Pretreatment of Concrete Pavement for Traffic Striping

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This paper describes experiments on treatment of portland cement concrete surfaces with phosphoric acid for the purpose of securing a better base for traffic marking paint, and the work that has been done toward the adoption of an asphaltic emulsion base for the same purpose. The causes of failure of traffic paints on concrete surfaces, as compared to asphaltic surfaces, also are discussed.

• IT IS generally recognized that portland cement concrete has a surface that makes efficient traffic striping difficult to maintain by comparison with asphalt concrete surfaces. Almost any traffic paint, regardless of its type and class, will show better durability on asphalt pavement than on portland cement concrete.

There probably are several factors to consider as reasons for this fact. The one that is generally given most weight by observers is the alkaline character of portland cement concrete surfaces. Because of this, paints having saponifiable vehicles will be slowly changed at the boundary. Water will soften the paint surface after it has been saponified and a few cycles of wet and dry conditions will cause a loosening at the boundary of the two surfaces. Chipping and general failure soon follow.

Another feature of portland cement concrete is the tendency to allow moisture to migrate to the surface from below the slab by capillarity. Moisture accumulated under the film of paint is vaporized as the temperature rises, with a consequent lifting of the film. Capillarity is not so marked in asphaltic concrete and dispersion of rising moisture is greater, so that lifting of the paint film is relatively rare.

Still another feature of portland cement concrete is its tendency to become slick and glass-like under traffic wear. Also a certain amount of oil may be absorbed into the surface. Both of these characteristics tend to make adhesion of a paint film less stable than that of the film on the asphaltic surface, where the solvent in the paint "bites" into the asphalt and fuses the surfaces of the asphalt and paint together to a certain degree.

For some time it has been the custom to etch concrete surfaces prior to painting. The treatment has been used to reduce the alkalinity of the surface as well as to provide a roughened surface whereby adhesion of an applied coat is improved. Hydrochloric acid is commonly used. The etching action of this acid leaves nothing to be desired, but a thorough rinsing with water is necessary following such treatment to insure removal of soluble salts formed by the interaction of the concrete and the acid. Most of the common etches require rinses, or at least profit by them. Phosphoric acid, however, is not in this category. Properly diluted and applied, phosphoric acid serves as an excellent etcher and surface conditioner and requires no rinsing. Unlike hydrochloric acid, phosphoric acid forms no soluble salts when applied to concrete; instead, the surface coatings produced are insoluble in water and of such character as to be nearly ideal as a base for painting.

With this in mind, it was decided to try this acid on some sections of pavement in California where adhesion had been a problem for several years. The first place chosen was the concrete deck of a bridge where the surface had become highly polished and glazed. A few days after application, paint would break away from the surface and extensive chipping and flaking followed. The surface to be painted was treated with a phosphoric acid solution corresponding to the diluent of Federal Specifications, MIL-P-15328. This material is about 15 percent orthophosphoric acid in alcohol and water. Application was by bristle brush. When the surface dried, the paint was applied by the spray technique regularly used by the California Division of Highways.

The results were very satisfactory, there being no appearance of failure for several months. The paint film wore down by abrasion, but the service of the line on this bridge deck has been good since the experiment was initiated about 1953. This bridge has now passed into the custody of the county and is painted once a year. Traffic is about 35,000 vehicles daily. General service of the paint on the portland cement concrete of the bridge deck is excellent by comparison with that on the asphalt appproaches on each side.

Having noted the success of this experiment, it was deemed appropriate to repeat it on a large scale with proper control. Accordingly, two separate sections of pavement were selected on four-lane highways where paint service had been very poor and where control sections of similar type were readily available. One of these sections was on a bridge deck, with a history comparable to the one previously described. The other section was on an ordinary highway where pea gravel and sand washed onto the pavement during heavy rains. The traffic paint on both sections and in both directions had given very poor service for several years. At the time of this experiment, the surfaces were almost completely bare and free of paint.

The phosphoric acid solution used in this test was applied by the striping machine in the same manner as paint is applied on pavement in California. After allowing adequate time for drying, a coat of California Specifications Traffic Paint was applied over the phosphated portions, at the rate of 7 gal per mile, consisting of 3/8 mile of actual striping. Similar striping was done on the non-phosphated section. Beads were dropped into all of the lines at the rate of 40 lb per mile.

The results of these tests are interesting, even if not conclusive. On the bridge deck where previous painting had never adhered well over a period of years, the adhesion and performance of the traffic stripe was excellent on the phosphated portion. It was equally good on the non-phosphated part. After 17 months, the two sections were repainted when both of them were worn thin, but there had been no flaking and no general failure in the films. Subsequent lines, placed on top of these over a period of more than three years, have worn well. Part of each section traverses a curve where wear on the traffic stripe is much greater than that of the normal line on a tangent section. These parts of the test sections showed no great deviation from the remainder of the test sections. Traffic density was in excess of 30,000 daily.

