Texturing of Concrete Pavement

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Preliminary work by California on texturing of concrete pavements is described. The problem has resolved into two general areas: securing adequate texture during construction, and maintaining texture, as built, by using materials and construction practices that insure durable surface mortar.

Various texture patterns were formed into the surface of laboratory-cast slabs using a variety of prototype devices. Skid tests were performed on these slabs. A promising pattern was selected and used on short sections of three freeways. Some of the results were disappointing. A uniform texture over a large area could not be achieved because of varying mortar properties. It was also discovered that the pattern selected, when formed too deeply, caused an adverse reaction by some vehicles. Additional work is planned using other texture patterns.

Other surface treatments included broadcasting of slag and selected coarse sand particles on the surface while dragging with burlap, and brooming. Skid tests are being performed on a periodic basis, but it is too soon to draw conclusions regarding the long-term skid resistance as affected by traffic and weather.

New curing compounds and so-called surface "hardeners" were applied to short test sections of freeways in an attempt to improve mortar durability. Laboratory tests previously performed indicated that some improvement could be expected from the use of better curing compounds and hardeners. Again, these test sections have not been in service long enough to form any conclusions regarding their effectiveness.

Planned future work includes a continuation of texturing studies, a search for effective surface treatments, a study of field practices that affect surface mortar quality and texture, and additional work on grooving of older pavements to obtain or restore adequate skid resistance. Specifications will be developed as work progresses to improve character and durability of the surface texture.

•THIS paper specifically covers the activities of the California Materials and Research Laboratory on texturing and surface treatments of concrete pavements, as a part of a larger overall project on skid resistance.

The problem of poor skid resistance of some of our concrete pavements has naturally led to the examination of surface textures. The problem seems to resolve itself into two parts: getting the desired texture and maintaining it. The tools developed and the work done so far have not resulted in an ability to adequately describe the best overall texture needed. To get started, we did some preliminary work on determination of factors that affect the surface abrasion resistance of concrete.

In tackling the first part of the problem, that of getting a desired texture, we asked some specific questions. Assuming you can get any texture you want, what texture pattern is best? Is there one general pattern that is superior? Or, are there many that are adequate?

Why are present texturing procedures inadequate? First of all, we think today's high volume of traffic tends to wear down texture at a more rapid rate. Higher speed of the traffic contributes to faster wear. We also believe that some texture is lost because we now permit traffic on many new pavements very early as compared to previous practice. The quality of the surface mortar, in some cases, is apparently not good enough to withstand the high traffic density and the early use, or whatever else contributes to its disappearance. Increased wear by the use of chains and the use of sand and salt accounts for some of the loss of surface texture. Bare pavement policies in mountainous areas resulted in the loss of most as-built texture within a few months. There may be no easy solution to loss of texture from these causes in snow areas short of grooving. Textures obtained were sometimes light, a condition believed to be related to the method of forming the texture, which was not positive. Variability of texture may be due to differences of wetness and setting time of the concrete, and thickness of the plastic mortar layer.

The geometrics of texture are believed to have a great effect on durability. For example, small ridges that are formed above the basic plane of the pavement would tend to wear off faster than wider bands, formed by narrow grooves a greater distance apart.

What texture depth is necessary for long life? We can obtain a rather high coefficient of friction with a sandpaper finish, but the coefficient of friction value itself is not considered adequate to describe what we need. At least two other measures are needed: physical roughness and toughness or abrasion resistance.

We have taken the broad approach, and have encountered many different opinions regarding texturing of concrete pavement. For example, is it possible to get a consistent texture without forming it positively by molding? Can any "floating" device, such as a burlap drag or broom, form a consistent texture under varying construction conditions? How long can we maintain any texture after we get it? Is it reasonable to expect a texture to last even half as long as the pavement? Or should we plan to retexture on a periodic basis as a maintenance function? If grooved, how wide should grooves be and how far apart should they be so as not to adversely affect vehicles? Should grooves or ridges be continuous? Or, would they have a hypnotic effect on the driver? If transverse, they might cause objectional noise; how much noise is "too much?" How will this affect tire wear? Obviously, we need to know a lot more about these things. Recognizing variability in surface mortar, how can this factor be controlled during construction to provide a material that can be uniformly textured and provide the durability needed? For example, can cement or a cement-aggregate mixture be sprinkled on the surface to improve strength and therefore durability? We know that higher cement factors improve strength and durability, why not go even further than 7½ sacks per cubic yard on the surface mortar?

Could a vacuum-type device remove excess water from the surface to produce a dense, durable mortar by lowering w/c? Or does the solution lie in the use of admixtures or hardeners on the surface, or perhaps other concreting aids such as moisture evaporation retardants? Another approach that has been suggested is that of forming no texture during initial strike-off, but return the next day or so and cut a texture in the green concrete with a machine yet to be built. Another suggestion has been the use of chips spread on the wet concrete surface and rolled in. These chips could be precoated with some material to improve bond, but there may be other materials that could be used to form nonskid textures when rolled in the fresh concrete, even "expendable" material that wears away under traffic, thereby leaving the desired texture molded in the surface.

