USE INFORMATION ON EPOXIES ADHESIVES - PATCHING - SEALING

INFORMATION BULLETIN

1-68-J

TEXAS HIGHWAY DEPARTMENT

THE INFORMATION BULLETIN SERIES IS INTENDED ONLY TO GIVE GENERAL INFORMATION ON A SUBJECT OF BROAD INTEREST. THE SERIES SHOULD IN NO WAY BE INTERPRETED AS PROMOTING ANY MATERIAL OR METHOD NOR INFLUENCING ANY SPECIFICATION OR POLICY OF THE DEPARTMENT.

Use Information on Epoxy Adhesives and Epoxy Patching and Sealing Materials

Introduction

This bulletin contains a brief description and basic use information on those epoxy adhesives, patching, and sealing materials which are currently being used in significant quantities by the Texas Highway Department. The Materials and Tests Division will be happy to receive any specific question, suggestions or comments regarding these materials and their use or possible use.

Epoxy Adhesive A-103

This material is currently stocked in the regional warehouses in 3/4 and 1-1/2 gallon units. It was designed primarily to bond fresh portland cement concrete to existing concrete. It may also be used to bond cured concrete to existing concrete, steel to fresh or hardened concrete, and steel to steel. The main use of Adhesive A-103 to date has been in bonding conventional portland cement concrete patches in place on bridge decks. It has also been used as the binder for rumble strips. On one particular job, Adhesive A-103 was mixed with selected sands to produce a stiff mortar for grouting between the underside of a bridge deck and steel beams which had been placed between the original beams to give added support to the deck. The purpose of the grout was to provide uniform bearing between the deck and the additional beams. More detailed information regarding the use of this material is

set forth in the pamphlet entitled "Instructions for Use of Texas Highway Department Epoxy Adhesive A-103", a copy of which is included in the appendix.

The cost of this material is approximately $5.75 for a 3/4 gallon unit and $11.00 for a 1-1/2 gallon unit.

Epoxy Binder B-102

This material is currently stocked in the regional warehouses in 3/4 and 2-1/2 gallon units. It was designed to be mixed with selected aggregates to form a quick-setting epoxy mortar or concrete which could be used to repair pot holes or spalled areas on concrete roadway or structures. The binder has a small amount of pigment added to give it a light gray color. Most of the B-102 purchased to date has been used to produce mortars for patching deteriorated bridge decks. It has also been used to make a grout for placing dowel bars. A number of Districts have added colorants to the B-102 and used it to surface picnic tables in roadside parks. A small amount of this material has been used to provide a protective coating and wearing surface on bridge decks.

For patching, the ratio of aggregate to binder has usually been about 10 or 12 to 1 by weight. Patches up to 2-1/2 inches deep and several feet in diameter have been placed with B-102 mortars and the majority of them have performed satisfactorily. Where it is desired to place patches as much as 1-1/2 inches in thickness

with a diameter greater than 3 feet, we believe it would be better to use a conventional concrete mortar or an epoxy mortar made up with a more flexible binder such as Guardkote 250 or its equivalent. All epoxy mortars will expand or contract with temperature change at a different rate than conventional concrete. Since Epoxy Binder B-102 is a fairly rigid material, a very large patch placed with B-102 mortar would be more likely to cause cracking in conventional concrete adjacent to the patch.

The aggregate used with the epoxy binder is very important. Where good quality silica sands are not readily available, we recommend using a coarse sandblast sand. Although this sand is more expensive than an ordinary concrete sand, the controlled grading will allow preparation of a workable mix using a lower percentage of binder and the finished mortar will have better physical properties.

Additional instructions concerning the use of B-102 are set forth in the pamphlet entitled "Instructions for Use of Texas Highway Department Epoxy Binder B-102". A copy is included in the appendix.

The cost of this material is approximately $6.00 per 3/4 gallon unit and $19.00 per 2-1/2 gallon unit.

Epoxy Traffic Marker Adhesives

Epoxy adhesives for bonding traffic buttons and jiggle bars to

both portland cement and asphaltic concrete are currently specified under Special Specification Item 1568, Epoxy Adhesive. This specification sets forth the requirements for four different adhesives, designated as Types I through IV. These adhesives differ in their rate of set. Type IV also has a longer working time or pot life. The set time as determined in Item 1568 is intended to correspond approximately with the time required at 75-80 degrees F. for the adhesive to attain sufficient strength that traffic will not damage the bond between the markers and pavement. The maximum set times at 77 degrees F. for each type of adhesive is as follows:

Type I - 45 minutes

Type II - 2 hours

Type III - 4 hours

Type IV - 12 hours

The pot life and set time of these adhesives will be affected considerably by temperature. The various adhesives which have been tested and have complied with the requirements of Item 1568 to date are shown in the table on the following page along with actual pot life and working time data.

Types II, III, and IV are what we consider conventional epoxy systems - i.e., a standard epoxy resin cured with an amine, polyamide, polysulfide or a combination of these materials. The only system which thus far has met the requirements for a Type I

Traffic Marker Adhesive Properties

Adhesive Designation	Manufacturer	Type	Approximate Working Time in Minutes of One Quart at: 50 F.	60 F.	77 F.	95 F.	Approximate Set Time in Hours for Pavement Temperatures of: 50 F.	60 F.	77 F.	95 F.
Epo-Stik B-32	Industrial Coatings Specialties Corp., Houston	I	30	20	15	12	1.3	0.8	0.6	0.4
Epo-Stik B-24	Ditto	II	--	25	12	8	---	4	2	1
ACF FC-11	American Clay Forming Company, Tyler	III	--	20	10	7	---	6	3	1.5
Stimsonite 88	Elastic Stop Nut Corp. of America, Elizabeth, N. J.	III	--	16	8	5	---	6	3	1.5
ACF 1001	American Clay Forming Company, Tyler	IV	--	60	30	20	---	17	8	4
ACF JB-16	Ditto	IV	--	80	40	25	---	17	8.5	4
Epo-Stik B-22	Industrial Coatings Specialties Corp., Houston	IV	--	70	35	20	---	16	8.5	4

adhesive consists of a special epoxy resin cured with a polymercaptan. This system has a disagreeable, skunk-like odor and is more toxic than the conventional epoxy systems. Which type adhesive should you specify for a given project? The critical property is the curing time available before opening to traffic since the strength requirements for the cured material is the same for all four types. Type I adhesive was intended for use in areas of very high traffic density or on any jobs where the markers will be placed at pavement temperatures lower than 60 degrees F. The epoxy-polymercaptan systems have the ability to cure satisfactorily down to 35 to 40 degrees F. Types II, III, and IV adhesives will not cure satisfactorily at temperatures below 50 degrees F. In order to be sure of obtaining a good cure, we do not recommend their use at pavement temperatures below 60 degrees F. Because of the toxicity and current high cost of Type I adhesives, we recommend that wherever possible one of the other types be used. Type II adhesive was intended for use in areas of medium to high traffic density. Type III adhesive was intended for use in areas of low to medium traffic density or on new projects subjected to considerable construction traffic. Type IV adhesive was intended for use only on construction projects not open to traffic. In actual practice, Type III adhesive has been used to place markers in medium to high traffic density areas and Type IV has been used in low to

medium density areas. If markers are to be placed in the summer when pavement temperatures will be 90 degrees F. or higher, the cure rate of Types III and IV may be adequate even under fairly heavy traffic conditions.

In placing traffic markers, preparation of the pavement surface is important. If the markers are to be placed on portland cement concrete, all surface laitence should be removed, preferably by sandblasting. Asphaltic concrete should be swept clean of any dust or dirt. Sufficient adhesive must be applied to the marker or the pavement so that when the marker is placed there will be a continuous film or cushion of adhesive under the marker. When using Type I, II, or III adhesives no more than one quart of material should be mixed in a given batch for hand application because of the short pot life. Adhesive which has become so stiff that it is quite difficult to apply to the marker or the pavement should not be used because a good bond will not be obtained.

Item 1568 is intended to provide adhesives suitable for hand application. During the summer of 1967, District 18 contracted the placement by machine of several lane miles of markers. The particular adhesive used conformed to the requirements for Type III under Item 1568. However, if adhesive and markers are to be placed by machine, preparation of another specification for

the adhesive should be considered. In order to perform well in machine application, the adhesive should have certain flow characteristics which are not covered by Item 1568.

The cost of Type I adhesive currently is approximately $18.00 per gallon. The cost of Types II, III, and IV ranges from about $7.50 to $9.00 per gallon.

