Table No. I.
Total Annual Cost of Transportation in Dollars Per Mile.

(Assuming 90% of tonnage is automobile and 10% truck. 50% of trucks on pneumatic tires, and 50% on solid tires.)

Annual Traffic in Tons	36,000	90,000	180,000	270,000	450,000	640,000
Ordinary Earth	4,672	11,411	22,524	-------	-------	-------
Best Earth	4,520	10,718	21,049	31,328	52,043	-------
Ordinary Gravel	4,761	11,016	21,442	31,868	52,718	126,000
Best Gravel	4,649	10,434	20,056	29,711	48,992	97,182
W. B. Macadam	6,166	12,597	21,171	31,691	51,325	100,319
Bit. Macadam	6,391	12,033	21,413	31,162	49,577	96,507
Sheet Asphalt	5,635	10,951	19,812	28,674	46,393	90,702
Asph. Concrete	5,633	10,947	19,804	28,661	46,373	90,648
Av. P. C. Concrete	5,253	10,563	19,415	28,266	45,967	90,225
Best P. C. Concrete	5,011	9,958	18,204	26,451	42,941	84,173
Vitrified Brick	5,682	10,990	19,843	28,696	46,395	90,648

Editor's Note: A more complete presentation of this subject including several diagrams and tables will be found in an article by Professor Agg in the "Engineering News-Record" of January 10, 1924.

DEVELOPMENT OF HIGHWAY SURFACES.

By C. M. Upham,
Chief Engineer, North Carolina Highway Commission.

In North Carolina every attempt has been made to immediately apply the results of research. Almost every step in construction is being studied in detail and when anything of value is discovered, it is immediately applied to construction on a large scale.

Possibly the road that can be considered as the most important in road building and the one that gives the best road service is the one that is termed the development road. A community usually undergoes a rapid development immediately after roads are constructed. In some communities this development does not take place for several years and in others it takes place immediately after the roads are improved. Therefore, the development roads, regardless of what type is selected, must be constructed in such a manner that they may be improved to the next higher step of road construction, so that when the communities develop it is possible to better the road without losing that part of the road that is already constructed. Progressive type roads take care of this feature.

In many states development roads are being constructed largely from local materials. In North Carolina the sand asphalt roads are becoming one of the chief development roads. This road is being constructed in the communities where there is an abundance of sand. A road of this character contains approximately 92 percent sand and 8 percent asphalt; therefore, 92 percent of the road is of local material. This road is being constructed single and double track at a cost of $1.38 per square yard to $1.90 per square yard. Hard surface roads in these communities would cost from $2.80 to $4.50 per square yard. The public is receiving a road service at a comparatively low cost and is getting just what it needs for the present.

In another locality in North Carolina, where there is no stone for road aggregate, there is an underlying strata of marl rock. This rock is the result of a large deposit of shells. While this deposit must have at some time been on the seashore, at the present time it is some 8 or 10 miles from the ocean and is about 4 or 5 ft. below the swamp. This marl rock is being quarried and crushed and is furnishing an excellent base for a sand asphalt surface. While the details of this construction were taken from earlier road work, still the use of this marl rock means the practical application of investigative research.

Another important application of research work is in the construction of stone veneer on earth roads. In the south there is an exceptionally large mileage of earth roads, consisting mainly of sand clay, topsoil and gravel types. The bearing power of these roads is high and the strength is great. There is still a great problem surrounding these roads, since they offer very little resistance to abrasion, and have with them the dust problem as well. Thus, the problem in this particular instance is to secure some means of protecting the surface against abrasion and to abate the dust nuisance. This seems to have been found in the stone veneer surface where the quality of an asphalt wearing surface is combined with the strength of an earth road. There have been several attempts made in applying bituminous material to earth roads. These in general have been unsuccessful, due to the fact that if the bituminous material was sufficiently light to penetrate the surface, it had no binding power or strength whatever, and if the bituminous material was sufficiently heavy to have a binding value, it would congeal on the surface and peel off, due to the fact that a dust mat was formed underneath the bituminous material. This problem seems to have been answered by applying a layer of stone of approximately 3 inches in size to the earth road surface and rolling it partly into the surface, after the surface has been scarified or loosened; and then penetrating the top of the stone with bituminous material of a consistency to give sufficient strength to hold the material in place and afford resistance to wear. This bituminous material is then covered with proper sized stone and rolled and opened to traffic. The stone is held in place from below by the earth road and has become an integral part of it. The bituminous material holds the stone in place on the surface and affords a resistance to traffic abrasion. Thus, we have a combination of the strength of an earth road and the wearing qualities of an asphalt pavement. This again is the practical application of research work.

Editor's Note: A more extensive discussion of this subject will be found in an article by Mr. Upham in "Engineering and Contracting" issue of January 2, 1924.