due to increased haul on materials resulting from scarcity of pits In most cases the surfacing material can all be secured within a one mile haul; however, in some few sections of our state acceptable pits are located widely apart and in such cases the price will increase to 60 or 70 cents per cubic yard

The annual cost for maintaining the surface of sand-clay and top-soil roads varies from $140 to $220, with an average figure of about $170 This figure does not include cleaning ditches and culverts, grass planting, and other items incidental to the right-of-way as a whole, but includes only the necessary work relative to the surface itself. These maintenance figures should show a wider variation, but owing to the fact that the highway laws of Georgia have a uniform distribution clause for maintenance, it is not usually possible

to exceed $200 per mile To secure the best efficiency it is felt that the average yearly maintenance figure should be between $200 and $225

4. *Serviceability.* Well selected sand-clay and top-soil road slabs return a rather surprising life period when serving under traffic densities of 400 vehicles per day, and less. On roads carrying less than 400 vehicles per day we have found that the average loss of material is usually *less than 1-inch per year* This means that a 9-inch slab should serve satisfactorily for a period of from 6 to 8 years. Of course, after the slab thickness is reduced to 2 or 3 inches there is evidence of breaking and cutting through and extensive replacement or reconstruction is necessary

This type of road gives a better service than is generally recognized Under traffic conditions, as outlined, a well maintained sand-clay surface will remain smooth and firm in wet or dry weather In extreme dry weather there is some annoyance due to dust, but the better graded and coarser mixtures do not present a serious dust problem

It has been found inadvisable to construct sand-clay and top-soil roads where the traffic exceeds 400 vehicles per day In such cases the surface becomes potty and corrugations appear very rapidly, and it is extremely difficult to maintain a satisfactory riding surface

5. *Salvage Values* The salvage value or worth of these slabs rests in their ability to bring about a highly stabilized subgrade for future pavements In stage construction they serve well as the first betterment for important roads and later bring a substantial supporting stability and increased life to the pavements that rest on them The salvage value of these slabs as subgrades under pavements is of material worth in that they have three distinct merits:

(a) A uniform and well-established initial supporting value under the pavement.
(b) A more or less porous structure not easily softened by water and one not conductive to capillary lift from the subsoil below.
(c) Lack of expansion under frost.

CHERT SURFACES

1. *Materials* The northwestern part of our state supplies abundant amounts of local chert, which makes an excellent surfacing material for medium traffic roads. This material although bordering on limestone, has been found by chemical analysis to be largely amorphous silica.

Natural chert occurs in heavy deposits, varying in depth from 5 to 50 feet. The material usually contains about 60 per cent rock in sizes up to a cubic foot, and, naturally, must be crushed before it is used It has been found that the finer this material is crushed the better will be the surface slab

Our specifications for chert surfacing call for all the material to pass a 1½-inch screen and at least 60 per cent must be retained on a 10 mesh sieve The material passing the 10 mesh sieve is known as binder, and its composition must be as follows

	Percentage
Clay	20-40
Silt	10-30
Total sand	30-60
Sand above No 60 sieve	20-40

Chert is quite different from gravel and other materials with true clay binder Although the material called "clay" in chert meets the requirements as to size, etc, for clay, it is, in fact, amorphous silica The large percentage is necessary to secure good binding value and with the presence of moisture it is non-swelling

2 *Methods of Construction.* The methods of construction are much the same as for a sand-clay surface except for mixing of materials and shape of cross section The material as it comes from the crushing plant represents a well graded and well mixed material. The chert surfacing is usually placed 19 feet wide with a uniform, compact depth of 8 inches The subgrade is given a crown of ¼-inch per foot Wooden side forms are used and are laid to correct line and grade The use of a templet is recommended in this type of construction As soon as the chert slab is sufficiently consolidated and shaped to the correct cross section the side forms are removed and suitable shoulder material placed next to the chert surface A heavy road machine is necessary during the process of shaping and consolidation.

3. *Costs of Construction and Maintenance* In most cases chert can be secured locally, in which case the average cost per mile for this type of surfacing is about $7000. In some places there is no available chert and it must be shipped in, in which case the average cost per mile is about $10,000

The annual cost per mile for maintaining the surface of a chert road in our state has been approximately $150 This figure does not include any appreciable replacement of material It includes such items as machining, scarifying, and patching We have found that it is very difficult to maintain a smooth surface if the chert is allowed

to contain material larger than 1½-inch in size. In fact, on some of our work we have required that all material should pass a 1-inch screen and as a wearing surface this material gives, by far, the best results It is very desirable that this class of material contain a large amount of material near the ¼-inch size It usually happens in crushing the chert that a large supply of such fine material will result. This material is very helpful in keeping a smooth surface, because in machining the surface a small cover of loose material can be worked back and forth across the slab, filling whatever small depressions are present.