Coal Tar and Oil Modified Epoxy Systems

The Texas Highway Department has used a substantial quantity of two modified or extended epoxy systems designed for patching and sealing or overlaying concrete roadway and structures to protect against water penetration and deicing salts. These systems were originally marketed by Shell Oil Company under the names Guardkote 140 and 250. Guardkote 140 or its equivalent is an epoxy-coal tar system which is black in color. This system initially is quite flexible (approximately 30 to 40 percent tensile elongation), but tends to become fairly rigid on aging. Guardkote 250 or its equivalent is an epoxy-petroleum oil system which is off-white in color. This system is even more flexible (45 to 60 percent tensile elongation) than the coal tar system. The oil modified epoxy system appears to have better retention of properties on aging than does the epoxy-coal tar system. Both of these systems can be mixed with selected aggregate to form a mortar for patching. The ratio of aggregate to oil or coal tar extended epoxy is usually about 7 to 1 by weight. The criteria for aggregate to be used with Epoxy Binder B-102 also apply to aggregate

for use with these epoxies.

The epoxy-coal tar system has been used in several states to provide a membrane seal on a bridge deck which is overlayed with asphaltic concrete. When used for this purpose the epoxy is normally applied at the rate of 2 to 3 pounds per square yard. Enough aggregate, approximately 1/8" size, is then broadcast into the fluid epoxy to provide a good surface for the asphaltic concrete to key into. The aggregate used should be rounded. The use of sharp or crushed aggregates should be avoided because of the tendency of sharp particles to puncture or cause pinholing in the epoxy film. Both the coal tar and oil extended systems will be applied as membrane seals on structures in District 2 later this year as part of an experimental project. The membranes will be overlayed with a rubberized asphaltic concrete.

When used to seal and provide a new wearing surface on bridge decks or roadway, either of these epoxies are normally applied at the rate of about 3 pounds per square yard. Rounded sand, 10 to 30 mesh, is then distributed to excess over the fluid epoxy. After the epoxy has attained an initial cure, the excess sand is swept off. This type of seal has been applied to structures in Districts 4, 9, and 24 with the epoxy-coal tar system and in District 24 with the epoxy-oil system. Special Specification Item 1473, "Epoxy Sealcoat", was prepared by District 24 for a project involving application of both types of epoxies as

sealcoats. A copy of this specification has been included in the appendix for your information. *

Shell Oil Company has advocated use of the oil extended epoxy system to produce an epoxy overlay on bridge decks. For this type of application, a fairly fluid epoxy mortar is prepared by mixing about 6 parts by weight sand and 1 part by weight binder in a plaster mixer or similar piece of equipment. The grading of the sand used approximates that of No. 1 concrete sand. This mix is placed using a vibrating screed which was designed by Shell Oil Company. The resulting overlay is 3/8 to 1/2 inch in thickness. This type of overlay has been applied in Districts 4, 5, and 24. In District 24, both the coal tar and oil extended systems were used in overlay work. This type of application provides better protection against water penetration and deicing salts and offers longer wear than a sealcoat. A copy of Special Specification Item 1472, "Epoxy Overlay", which was prepared by District 24, is included in the appendix. *

The preparation of the concrete surface prior to application of any of these protective coatings is very important. Any deteriorated

* The current specification for the oil modified epoxy differs from that shown in these special stencils. The current specification should be used in purchasing or specifying the oil modified material. Copies of this specification can be obtained from D-18 or D-9.

concrete must be removed using an electric or light air hammer. The remainder of the deck surface can be prepared by acid etching or sandblasting. Experience has indicated that sandblasting to a clean sound surface is the best method of preparation. Solvents may have to be used to remove any heavy oil or grease spots.

The cost of the epoxy-coal tar material supplied in 55 gallon drums is currently about $3.75 per gallon. The oil-modified epoxy costs about $4.00 per gallon in 55 gallon drums. An average cost figure for a finished sealcoat placed by Highway Department maintenance personnel using either of these materials is $3.00 per square yard. These figures are for a moderately deteriorated bridge deck and include the cost of all materials plus cleaning out deteriorated areas, patching, sandblasting and placing the sealcoat or overlay. If the work is contracted, the cost will be approximately 20% higher.

Sampling of Epoxy Materials

The following suggestions are made regarding samples of epoxy materials to be submitted to D-9 for testing.

The size of the sample should be as follows. For traffic marker adhesives or proprietary adhesives to be used for other purposes, a pint of each component is sufficient. If the adhesive is packaged in quarts, we suggest that an original container of each

component be submitted. In the case of adhesive packaged in tubes, submit the number of tubes of each component that will be equivalent to approximately one pint.

For overlay and patching materials, such as the oil and coal tar modified materials, at least one quart of each component should be submitted. If large quantities are purchased (over 100 gallons), a sample should be taken for each separate batch represented.

When the sample is to be taken from a large container, thoroughly mix the component and transfer the sample to a clean pint or quart can. Be sure the component identification appears on each can. The manufacturer's instructions regarding the mixing ratios of the two components must be included along with the samples.

APPENDIX

INSTRUCTIONS FOR USE OF TEXAS HIGHWAY DEPARTMENT EPOXY ADHESIVE A-103

Materials and Tests Division

Epoxy Adhesive A-103 has been designed to be as near as possible a general epoxy adhesive for highway use. It may be used for bonding fresh portland cement concrete to existing concrete, bonding cured concrete to existing concrete, bonding steel to fresh or hardened concrete, and in some cases, bonding steel to steel. It may be used either on vertical or horizontal surfaces. This adhesive has been designed to be applied by brush, squeegee, roller, or some similar means of application. It is currently available in 3/4 gallon and 1½ gallon units.

Instructions concerning the use of this material are given on the following pages. It should be kept in mind that this material will perform satisfactorily only if it is used properly.

General Instructions

Handling Precautions

The epoxy materials are capable of causing irritation or other physiological reaction in some individuals. For this reason, care should be exercised in handling this material. If a workman should develop a skin rash or similar reaction while working with the epoxy, it would be best for him to discontinue handling this material, as continued contact with the epoxy will result in greater irritation or reaction.

Mixing

The two components of this material are to be mixed in the following ratio:

1 part resin component by volume
1 part hardener component by volume

or

1 part resin component by weight
1.1 part hardener component by weight

The two components must be thoroughly mixed together, preferably with a small mechanical mixer. If a mechanical mixer is not available, the adhesive may be mixed by hand. The resin component should be added in small amounts to the hardener component and the mixture stirred well after each addition. Adequate mixing will require 5 to 10 minutes. No more than approximately 1½ gallons of finished adhesive should be prepared in a single batch. The reaction of the resin and hardener components generates heat and in a large batch this heat is trapped and cannot be given off as rapidly as it is generated. This results in a build-up of heat which causes the reaction to proceed at a more rapid rate thus shortening the working time.

Working Time

After the two components have been mixed, one unit of the adhesive will retain good working properties for about 20 minutes. The adhesive will then begin to thicken. This time is based on the initial temperature of the two components and the ambient temperature being approximately 80 degrees F. If the initial temperature of the two components or the ambient temperature is less than 80 degrees F., the working time will be somewhat longer. If the initial temperature of the two components or the ambient temperature is greater than 80 degrees F., the working time will be somewhat shorter than that shown. This material should not be used if the ambient temperature is below 60 degrees F.

The adhesive will remain workable for a longer period of time if it is removed from the container and spread over the surface to be coated immediately after mixing. If the material is allowed to remain in the container after mixing, the heat from the reaction between the hardener and the resin will build up and cause the adhesive to thicken more rapidly.

Coverage

For best results, enough Epoxy Adhesive A-103 should be applied to the surfaces to be bonded at least 0.02 inch (20 mils) thick. One 3/4 gallon unit of this material will cover approximately 50 square feet if applied to this thickness. If the adhesive is being applied to a rough surface, a heavier coat may be necessary.

Clean-up

Any equipment used in applying the adhesive must be cleaned before the adhesive hardens. Toluene is recommended as a solvent for removing the epoxy material. BBT-9 Bead Binder Thinner may also be used for this purpose if it is more readily available. Both of these solvents are stocked by the Highway Department regional warehouses in 5 gallon containers. The stock numbers are as follows:

307700 - - - - Thinner, BBT-9 Bead Binder
307800 - - - - Toluene

It should be kept in mind that these solvents are quite flammable and should be used with caution.

Specific Applications

I. Bonding fresh portland cement concrete to existing portland cement concrete.

A. Surface Preparation
The existing concrete surface should be free of any loose or unsound concrete. After this has been assured, the surface may be prepared in one of several ways. These methods of surface preparation are described below.

1. Sandblasting
The area to be coated should be blasted sufficiently to remove any

laitence or road film present and provide a roughened surface. Before applying the adhesive, see that the surface is free from loose fines.