The second test gave concordant results on the control and test sections — both were poor. There was no significant difference between the control and the experimental sections. Gravel that had washed onto the pavement was ground into the traffic line paint and removed it within about 3 months from the time of application. The paint and phosphoric acid used in this part of the test were out of the same tank as that used in the previously described test and were applied on the same day.

In addition to this large-scale testing, a few dozen transverse lines were tested in a similar way over a couple of years time. Many classes of paints were used. The performance of the lines under which the base had been treated with phosphoric acid was generally superior to those with untreated bases. There were some notable exceptions from which no consistent pattern could be discerned.

With no significant advantage showing up in the large-scale tests between sections painted with the same paint on treated and untreated bases, the work was dropped.

In the meantime, Painting Superintendent Leroy Smith, of the Los Angeles area, conceived and developed an idea that has been adopted for statewide use. This step was taken after extensive experimentation on a large scale on new portland cement concrete pavements. The California specification paint has shown up to 3 years of good performance on pavements which had been given this preliminary treatment.

The following excerpts from a section soon to be entered in the California Highways Maintenance Manual serve to describe the procedure used in striping new portland cement concrete pavement:

> An asphalt line should be applied to new concrete surface 5 to 10 days before the road is open to traffic. Emulsified asphalt is placed in the black tank and applied with the regular striping equipment. Sand is placed in a special sand dispenser and applied to the emulsified asphalt line. The secret for success with this line is to first apply a minimum amount of asphalt and a maximum amount of sand. . . . The following material is required to paint a 4-in. broken line per mile (equivalent to ⅜ mile of solid line):
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> 200 lb 14- to 16-mesh dry sand
> 8 to 10 gal penetration type asphalt emulsion

The black tank, of course, refers to a tank in the striping equipment that is reserved for black paint. The sand dispenser is arranged to deliver immediately behind the spray of asphalt as it is applied. No rolling or compaction is necessary under these circumstances, assuming that the viscosity of the emulsion is sufficiently low to encompass the falling sand.

The asphalt specified shows a nonvolatile content of 57 to 62 percent at 163 C. A viscosity (Saybolt-Furol) of about 50 is chosen. The line is allowed to cure for several days prior to painting. After the excess sand is swept off the pavement, the painting of the asphalt base line is carried out in two steps: First, a white coat of 3 or 4 gal per mile is applied without beads. The California paint dries rapidly enough to avoid bleeding at this rate of application. After the first coat has dried (a matter of 20 to 60 min), a second coat of 7 to 7½ gal per mile is applied with drop-in beads at the rate of 40 to 42 lb per mile. If this procedure is carried out faithfully, there is no bleeding through the surface of the white line. The line durability has been generally sufficient to warrant the procedure even as an economy measure.

The 14- to 16-mesh sand may be difficult to procure in some areas, but it seems reasonable to assume that this restrictive mesh is not critical. This material is readily available in Los Angeles and works well, hence this restriction. It should be re-emphasized that a large excess of sand is mandatory for successful striping. Used with an 8- or 9-gal application of the emulsion on a broken line, the rise in the surface of the line above the pavement is not significant. There is, of course, some rise; but no significant difference has been observed in the appearance of the line under wet conditions at night.

DISCUSSION

It is difficult to account for the anomalous behavior of the phosphoric acid treated lines described in the beginning of this paper. In part, it may have been due to the type of paints used prior to the experiments. The original paint placed on these spots was probably the California Manila gum-China wood oil formula, which was highly acid in character and consequently quite susceptible to neutralizing action at the juncture of the surfaces. Such reaction would reduce adhesion, cause flaking and general failure. The paint used at the time of experimentation was of the chlorinated rubber type, which is quite resistant to saponification and has pretty good adhesion. Transverse lines of the Manila gum formula showed marked improvement in durability when placed on the phosphoric acid pretreated base. Generally, the same thing was true of the chlorinated rubber type, though not as markedly so.

From such data as are available, the emulsified asphaltic pretreatment or "foundation stripe" would appear to be an economical and effective procedure. It should be noted, however, that this procedure has been observed in a relatively mild climate with no extreme variations in temperature. There is no reason to expect any great deviation in behavior in a climate of extremes, but it could be different. Some failures have been noted where insufficient sand was dropped into the emulsion, leaving a "fat" stripe. An excess of sand is important, as it allows time for complete curing of the asphalt before painting is done.

In California a curing compound, usually of the wax type, is used on the pavement. Generally it is thin, and so far has caused no separation at the surface boundary of the asphalt and pavement that is apparent. There is nearly always a considerable period of traffic by workmen and others on such pavement prior to its being striped. This may or may not be of significance in the behavior of the asphalt as an adhesive.