Our approach to forming textures on pavements has been first to experiment with laboratory-cast slabs and transfer the most promising methods to the field for trial. One such promising texture developed has been used in short test sections on three freeways. This work, in some respects, has been disappointing. With small hand-operated prototypes, texture obtained has not been uniform, nor could it be formed over very large areas in the field. In some areas, the mortar cover over coarse aggregate was very thin—1/16 in. or less. Mechanical devices tend to cut through this thin layer and ride upon rocks. Other areas of the concrete hardened at varying rates which also caused a nonuniform texture. Under these conditions, rocks were dislodged and the surface torn. Timing of texturing appears to be critical. Difficulty in obtaining uniformity appears to be a good argument for positive power forming texturing devices. It may be that ultimately we will need a special texturing machine following the slipform paver which by mechanical tamping of rocks near the surface and by other vibrations and movements, would provide a neat, uniformly plastic mortar which can be extruded or formed into any texture we desire. Equipment manufacturers have been cooperative, but understandably reluctant to build machines until we can tell them precisely what we want and can define it. We believe the proper machines can be built once we know what we want.

Durability of surface mortar is an integral and perhaps the most important part of the texturing problem. Texture is lost by tire wear, and by the action of abrasives, tire chains, tire studs, salt, and freezing and thawing. We have recently completed a study of surface durability of concrete and have found results similar to the investigators. Abrasion resistance is generally proportional to strength. Therefore, any means of increasing the strength of the mortar seems worthwhile. How can this be done? This is where application of established concrete technology can be of help. Strength and abrasion resistance of mortar can, among other ways, be improved by (a) being sure materials used have the potential to produce quality mortar; (b) increasing the cement factor which is in effect lowering water-cement ratio; (c) avoiding any surface drying before curing is started, and making sure that curing is not neglected (curing is believed to be even more important than thought in the past); (d) allowing sufficient time for concrete to gain strength before subjecting it to abrasive loads; (e) and where aggressive elements will be present, like salt, using air-entrained mortar.

Some surface treatments have been demonstrated to be of some value in strengthening the mortar, but this is an after-the-fact approach and it is believed that we should first attempt to get good mortar during construction rather than rely on such treatments. They would probably be more costly than some steps we might take during construction to produce equal results. It is nice, however, to have a few tools to take care of some of these problems should other efforts fail.

All of these factors are goals of specifications, but they cannot always be met. For example, under very adverse conditions it may be necessary to use some additional water to complete finishing in order to "save" it. However, it is recognized that often, more water is used than is needed. Alternatives to not using water, such as waiting for damp weather, or covering the mortar with plastic film to prevent any drying during delay of finishing, may not be practical. In general, there are never ideal laboratory conditions in the field and some compensation may have to be provided for their absence. Perhaps the entire finishing operations currently being used need to be altered. Because of different bleeding characteristics of concrete and variable weather conditions, finishing and texturing will always be a problem, one that will require some skill and judgment in the field. One of our goals is to provide materials or procedures that are less dependent upon these factors. Things that we believe would help are more realistic specifications that recognize principles of good practice, good enforcement of these specifications, and additional requirements, if necessary, even if they make the work cost more.

In summary, specific laboratory activities undertaken so far are (a) studying factors affecting abrasion resistance; (b) using technology now available, developing specifications to improve performance; (c) developing texturing devices and trying them in the field; (d) investigating the use of admixtures and surface treatments, such as epoxy penetrants, linseed oils, and curing seals that are claimed to harden and toughen the surface; and (e) using higher grade curing compounds and different types of liquid sealants. Discussions with vendors concerning new materials have also been helpful. We have made laboratory abrasion and compression tests on cores from test sections.

Our plans are to extend and continue our activity in the field of varying finishing and curing procedures under field conditions. We will continue to investigate use of surface treatments such as chips, hardeners, special mortar applications, and monomolecular films to retard evaporation. We intend to monitor wear on established test sections by means of skid tests made periodically while taking traffic into account. We propose to extend studies of wear resistance when our laboratory tire abrasion device is available. We are attempting to develop criteria for adequate initial skid resistance.

The coefficient of friction is not by itself adequate, and we need some test to measure texture properties other than "f." Perhaps a test similar to the sand patch test used in England would be suitable, or the use of some other texture measuring device. We intend to explore the feasibility of using our abrasion test on cores from finished pavements to demonstrate adequate strength of mortar in service. We hope to develop information about the effect of a time delay in allowing traffic on pavement at various intervals after construction. We will help others develop methods of obtaining or restoring skid resistance of hardened concrete by grooving, etching, bush hammering, flail grooving, or any other method that might be proposed.

There is a lot of work yet to be done and many questions to answer. We hope that in working with contractors, materials suppliers, construction machinery manufacturers, and others concerned, we will find the proper solutions to this important highway problem.