2. Acid etching
Acid etching is generally used as an alternate to sandblasting for removing laitence and road film and providing a roughened surface. The concrete to which the adhesive is to be applied may be treated with a solution of 2 parts water and 1 part 20 degree Baume' muriatic (commercial hydrochloric) acid by volume. The amount of acid required is approximately one gallon per square yards. The acid should be spread over the surface and scrubbed in with a broom or brush. After the reaction between the acid and the concrete has taken place, the surface should be thoroughly washed to remove the salts formed in the reaction. In most cases, acid etching will provide a surface to which the epoxy will adhere quite well. However, there are several problems involved in the use of acid. The personnel engaged in working with the acid must exercise care in order to prevent burns and damage to clothing. Goggles and rubber gloves should be supplied the personnel applying the acid. Hydrochloric acid gives off noxious fumes which in some cases may present a hazard to the personnel. Any equipment used in the operation must be protected from the hydrochloric acid due to its extreme corrosiveness.

3. Detergent Washing
If the concrete to which the adhesive is to be applied does not have an extreme amount of laitence or road film present, washing with a detergent followed by rinsing with plain water may be sufficient surface preparation. The concrete surface should be scrubbed by broom or brush with the detergent solution and then thoroughly rinsed.

All three of the above methods of surface preparation have been used successfully. In some cases, where the adhesive is to be applied to a concrete surface which has been jackhammered to expose sound relatively clean concrete, all that may be needed in the way of surface preparation is pressure washing with water. In all cases where the concrete has been washed, the epoxy adhesive should not be applied until the surface is reasonably dry.

B. Application
After the existing concrete has been prepared, the mixed adhesive may be applied. The adhesive should be allowed to become tacky before pouring the fresh concrete against it. This is essential to obtaining a good bond. The time required, after mixing, for the adhesive to become tacky will vary with temperature. The following chart gives, for several different ambient temperatures, the minimum and maximum time which may elapse between mixing the epoxy adhesive and pouring the fresh concrete against the epoxy.

Temperature, Degrees F.	Time Between Mixing of Epoxy and Pouring of Fresh Concrete Minimum	Maximum
60	45 Minutes	3 Hours
70	30 "	2½ "
80	15 "	2 "
90	15 "	1½ "
100	15 "	1 Hour

The fresh concrete which is to be bonded to existing concrete should be a slow slump workable mix. The presence of excessive water in the fresh concrete will hinder the development of a good bond. The fresh concrete may be worked in the usual manner after it is poured in place.

II. Bonding cured concrete to existing concrete.
In this case, both of the surfaces to be bonded should be prepared in one of the ways previously described. A thin coating of the adhesive (approximately 10 mils) may be applied to each surface and the coated surfaces then joined together.

III. Bonding steel to concrete.
Once again, the concrete surface should be prepared either by sand-blasting, acid etching or detergent washing. For best results, the surface of the steel which is to be bonded should be sandblasted to white metal in order to obtain a clean rough surface which will provide maximum adhesion. The steel surface must be free of any oil or grease. The steel should be degreased with toluene if there is any evidence of oil or grease present.

IV. Bonding steel to steel.
In cases where there is no need for high structural strengths, Epoxy Adhesive A-103 may be used to join steel to steel. All surfaces should be sandblasted and brushed free of dust and fines and then coated with approximately 10 mils of the adhesive. All surfaces to be joined must be free of oil or grease. If any oil or grease is present, degrease the surfaces with toluene.

INSTRUCTIONS FOR USE OF TEXAS HIGHWAY DEPARTMENT EPOXY BINDER B-102

Materials and Tests Division

Epoxy Binder B-102 is intended to be mixed with selected aggregates to form a quick-setting epoxy mortar or concrete. The resulting epoxy mortar or concrete may be used to fill cracks and to repair pot holes or spalled areas on concrete structures. This material may be used when the concrete temperature is between 60 and 120 degrees F. and the ambient temperature between 60 and 105 degrees F. Epoxy Binder B-102 should not be used outside these temperature limits. This material is currently available in 3/4 gallon and 2½ gallon units. Instructions concerning its use are given on the following pages. It should be kept in mind that in order to obtain the best results with this material, it must be properly used.

Aggregates to be Used in Preparing Epoxy Concretes and Mortars

The aggregates to be used with Epoxy Binder B-102 should meet the quality requirements specified under Item 421, "Concrete for Structures," THD 1962 Standard Specifications for Road and Bridge Construction. The aggregates to be used should be dry. The maximum size of the aggregate to be used will depend upon the dimensions of the fill. A good rule to follow is that the maximum size aggregate should not exceed one-fourth of the smallest dimensions of the fill. For an epoxy concrete to be used where a large volume of fill is required, gravel or crushed stone, 3/4 to 1/2 inch maximum size, uniformly graded from coarse to fine may be used. For most work, an epoxy mortar prepared using an aggregate with a grading approximating that of THD Grade No. 1 Fine Aggregate would be desirable. The grading limits for this material are as follows:

Sieve Size		Per Cent Retained, Cumulative
No. 4	(4.76 mm)	0-5
No. 8	(2.38 mm)	0-20
No. 16	(1.19 mm)	15-50
No. 30	(595 microns)	40-75
No. 50	(297 microns)	70-90
No. 100	(149 microns)	90-100

THD Grade No. 1 Fine Aggregate (Concrete Sand) may be used in preparing epoxy mortars. However, somewhat higher strengths and better workability may be obtained if all material passing the No. 50 sieve is screened out before use. Even better results may be obtained by using a rounded grain sand free of fines. A specification for this type of sand is given below.

> The sand to meet this specification shall be a rounded grain washed sand free of fines. It shall comply with the following physical and chemical requirements:
>
> Moh Hardness - - - - 7 Minimum
> Specific Gravity - - 2.60 Minimum
> Per Cent Silica - - 99.5 Minimum by Wt.
> Grading - To be specified

Note: A sand meeting these requirements is produced by Pennsylvania Glass Sand Corporation, San Saba, Texas. The following gradings of this sand are packaged in 100 pound sacks:

8 - 12 mesh
10 - 20 mesh
16 - 30 mesh
20 - 40 mesh

Because of the availability of this sand, the Materials & Tests Division used it in experimental work involving aggregates. The best results were obtained using a combination of the gradings shown above. The composition of a typical mix prepared with special sand and 3/4 gallon of Epoxy Binder B-102 is shown below:

24 pounds 8 - 12 mesh sand
6 " 10 - 20 mesh sand
6 " 16 - 30 mesh sand
12 " 20 - 40 mesh sand
7 " B-102 Epoxy Binder

or by Volume:

1½ gallons 8 - 12 mesh sand
½ " 10 - 20 mesh sand
½ " 16 - 30 mesh sand
3/4 " 20 - 40 mesh sand
3/4 " B-102 Epoxy Binder

In some cases where it is desired to fill shallow spalled areas or relatively small cracks, a relatively fine sand of uniform grading may be used. A 30 mesh sand has been used successfully as the aggregate for this type of application.

General Instructions

Handling Precautions

The epoxy materials are capable of causing irritation or other physiological reaction in some individuals. For this reason, care should be exercised in handling this material. If a workman should develop a skin rash or similar reaction while working with the epoxy, it would be best for him to discontinue handling this material, as continued contact with the epoxy may result in greater irritation or reaction.

Mixing

The two components of Epoxy Binder B-102 must be thoroughly mixed together, preferably with a small mechanical mixer. If a mechanical mixer is not available, the binder may be mixed by hand. If an entire unit is to be mixed and used at one time, the hardener component should be added to the resin component and mixing done in the resin component container. If less than a full unit of binder

is needed for a particular application, the two components may be mixed in the following ratios:

3 parts resin component by volume
2 parts hardener component by volume

or

1.9 parts resin component by weight
1.0 part hardener component by weight

After the two components of the binder have been mixed together, the binder is ready to add to the aggregate which has been selected. The ratio of aggregate to the epoxy binder will usually range from 5 to 10 parts aggregate by weight to 1 part binder by weight. The ratio will depend upon the type of aggregate used and the working characteristics desired. In order to determine for any given aggregate the ratio of aggregate to binder that will give the desired finishing and placing characteristics, it is a good practice to make up small trial batches of the epoxy mortar. Batches of material made up experimentally should contain at least 2 pounds total weight of aggregate and binder.

The simplest method of mixing the aggregate and binder is by hand in metal pans. This simplifies clean-up of the equipment following the mixing of the epoxy mortar. The aggregate to be used may be placed in a metal pan of suitable size and the binder added gradually, with mixing, to the aggregate. Note: The binder should be added to the aggregate immediately after the resin and hardener components have been mixed together. A small amount of the binder should be saved rather than added to the aggregate. This amount of binder should be used to prime the concrete surfaces against which the epoxy mortar is to be placed. A thin coat of the pure binder should be brushed onto all the surfaces to which the epoxy mortar is to be bonded.