4. *Serviceability* We have found this class of road to be well adapted to traffic up to 1000 vehicles per day Chert roads serving an average of 800 vehicles per day will lose from ½ to ¼ of an inch of slab thickness per year. This loss of materials is not always dependent on the volume of traffic, however. Several forces have a part in reducing the thickness of the slab, such as rain, wind, constant machining, and occasional scarifying The presence of dust on our chert roads is more noticeable than on coarse sand-clay roads, due to the fact that the binding material contains a greater percentage of fines The surface itself is usually quite smooth except in those cases where the material is not crushed fine enough

The average life of a chert slab is about 12 years, without heavy replacements.

5. *Salvage Value.* The salvage value of a chert surface can usually be roughly figured by deducting from the first cost per mile the sum of $500 for each year of service This sum represents the loss of about ½-inch of material per year. This means that a chert road with an initial cost of $7000 per mile would have a salvage value of approximately $4500 per mile at the end of 5 years of service

In Georgia where the slab thickness has been reduced to the point where the slab tends to break and cut through (usually about 3 inches) it is brought back to its own original thickness If traffic has increased to such an extent that the chert slab will not serve successfully it is usually our practise to use it as a base course for a 3-inch penetration macadam top. This form of stage construction has proved very economical and in the end has given us a pavement which served very well under all of our traffic conditions

GRAVEL SURFACES

1. *Materials.* Two general classes of gravel are to be found in Georgia Along the fall line running east and west through the

state, there is a belt where sedimentary deposits of gravel may be found. These gravels contain well rounded quartz pebbles up to 2 inches in size although usually the material will pass a 1½-inch screen. This material is found naturally mixed with a good sand-clay binder, similar to that of a good sand-clay surface. It is considerably different from the glacial deposits in the central and western part of the country and depends entirely on the sand-clay material for its binding qualities

Concretionary gravels are found in a large portion of southwest Georgia; their composition is mostly silicate of iron These gravels rarely contain material larger than 1-inch in size and have wonderful binding properties due to their iron content

We have found that it is impossible to secure satisfactory results by trying to secure gravel roads which contain as much as 50 per cent material retained on a ¼-inch screen The sand-clay binder is not sufficiently strong to satisfactory hold this much gravel together Our specifications for gravel roads call for the following composition:

All to pass 1½-inch screen
At least 40 per cent retained on ¼-inch screen
At least 50 per cent retained on 10-mesh sieve

The material passing a 10 mesh sieve is known as binder and its composition must be the same as for sand-clay roads except the clay content, which should be from 15 to 30 per cent

2. *Methods of Construction.* The subgrade is given a crown of ¼-inch per foot and the gravel is placed 19 feet wide with a uniform consolidated depth of 8 inches. Wooden side forms are used and set to correct line and grade. These are removed and shoulders are built as soon as the gravel surface has taken the proper shape, and is thoroughly consolidated. An important point in the construction of gravel and chert roads is that the material must not be allowed to become consolidated without being shaped to a true cross section. Machining will not rectify an improper cross section. Scarifying and reshaping are necessary if the shape of the road surface is to be materially changed. The use of a heavy road machine is necessary during the period of shaping and packing.

3. *Cost of Construction and Maintenance.* Where local gravel is available, the cost of construction for a standard gravel road is about $6000 per mile. As the gravel deposits in our state are rather limited, most of the material must be shipped in. In this case the cost per mile for construction is about $10,000. Where local deposits of con-

cretionary gravel are found the usual cost of construction is about $5000 per mile.

The average cost of maintenance is about $200 per mile This figure does not include any replacement of material Maintenance costs on gravel roads usually run a little higher than for chert roads, due to the difference in the binder The presence of dust is not very marked, due to the coarseness of the binding material

4 *Serviceability.* Well constructed gravel roads serve well where the traffic does not exceed 1000 vehicles per day. Frequent machining is always necessary, however, to keep the road surface free from corrugations and irregularities We have found that by increasing the clay content of the binding material the gravel slab will tend to corrugate less When the traffic exceeds 1000 vehicles per day, it is difficult to keep a smooth uniform surface We have not found it advisable to construct gravel roads where traffic amounted to more than this amount.

Recent research studies in our state have demonstrated the fact that a gravel slab is reduced in thickness about ¾ of an inch per year. This amount of loss varies, depending upon the quality and adhesiveness of the clay At the present time we have no means of definitely determining the relative adhesiveness of various clays and we are unable to distinguish between them Most of our own clays give good results, but a means of securing an index of their binding value is needed

5 *Salvage Value* The loss of ¾-inch of gravel surfacing per year means the loss of approximately $1000 per mile For this reason, we have found it advisable and economical to surface treat our gravel roads as soon as possible after completion The salvage value of one of our gravel roads can be computed by deducting from its initial cost per mile the sum of $1000 per mile for each year of its service

It is our practise to use the 8-inch gravel slab as a base either for surface treatment or a 3-inch penetration top in case the amount of traffic warrants it.

RESEARCH DATA

The State Highway Department of Georgia in cooperation with the Bureau of Public Roads, has just completed an important research project dealing with the economic value of sand-clay roads This report is to be printed shortly and those engineers interested in the details of this subject will be able to avail themselves of that information.