The size of the batch of epoxy mortar made up using 3/4 gallon of binder will vary from about 40 to 80 pounds. The average time required to mix the binder and aggregate by hand with a hoe or trowel will be about 10 minutes. The working time after the mortar is ready for use will vary from about 20 to 50 minutes depending upon the ratio of aggregate to binder, the size of the batch, and the ambient temperature. The working time can be extended somewhat by spreading the mix out thin prior to placing it so that there will not be a heat build-up due to the reaction which takes place between the epoxy resin and the hardener.

Placing of the Epoxy Mortar

Prior to placing the epoxy mortar, the surfaces to which it is to bond must be properly prepared. Any loose or unsound concrete must be removed. Areas to be patched should be chipped out so that the edges will be essentially perpendicular to the top surface of the finished patch. This will eliminate thin featheredging. Layers of epoxy mortar less than ¼ inch in thickness are susceptible to chipping and for this reason it is generally best to avoid featheredging patches. The surfaces to which the epoxy mortar is to be bonded must be clean. Pressure washing with water followed by drying with compressed air is adequate in many cases. In cases where the concrete surface is soiled with oil, grease, or

other foreign matter which cannot be removed by water washing, sandblasting is desirable. The sandblasted area should be washed and dried prior to placing the epoxy mortar. In some cases, acid etching of the concrete may be feasible. A solution of 2 parts water and 1 part 20 degree Baume' muriatic (Commercial hydrochloric) acid by volume may be used for this purpose. The amount of acid required is approximately one gallon per four square yards. The acid is spreas over the surface and allowed to react with the concrete. This must be followed by a thorough washing with water. The concrete should then be dried before applying the epoxy mortar. It should be kept in mind that if acid etching is used as a method of surface preparation, precautions must be taken to protect both personnel and equipment from the acid and its fumes. Personnel applying the acid should be supplied with goggles and rubber gloves.

After the concrete surfaces have been prepared, the binder to be used as a primer should be brushed on. The epoxy mortar may then be placed. Working of the epoxy mortar while putting it in place should be kept to a minimum to prevent the binder portion from being worked up to the surface of the mortar. If it is necessary to use forms in conjunction with placing the epoxy mortar, the surfaces of the forms may be greased in order to prevent adherence of the mortar to the forms. Polyethylene sheeting may also be used between the epoxy mortar and the form in order to prevent adhesion.

After being put in place, the epoxy mortar will require about 6 hours at 80 degrees F. to obtain a good initial set. If the ambient temperature and the temperature of the concrete is 90 degrees F. or higher, it would be possible, if necessary, to turn traffic on the repaired areas 3 to 4 hours after placement of the epoxy mortar. However, it is best to wait 6 hours if conditions permit.

Clean-up

Any equipment used in mixing and applying the epoxy binder and mortar should be cleaned before the material hardens. Toluene is recommended as a solvent for approxing the epoxy material. BBT-9 Bead Binder Thinner may also be used for this purpose if it is more readily available. Both of these solvents are stocked by the Highway Department regional warehouses in 5 gallon containers. The stock numbers are as follows:

307700 - - - - Thinner, BBT-9 Bead Binder
307800 - - - - Toluene

It should be kept in mind that these solvents are quite flammable and should be used with caution.

TEXAS HIGHWAY DEPARTMENT

SPECIAL SPECIFICATION
ITEM 1568
EPOXY ADHESIVE

1. GENERAL. This specification describes four types of epoxy adhesives designed to bond ceramic or plastic traffic markers to roadway and bridge surfaces. Each adhesive shall be furnished in two components, herein referred to as the epoxy resin component and the hardener component, the two components to be mixed together just prior to use.

The type adhesive to be used on a specific project shall be designated by the Engineer based upon weather and traffic conditions. The various types of adhesives are as follows:

Type I - Rapid Setting Marker Adhesive (For use in areas of very high traffic density or if markers must be placed when pavement temperatures are below 60 degrees F. Epoxy systems meeting requirements for Type I are more toxic and currently more expensive than conventional systems.)

Type II - Medium Setting Marker Adhesive (For use in areas of medium to high traffic density.)

Type III - Standard Setting Marker Adhesive (For use in areas of low to medium traffic density or on new projects subjected to considerable construction traffic.)

Type IV - Slow Setting Marker Adhesive (For use on construction projects.)

Approximate set times at different temperatures for adhesives meeting the maximum set time allowed for each type are shown below.

Pavement Temp., Degrees F.	Approximate Set Time, Hours			
	Type I	Type II	Type III	Type IV
95	0.5	1	2	6
77	0.75	2	4	12
60	1	4	8	24
50	1.5	-	-	-

2. COMPONENT PROPERTIES. The ratio of the resin and hardener components to be mixed together to form the finished adhesive shall be specified by the manufacturer and the components packaged in the proper proportions.

Any pigments, fillers and/or thixotropic agents present in either the resin or hardener component must be sufficiently dispersed so that no appreciable separation or settling will occur during storage.

3. ADHESIVE PROPERTIES. The adhesive mixture must be of such a consistency that it can be applied to the surfaces which are to be bonded without difficulty. The adhesive must be capable of wetting the surfaces to be bonded so that good adhesion will be obtained. The requirements for the

various types of marker adhesive are shown below.

Property	Requirements			
	Type I	Type II	Type III	Type IV
Set Time at 77 Degrees F., Maximum	45 Min.	2 Hrs.	4 Hrs.	12 Hrs.
Pot Life at 77 Degrees F., Minutes, Minimum	10	10	10	30
Thixotrophy (Avg. Thickness of Cured Material Remaining on Test Panel, Mils, Minimum)	30	30	30	30
Adhesive Shear Strength, PSI Minimum	1800	1800	1800	1800
Cleavage Strength, PSI Minimum	800	800	800	800
Water Gain, Percent by Wt., Maximum	0.4	0.4	0.4	0.4
Impact Strength at 70-80 Degrees F, Ft.-lbs. Minimum	6½	6½	6½	6½

Test methods to be used in determining these qualities are listed below.

Set Time at 77 Degrees F.

The ambient temperature and the initial temperature of the materials used in this test shall be 77 ± 2 degrees F.

Cement mortar briquettes prepared and tested according to ASTM C190-63 (Tensile Strength of Hydraulic Cement Mortars) shall be used in this test. The broken briquettes shall be surface dry before use. Approximately 50 grams of the adhesive shall be mixed with a metal spatula in a 6 ounce ointment can for five minutes. The broken areas of the briquettes shall then be coated with the adhesive and put together with light pressure. The excess adhesive shall be removed from the edges of the bonded area and the briquettes allowed to remain undisturbed until time for testing. No more than 10 minutes shall elapse during preparation of the specimens. A minimum of three briquettes shall be prepared. The amount of time allowed to elapse between initiation of mixing and testing shall be as follows:

Type I - 45 minutes
Type II - 2 hours
Type III - 4 hours
Type IV - 12 hours

The briquettes shall be subjected to tensile loading with the Riehle briquette tester and the load at failure recorded.

Requirements:

The briquettes shall evidence an average strength of 200 psi minimum. If any of the briquettes tested fail in the mortar at strengths below 200 psi, an additional set of specimens shall be prepared and tested.

Pot Life at 77 Degrees F.

The initial temperature of the adhesive components and the ambient temperature shall be 77 ± 2 degrees F. for this test. A total of 100 grams of the adhesive shall be weighed into a 6 ounce metal ointment can, the time recorded and the two components mixed for three minutes with a metal spatula. The sides and bottom of the can should be scraped periodically during the mixing. For Type I, II and III adhesives, the following procedure should then be followed:

The can shall be set on a wooden block and probed every minute with a glass stirring rod, starting five minutes from the initiation of mixing.

For Type IV adhesive, the can shall be set on a wooden block and probed every two minutes with a glass stirring rod, starting 20 minutes from the initiation of mixing.

In all cases, the time at which the material becomes unworkable or begins to solidify is recorded as the pot life.

Thixotrophy

The ambient temperature and the temperature of the materials used in this test shall be 77 ± 2 degrees F.

The two components of the epoxy adhesive shall be stirred together for approximately 5 minutes and then applied to a smooth clean steel plate to form a panel of epoxy material 2 inches wide, 4 inches in length and 0.10 inch (100 mils) in thickness. A removable form of the proper dimensions may be used in placing the epoxy on the steel plate. The epoxy may be poured into the form and the excess struck off level with the top edge and then the form removed. Immediately after forming the epoxy adhesive, the steel panel shall be placed in a vertical position, the 4 inch dimension of the epoxy panel perpendicular to the horizontal. Not more than 7 minutes shall elapse between the initiation of mixing and the placing of the panel in the vertical position. After the adhesive has hardened, the average thickness of material remaining within the original 2 x 4 inch area of the panel shall be determined.

*Adhesive Shear Strength

The procedure used shall be as outlined in ASTM D1002-64 (Strength Properties of Adhesives in Shear by Tension Loading - Metal to Metal). Steel specimens shall be used. The surfaces of the test specimens used in the adhesive shear strength test shall be prepared by blasting to white metal. The blasted surfaces shall be washed with methyl ethyl ketone and allowed to dry before applying the adhesive. The test specimens shall have a prepared surface of equivalent "anchor pattern" to that which would be obtained by abrasive blasting the surfaces to be bonded with a gun pressure of 50 to 75 psi using a 1/4 inch diameter nozzle and employing Garnet Blasting Abrasive "Gem Blast", 60 mesh (No. 45 to No. 74 U.S. Standard Screens), as marketed by Clemtex, Inc., of P. O. Box 15214, Houston, Texas 77020.

*Cleavage Strength

The procedure used shall be as outlined in ASTM D1062-51 (Cleavage Strength of Metal-to-Metal Adhesives). Steel specimens shall be used. Surface preparation shall be as outlined in Adhesive Shear Strength.

*Water Gain (24 Hour Immersion at 23 Degrees C.)

The procedure used shall be as outlined in ASTM D570-63 (Water Absorption of Plastics) with the indicated modification.

The given ASTM procedure shall be modified in that the specimens shall be prepared by casting disks of the epoxy adhesive 2-3/4 inches in diameter and approximately 3/8 inch thick. Prior to testing, the plane surfaces of the disks shall be ground or machined flat and parallel. The machining or grinding must be done in such a way as to not heat the disks above 120 degrees F. The thickness of the disks after preparing the surfaces shall be 0.30 ± 0.02 inch.

*Impact Strength at 70-80 Degrees F.

For this test the specimens shall be prepared as outlined in Water Gain. The finished specimens shall be placed on a concrete slab and a one pound steel ball dropped on to the center of the disks from an initial height of 5 feet. The height shall be increased by 1/2 foot for each successive drop until the specimen fails by cracking or shattering. The height of drop at which failure occurs shall be recorded as the impact strength in foot-pounds. A minimum of three specimens shall be tested and the average reported to the nearest 1/2 foot-pound.

*These tests are to be performed on specimens that have been cured for seven days at 70-80 degrees F.

4. HANDLING INSTRUCTIONS. Each component container shall be clearly labeled concerning toxicity and handling precautions. The manufacturer shall furnish instructions regarding mixing of the adhesive. In the case of Type I, II and III adhesives, no more than one quart of finished adhesive should be mixed in a given batch due to the short working life of these materials.

5. MEASUREMENT AND PAYMENT. No direct measurement or payment will be made for the work to be done or for the materials to be furnished under this Item, but shall be considered subsidiary to the particular items required by the plans and specifications.

TEXAS HIGHWAY DEPARTMENT
Special Specification
Item

"Epoxy Sealcoat"

I. Description.

This item shall consist of a thin, lightweight sealcoat for Portland cement concrete bridge decks composed of an epoxy cement binder and fine aggregate and placed in accordance with these specifications and the details shown on the plans, or as directed by the Engineer.

The Bidder shall examine the site of the work and familiarize himself with the proposal, plans, specifications and contract forms. He shall acquaint himself with the materials specified and their handling characteristics. In the case of the binder, the Bidder shall, through direct contact with the manufacturer of materials, be thoroughly familiar with the construction procedures recommended by the manufacturer.

II. Qualification and Requirements.

A. Qualification of Materials:

All materials to be used shall be approved by the Engineer. The Contractor shall submit, with his bid, the following information in writing:

Three (3) copies of a list of all materials to be used, stating the name and address of the supplier (s) of each material.

Three (3) copies of a certification by the manufacturer of the materials to be used, or an approved independent testing laboratory, which establishes that they meet the requirements in this specification.

B. Qualification of the Contractor's Construction Methods:

To establish the ability of the Contractor to perform this work to the satisfaction of the Engineer, the Contractor shall obtain the services of a qualified Advisor

who is employed by the manufacturer of the binder and approved by the Engineer to assist the Engineer and the Contractor as required with the work in connection with this contract.

The epoxy resin manufacturer shall furnish three copies of certification that the contractor has adequate equipment and will receive sufficient technical help from the manufacturer of the resinous material to insure satisfactory performance of the material.

III. Materials.

Epoxy pavement surfacing materials shall conform to the following requirements.

A. Epoxy Cement:

Epoxy cement shall consist of two (2) components hereinafter referred to as Component "A" and Component "B", packaged separately in clean, adequately labeled containers. Each container shall be labeled to identify the component and show the formulation batch numbers. Each component shall be formulated in such a manner that equal parts by volume of the two components, when blended according to the formulator's instruction, will harden into a solid resinous material with the properties herein specified. The two components and their required characteristics shall be as follows:

1. Coal Tar Modified Epoxy Binder:

Component "A" (Modified Epoxy Resin): This material shall be based on a liquid epoxy resin obtained from the condensation of bisphenol "A" and epichlorohydrin. It shall be amber in color and contain no contaminants or insolubles and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD
Viscosity, 77°F, poises	8-16	(000-2882) Addendum No. 1
Epoxide Content, WPE(1)	225-275	ASTM D-1652-59T
Volatile Content, %Volume- Distilled below 350°F	3 max.	ASTM D-1078-58
Water Content, %W	0.1 max.	ASTM D-1744-60T

Component "B" (Modified amine hardening agent for use with Component "A"): This material shall be the hardening agent for the modified epoxy resin and shall be a blend of coal tar and an aliphatic polyamine. It shall contain no contaminants and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD
Viscosity, 77°F, poises	2-8	(000-2882) Addendum No. 1
Alkalinity, mg KOH per g	120-140	ASTM D-644-48(2)
Water Content, %W	0.2 max.	ASTM D-1744-60T
Ash Content, %W	0.5 max.	ASTM D-482-59T
Volatile Content, %Volume - Distilled below 350°F	3 max.	ASTM D-1078-58

2. Properties of Cured Coal Tar Modified Epoxy Binder:

Tests for properties specified in this section shall be performed on castings prepared from the binder components, "A" and "B", after these components have been mixed thoroughly in a 1:1 ratio by weight and allowed to harden for 7 days at 77°F, or 3 hours or more at 77°F followed by 5 to 8 hours in a 140° oven.

Tensile Properties at 77°F

(ASTM D-638-61T, Type I specimen, 0.22 to 0.25 inch thick, testing rate 0.20 to 0.25 inch per minute) ultimate strength, psi	450 min.
Elongation at break, percent	30 min.

(1) Weight per epoxy equivalent or grams material containing one gram equivalent of epoxide.
(2) Titrated to the first end point which will occur at a pH of about 6.3.

Binder Curing Characteristics

Gel Time

Gel Time, minutes	25-50	Addendum No. 2 (000-2882)

3. Oil Modified Epoxy Binder:

Component "A" (Modified Epoxy Resin): This material shall be based on a liquid epoxy resin as obtained from the condensation of bisphenol "A" and epichlorohydrin. It shall be amber in color and contain no contaminants or insolubles and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD
Viscosity at 77°F, poises	55 max.	(000-2882) Addendum No. 1
Epoxide Content, WPE (3)	290-320	ASTM D-1652-59T
Water Content, %W	0.1 max.	ASTM D-1744-60T
Volatile Content, % Volume-Distilled below 350°F	3 max.	ASTM D-1078-58

Component "B" (Modified amine hardening agent for use with Component "A"): This material shall be the hardening agent for the modified epoxy resin and shall be composed of a polyamine modified with petroleum oils, flexibilizers and accelerators. It shall contain no contaminants or insolubles and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD
Viscosity, 77°F, poises	0.4-0.6	(000-2882) Addendum No. 1
Alkalinity, mg KOH per g	120-140	ASTM D-664-58(4)
Water Content, %W	0.25 max.	ASTM D-1744-60T
Volatile Content, %Volume - Distilled below 350°F	3 max.	ASTM D-1078-58

(3) Weight per epoxy equivalent or grams material containing one gram equivalent of epoxide.

(4) Titrated to the first end point which will occur at a pH of about 6.3.

4. Properties of Cured Oil Modified Epoxy Binder:

Tests for properties specified in this section shall be performed on castings prepared from the binder components, "A" and "B" after these components have been mixed thoroughly in a 7:6 ratio by weight (equal volumes) and allowed to harden for 7 days at 77°F, or 3 hours or more at 77°F followed by 5 to 8 hours in a 140°F oven.

Tensile Properties at 77°F

(ASTM D-638-61T, Type I specimen 0.22 to 0.25 inch thick, testing rate 0.20 to 0.25 inch per minute)	
Ultimate strength, psi	900 min.
Percent elongation at break	40 min.

Binder Curing Characteristics

		(000-2882)
Gel time, minutes	30-60	Addendum No. 2

B. Aggregate:

Aggregate shall be a clean, dry (free flowing) and hard (not brittle or friable) natural silica sand and shall be essentially round in particle shape.

Screen Analysis % Retained	
#10	- 0
#20	- 5-15
#40	- 90-95
#80	-98-100

IV. Sampling and Testing.

The contractor shall furnish affidavits that the epoxy cement components meet specifications. Certification shall refer to batch numbers.

V. Construction Methods.

The resinous material shall be applied to clean, dry, Portland cement concrete to provide a uniform new wearing surface that seals the concrete deck against moisture.

A. Surface Preparation:

All scaled and potholed areas shall be broken back to sound concrete and patched with epoxy grout. Cracks shall be repaired by routing to a minimum width of 3/8" and a minimum depth of ½". Cracks shall be poured with epoxy grout material and this material thoroughly worked into the crack to preclude holidays and voids and to insure adequate wetting of the surfaces for proper adhesion. Patching and crack repairs shall be sufficiently in advance of seal coat application to permit curing of resinous cement. These areas will be sandblasted before sealing. Scaled and potholed areas and cracks requiring special attention shall be shown on the plans and/or marked on the bridge deck at the time the project is shown to prospective bidders.

All surfaces to be sealed shall be thoroughly cleaned of all paint, oil, grease, road grime and surface laitence.

1. Sand Blasting:

Portland cement concrete bridge deck to be surfaced shall be sandblast cleaned over the entire area in such a manner as to remove the surface of Portland cement concrete together with all dirt, grease, paint, loose concrete, and other foreign materials, exposing a clean surface of sound concrete which will receive the epoxy resinous cement. Sandblasting equipment shall be equipped with suitable traps and filters to prevent water and oil from being deposited on roadway surfaces. After sandblasting, roadway surfaces shall be swept or vacummed and cleaned of all grit, dust and other foreign materials before application of epoxy cement binder. Metal surfaces shall be sandblast cleaned to white metal as provided above for Portland cement concrete bridge deck. Sandblast sand shall be clean and sharp and of a grading effective in obtaining the specified results.

2. Special Cleaning:

Special cleaning may be required in areas having heavy local deposits of oil, grease, tar, traffic paint, grime, dirt, etc., which may prevent proper cleaning by the

method outlined above. These areas shall be completely cleaned by use of trichloroethylene, perchloroethylene, xylene, or other solvents approved by the Engineer, or by mechanical scrapers or scarifiers, or by heavy-duty detergents.

B. Proportioning and Mixing Epoxy Resinous Cement:

Components "A" and "B" shall be thoroughly blended in equal parts by volume within plus or minus 2 percent accuracy before they are applied to the roadway surface.

Care shall be taken to avoid errors due to clingage in the containers. The components shall be thoroughly and completely mixed, using a mixer employing rotating drums (KOL, Incorp., Model M-60, or equal), a heavy-duty electric drill equipped with mixing propeller or other approved device such as a Jiffy Mixer. Mixing time shall not be less than five minutes for each batch. Mixing temperature shall not exceed the maximum of 90°F or a minimum of 60°F.

The equipment used shall be accurately calibrated before use. Each binder component tank shall be provided with an accurate method of measuring the liquid level in that tank.

C. Application:

Application of the binder shall be such that a uniform coating of 1/3 gallon per square yard is distributed evenly over the area to be surfaced. Unless specifically directed otherwise by the Engineer, application shall proceed only when the ambient and deck temperatures are 60°F and rising, or above 65°F.

Application of epoxy surfacing on any area shall commence only if the Engineer believes the epoxy sealcoat will be sufficiently cured to meet the specified penetrometer hardness required by field control tests by the time such area must be reopened to traffic.

Epoxy cement applications to bridge deck surfaces adjoining the curb line shall be made so that resinous cement extends at least two inches up the curb. Spatters and smirches of resinous cement on the curb face shall be removed. Also,

each batch of epoxy cement applied by hand, or each pass with a machine, shall overlap the previous or adjacent batch or pass by at least two inches.

Deck armor angles and other metal parts with exposed wearing surfaces shall receive epoxy surfacing, except that drain openings and slide surfaces of expansion joints, and other metal surfaces specifically designated by the Engineer not to be surfaced shall be protected by masking, or other means approved by the Engineer. No application of the epoxy surfacing will be permitted which interferes with the action of expansion joints, or other moving parts.

Application of aggregate to the epoxy cement shall be made within five minutes after application of epoxy cement. Aggregate shall be broadcast into the epoxy cement in sufficient quantity so that no wet spots remain. No vehicular or pedestrian traffic will be permitted on the surface before the surface hardens. The aggregate may be applied by hand, with shovels, or with suitable continuous spreading devices. In any case, the aggregate shall be dropped into the epoxy cement approximately vertically and in such a manner that the continuity or the level of the epoxy cement is not permanently disturbed.

VI. Field Control Tests.

A. Soundness and Cleanliness of Portland Cement Surfaces:

The Engineer shall establish that the Portland cement concrete meets the requirements for the cleanliness and soundness of Portland cement concrete surfaces.

B. Material Quality:

Each binder component to be used on this project may be sampled and tested by the Engineer in accordance with test procedures described in these specifications. Any materials not considered satisfactory by the Engineer shall not be used in this work and shall be taken from the premises. The Engineer shall have the authority to postpone all work at any time for the purpose of obtaining gel time or other data as herein specified to establish satisfactory quality of the resinous cements.

C. Metering and Mixing of Binder Components:

When automatic, continuous metering and mixing equipment is used in connection with the binder application the equipment shall be accurately calibrated before use. Data and resinous cement samples shall be furnished to the Engineer at his request for determining the calibration of the proportioning equipment and the mixing equipment efficiency. The contractor shall correct the deficiencies in the equipment to the satisfaction of the Engineer before commencing operation.

The Engineer shall, at the beginning and end of each run read and record the liquid level in each of the two binder component tanks.

D. Seal Coat Curing:

The seal coat shall be opened to traffic only at the direction of the Engineer and only after the maximum scale reading, 4.5, is obtained on a "Pocket Penetrometer, Model CL-700", (5), when the instrument is pushed into the overlay at a 30^{o} angle to the roadway surface.

E. Seal Coat Quality:

Should the Engineer have reason to doubt the quality of the seal coat applied to Portland cement roadway, i.e., the bond of the seal coat to the roadway surface, or the strength of the binder, he may perform tests described in Addendum No.3, "Test for Determining Cleanliness and Soundness, etc.". The test procedure provides useful information as to the nature and strength of the existing bond between the seal coat and the pavement. If after sufficient testing and analysis of the results, the bond is unsatisfactory in the judgement of the Engineer, the Contractor shall, if so directed by the Engineer, remove and replace at his own expense the unacceptable seal coat or perform at his own expense other remedial action satisfactory to the Engineer, to render the binder acceptable. The epoxy supplier will at the request of the Engineer, supply data and test values at its disposal

(5) Manufactured by Soilest, Inc., 4711 W. North Ave.,Chicago 39, Illinois.

for his comparative analysis. Areas where epoxy thickness is finished, seal coat is less than 3/32" due to inadequate resin application or where areas are bare of aggregate or where there is insufficient aggregate, shall be replaced or repiared as directed by the Engineer.

VII. Measurement.

Epoxy seal shall be measured by the square yard complete in place.

VIII. Payment.

The work performed as prescribed in this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Epoxy Seal" which price shall be full compensation for furnishing all labor, tools, equipment, materials, cleaning, preparation, handling of traffic and incidentals necessary to complete the work.

The contractor shall guarantee the seal coat against stripping due to workmanship or material failure for a period of one year from the date of seal coat completion.

TEXAS HIGHWAY DEPARTMENT
Special Specification
Item

"Epoxy Overlay"

1. Description.

This item shall consist of an overlay pavement for Portland cement concrete bridge decks composed of an epoxy cement binder and graded aggregates and placed in accordance with these specifications and the details shown on the plans or as directed by the Engineer.

The Bidder shall examine the site of the work and familiarize himself with the proposal, plans, specifications and contract forms. He shall acquaint himself with the materials specified and their handling characteristics. In the case of the binder, the Bidder shall, through direct contact with the manufacturer of materials, be thoroughly familiar with the construction procedures recommended by the manufacturer.

II. Qualifications and Requirements.

A. Qualification of Materials:

All materials to be used shall be approved by the Engineer. The Contractor shall submit, with his bid, the following information in writing:

Three (3) copies of a list of all materials to be used, stating the name and address of the supplier(s) of each material.

Three (3) copies of a certification by the manufacturer of the materials to be used, or an approved independent testing laboratory, which establishes that they meet the requirements in this specification.

B. Qualification of the Contractor's Construction Methods:

To establish the ability of the Contractor to perform this work to the satisfaction of the Engineer, the Contractor shall obtain the services of a qualified Advisor

who is employed by the manufacturer of the binder and approved by the Engineer to assist the Engineer and the Contractor as required with the work in connection with this contract.

The epoxy resin manufacturer shall furnish three copies of certification that the contractor has adequate equipment and will receive sufficient technical help from the manufacturer of the resinous material to insure satisfactory performance of the material.

III. Materials.

Epoxy pavement surfacing materials shall conform to the following requirements:

A. Epoxy Cement:

Epoxy cement shall consist of two (2) components hereinafter referred to as Component "A" and Component "B", packaged separately in clean, adequately labeled containers. Each container shall be labeled to identify the component and show the formulation batch numbers. Each component shall be formulated in such a manner that equal parts by volume of the two components, when blended according to the formulator's instruction, will harden into a solid resinous material with the properties herein specified. The two components and their required characteristics shall be as follows:

1. Coal Tar Modified Epoxy Binder:

Component "A" (Modified Epoxy Resin): This material shall be based on a liquid epoxy resin obtained from the condensation of bisphenol "A" and epichlorohydrin. It shall be amber in color and contain no contaminants or insolubles and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD (000-2882)
Viscosity, 77°F, poises	8-16	Addendum No. 1
Epoxide Content, WPE(1)	225-275	ASTM D-1652-59T
Volatile Content, % Volume distilled below 350°F	3 max.	ASTM D-1078-58

(1) Weight per epoxy equivalent or grams material containing one gram equivalent of epoxide.

PROPERTY	SPECIFIC VALUE	TEST METHOD
Water Content, % Weight	0.1 max.	ASTM D-1744-60T

Component "B" (Modified amine hardening agent for use with Component "A"): This material shall be the hardening agent for the modified epoxy resin and shall be a blend of coal tar and an aliphatic polyamine. It shall contain no contaminants and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD
Viscosity, 77°F, poises	2-8	(000-2882) Addendum No. 1
Alkalinity, mg KOH per g	120-140	ASTM D-644-48 (2)
Water Content, % W	0.2 max.	ASTM D-1744-60T
Ash Content, % W	0.5 max.	ASTM D-482-59T
Volatile Content, %Volume distilled below 350°F	3 max	ASTM D-1078-58

2. Properties of Cured Coal Tar Modified Epoxy Binder:

Tests for properties specified in this section shall be performed on castings prepared from the binder components, "A" and "B", after these components have been mixed thoroughly in a 1:1 ratio by weight and allowed to harden for 7 days at 77°F, or 3 hrs or more at 77°F followed by 5-8 hrs in a 140°F oven.

Tensile Properties at 77°F

(ASTM D-638-61T, Type 1 specimen, 0.22 to 0.25 inch thick, testing rate 0.20 to 0.25 inch per minute) ultimate strength, psi	450 min.
Elongation at break, percent	30 min.

Binder Curing Characteristics

Gel Time

Gel Time, minutes	25-50	(000-2882) Addendum No. 2

(2) Titrated to the first end point which will occur at a pH of about 6.3.

3. Oil Modified Epoxy Binder:

Component "A" (Modified Epoxy Resin): This material shall be based on a liquid epoxy resin as obtained from the condensation of bisphenol "A" and epichlorohydrin. It shall be amber in color and contain no contaminants or insolubles and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD (000-2882)
Viscosity at 77°F, poises	55 max.	Addendum No. 1
Epoxide Content, WPE[3]	290-320	ASTM D-1652-59T
Water Content, %W	0.1 max.	ASTM D-1744-60T
Volatile Content, %Volume Distilled below 350°F	3 max.	ASTM D-1078-58

Component "B" (Modified amine hardening agent for use with Component "A"): This material shall be the hardening agent for the modified epoxy resin and shall be composed of a polyamine modified with petroleum oils, flexibilizers and accelerators. It shall contain no contaminants or insolubles and shall have the following characteristics:

PROPERTY	SPECIFIC VALUE	TEST METHOD (000-2882)
Viscosity, 77°F, poises	0.4-0.6	Addendum No. 1
Alkalinity, mg KOH per g	120-140	ASTM D-644-58[4]
Water Content, %W	0.25 max.	ASTM D-1744-60T
Volatile Content, %Volume Distilled below 350°F	3 max.	ASTM D-1078-58

4. Properties of Cured Oil Modified Epoxy Binder:

Test for properties specified in this section shall be performed on castings prepared from the binder components, "A" and "B" after these components have been mixed thoroughly in a 7:6 ratio by weight (equal volumes) and allowed to harden for 7 days at 77°F, or 3 hrs. or more at 77°F followed by 5-8 hours in a 140°F oven.

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(3) Weight per epoxy equivalent or grams material containing one gram equivalent of epoxide.

(4) Titrated to the first end point which will occur at a pH of about 6.3.

Tensile Properties at 77°F

(ASTM D-638-61T, Type 1 specimen, 0.22 to 0.25 inch thick, testing rate 0.20 to 0.25 inch per minute)

Ultimate strength, psi	900 min.
Percent elongation at break	40 min.

Binder Curing Characteristics

(000-2882) Addendum No. 2

Gel time, minutes	30-60

B. Aggregate:

1. Composition:

Aggregates shall consist of clean, hard, durable, non-absorptive particles of crushed materials. They shall be dry (free flowing) and at a temperature of 60° to 95°F at the time of use. Care must be taken to prevent classification of the dry graded aggregate during bulk handling and transportation.

2. Gradation:

The aggregates shall meet the requirements of ASTM C33-57, for concrete subject to abrasion. The appropriate gradations are shown below.

Sieve Size	% Passing by Wt.	% Retained
3/8"	100	0
No. 4	95-100 (a)	0-5 (a)
No. 8	80-100	0-20
No. 16	50-85	15-50
No. 30	25-60	40-75
No. 50	10-30	70-90
No. 100	2-10	90-98
No. 200	0-3	97-100

IV. Sampling and Testing.

The contractor shall furnish affidavits that the epoxy cement components meet specifications. Certification shall refer to batch numbers.

(a) Where completed overlay thickness is less than ½", this requirement should be altered to read 100% passing.

V. Construction Methods.

The resinous material shall be applied to clean, dry, Portland cement concrete to provide a uniform new wearing surface that seals the concrete deck against moisture.

A. Surface Preparation:

The concrete to be overlayed shall be thoroughly cleaned of all paint, oil, grease, road grime and surface laitence. All spalled and scaled areas shall be broken back to sound concrete as determined by the Engineer. Cracks shall be repaired by routing to a minimum width of 3/8" and a minimum depth of ½". Cracks shall be poured with epoxy grout material and this material thoroughly worked into the crack to preclude holidays and voids and to insure adequate wetting of the surfaces for proper adhesion. If spalled, scaled and crack areas must be patched ahead of the overlay to avoid traffic hazards, those areas shall be given sufficient time to cure and shall be sand blasted prior to being overlayed. Spalled and scaled areas and cracks requiring special attention shall be shown on the plans and/or marked on the bridge deck at the time the project is shown to prospective bidders.

1. Sand Blasting:

Portland cement concrete bridge deck to be surfaced shall be sandblast cleaned over the entire area in such a manner as to remove the surface of Portland cement concrete together with all dirt, grease, paint, loose concrete, and other foreign materials, exposing a clean surface of sound concrete which will receive the epoxy resinous cement. Sandblasting equipment shall be equipped with suitable traps and filters to prevent water and oil from being deposited on roadway surfaces. After sandblasting, roadway surfaces shall be swept or vacuumed and cleaned of all grit, dust and other foreign materials before application of epoxy cement binder. Metal surfaces shall be sandblast cleaned to white metal as provided above for Portland cement concrete bridge deck. Sandblast sand shall be clean and sharp and of a grading effective in obtaining the specified results.

2. Special Cleaning:

Special cleaning may be required in areas having heavy

local deposits of oil, grease, tar, traffic paint, grime, dirt, etc., which may prevent proper cleaning by the method outlined above. These areas shall be completely cleaned by use of trichloroethylene, perchloroethylene, xylene, or other solvents approved by the Engineer, or by mechanical scrapers or scarifiers, or by heavy-duty detergents.

B. Proportioning and Mixing Epoxy Resinous Cement:

Components "A" and "B" shall be thoroughly blended in equal parts by volume within plus or minus 2 percent accuracy before they are charged in to the mixer.

Care shall be taken to avoid errors due to clingage in the containers. The "A" and "B" components of the binder shall be thoroughly and completely mixed, using a mixer employing rotating drums (KOL, Incorp., Model M-60, or equal), a heavy-duty electric drill equipped with mixing propeller or other approved device such as a Jiffy Mixer. Mixing time shall not be less than five minutes for each batch. Mixing temperature shall not exceed the maximum of 90°F or a minimum of 60°F.

The exact binder content of the mixture shall be as set by the Engineer based upon the specific aggregate employed in the project within the range of binder contents lying between 13.5-16 parts by weight of binder to 100 parts by weight of aggregate.

Mortar shall be prepared in a paddle-type mixing device (conventional plaster or mortar mixer with horizontal shaft or equal). The clean dry aggregate shall be accurately measured by weight or volume and shall be charged into the mixer, followed immediately by the slow addition of the required amount of binder. Mixing shall be continued until the mixture is homogeneous.

C. Placing of the Mixture:

Application of epoxy surfacing on any area shall commence only if the Engineer believes the epoxy overlay will be sufficiently cured to meet the specified penetrometer hardness requried by field control tests by the time such area must be reopened to traffic. Unless specifically directed otherwise by the Engineer application shall proceed only when the ambient and deck temperatures are 70°F or above.

1. Forming:

The area to be overlayed shall be divided into individual strips of a width suitable for the screeds involved. Such widths shall be placed in a single pass of the paving screed, and shall, prior to placement, be defined by placement of suitable forms. The forms shall either be of sufficient length to run the entire length of the area to be paved or shall be easily removable so that they may be carried ahead of the screed as the paving operation advances, and shall be of sufficient strength and durability to carry the weight of the screed without being damaged. These forms shall be of such a height above the surface to be overlayed as to provide a pair of reference lines for determining the specified thickness of overlay.

2. Screeding:

The mortar shall be transported to the paving site in suitable vehicles, (e.g. wheelbarrows or concrete buggies) and dumped between the forms in front of the screed. The mortar shall then be roughly spread using an asphalt rake, then finished and compacted with a vibrating screed of a design approved by the Engineer.

The screed shall be operated so as to move smoothly and continuously forward, and shall so place the mixture as to completely fill the area between the forms. The finished surface shall have a uniform, non-skid texture and shall be true to line and grade and shall be a minimum of ¼" thick.

Holidays or areas of non-uniformity shall be immediately repaired with hand trowels, using fresh mix.

D. Spalled Areas:

Where spalled areas exist in the deck to be overlayed, it is not necessary to carry out a separate patching operation prior to the overlay placement. However, areas which are spalled below the reinforcing steel shall, at the discretion of the Engineer, be partly filled with fresh mix to a level above the steel, and lightly hand tamped. This filling

operation shall be carried out immediately prior to the passage of the screed and in no case shall be done earlier than one hour before the screeding operation.

E. Joints:

1. Expansion Joints:

Deck armor angles and other metal parts with exposed wearing surfaces shall receive overlay except that drain openings and steel expansion joints in the concrete deck shall be protected with heavy kraft or building paper, securely fastened to the plate with masking tape or other suitable means. Following passage of the screed, the mix shall be removed from the protected area. The joint may either be raised to meet the new grade, or the mix feathered back on either edge by hand trowelling to give a smooth transition as specified on the plans.

2. Paving Joints:

Where a screed pass adjoins a previously placed section of overlay, the form on that side shall be replaced by a suitable piece of steel flat stock placed on the previously-placed section. Where the previously placed section is more than eight hours old, the edge shall be lightly sandblasted prior to placement of the adjacent lane. The screed shall be so operated as to leave a level tight joint.

Prior to placement of the second lane, the engineer shall establish that the previously placed section is sufficiently cured to bear the weight of the screed in the placement operation (normally about two hours). Where the screed-placed material leaves holidays, excess mortar or porous areas in the joint, repairs shall be made immediately following the screed using hand finishing techniques.

Where it is necessary to halt the paving operation, during a pass, the end of the existing pass shall be squared off to leave a vertical face for a butt joint when paving is resumed.

If the uncompleted lane must be open to traffic, and the specified overlay depth is thick enough to require a transition section, then the mortar shall be hand finished to

give a 45° bevel in the transverse section. If the resumption of paving is delayed overnight, either the beveled or butt edge shall be lightly sand-blasted prior to starting the paving operation. Due to the self-tacking nature of the mortar mixture, care should be taken to completely remove any epoxy film from the surface prior to startup.

F. Curbs:

Where the lane to be paved abuts a curb line, the mortar shall be brought tightly against the curb by use of a suitable device attached to the screed, or by hand-coving of fresh mix.

VI. Field Control Tests.

A. Soundness and Cleanliness of Portland Cement Surfaces:

The Engineer shall establish that the Portland cement concrete meets the requirements for the cleanliness and soundness of Portland cement concrete surfaces.

B. Material Quality:

Each binder component to be used on this project may be sampled and tested by the Engineer in accordance with test procedures described in these specifications. Any materials not considered satisfactory by the Engineer shall not be used in this work and shall be taken from the premises. The Engineer shall have the authority to postpone all work at any time for the purpose of obtaining gel time or other data as herein specified to establish satisfactory quality of the resinous cement.

C. Overlay Curing:

The seal coat shall be opened to traffic only at the direction of the Engineer and only after the maximum scale reading, 4.5, is obtained on a "Pocket Penetrometer, Model CL-700"(5), when the instrument is pushed into the overlay at a 30° angle to the roadway surface.

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(5) Manufactured by Soilest, Inc., 4711 W. North Ave., Chicago 39, Illinois.

D. Overlay Quality:

Should the Engineer have reason to doubt the quality of the overlay applied to Portland cement roadway surface, i.e., the bond of the overlay to the roadway surface, or the strength of the binder, he may perform tests described in Addendum No. 3, "Test for Determining Cleanliness and Soundness, etc.". The area in which the tests are to be run shall be decided by the Engineer. The test procedure provides useful information as to the nature and strength of the existing bond between the seal coat and the pavement. If after sufficient testing and analysis of the results the bond is unsatisfactory in the judgment of the Engineer, the Contractor shall, if so directed by the Engineer, remove and replace at his own expense the unacceptable overlay or perform at his own expense other remedial action satisfactory to the Engineer, to render the overlay acceptable. The epoxy supplier will at the request of the Engineer supply data and test values at its disposal for his comparative analysis.

VII. Measurement.

Epoxy overlay shall be measured by the square yard complete in place.

VIII. Payment.

The work performed as prescribed in this item, measured as provided under "Measurement" will be paid for at the unit price bid for "Epoxy Overlay" which price shall be full compensation for furnishing all labor, tools, equipment, materials, cleaning, preparation, handling of traffic and incidentals necessary to complete the work.

The Contractor shall guarantee the overlay against stripping due to workmanship or material failure for a period of one year from the date of overlay completion.

TEXAS HIGHWAY DEPARTMENT

SPECIAL PROVISION

IMPORTANT NOTICE TO CONTRACTORS

ADDENDUM 1

DETERMINATION OF VISCOSITY USING BROOKFIELD VISCOMETER

SCOPE

This test method is intended to determine the absolute viscosity of liquid resins, curing agents, and other materials in the 20 to 2,000,000 centipoise (0.2 to 20,000 poise) range. Unless otherwise specified, it is determined on materials preconditioned to 77°F.

APPARATUS

1. Brookfield Synchro-Lectric Viscometer[1] (Model LVT preferred, but RVT, LVF, and other models of suitable range may be substituted)

This is a rotating spindle viscometer which employs four interchangeable spindles. The unit has an adjustment to provide eight rotational speeds ranging in steps from 0.3 to 60 rpm. Four cylindrical spindles of varying length and diameter are provided to cover a range of 0.2 to 20,000 poises. The torsional shear force is measured by a spiral spring linking the spindle to the motor and is indicated on a rotating dial reading from 1 to 100 units. The proper factor for the speed and spindle used must be employed to convert the scale reading to centipoises.

2. Containers

The liquid is placed in a container of such size that at least one inch of clearance is provided between the bottom and sides of the spindle and the vessel when the spindle is immersed to the proper depth in the liquid.

3. Constant Temperature Apparatus

Some means of providing a temperature of 77°F ± 1°F (25°C ± 1/2°C) (unless otherwise specified). A constant temperature room is preferred, but a constant temperature water bath may be used.

TEST SPECIMENS

Representative samples shall be taken from the containers provided. Any evidence of separation of solid or liquid layers shall be noted, then the material shall be stirred to obtain a uniform sampling. Samples shall be

[1] Brookfield Engineering Laboratories, Stoughton, Massachusetts.

stored in a suitably sized (see above) closed container long enough to come to the specified temperature before testing. In no case shall the sample be less than four ounces.

PROCEDURE

An appropriate spindle is selected with the aid of the table below plus knowledge regarding the approximate viscosity of the material being tested. Since for a given viscosity there may be up to eight combinations of spindle size and speed that may be used, first the largest applicable spindle that may be used is selected, then the fastest speed that can be used with this spindle is employed. The consistent use of identical speeds and spindles for given viscosity ranges will eliminate deviations caused by variations in non-Newtonian fluids. Attach the spindle to the lower end of the motor shaft. With disc type spindles, the spindle is first immersed in the liquid at an angle to eliminate air bubbles, then screwed onto the shaft. Attach the guard to the motor housing, then adjust the height to bring the liquid level to the indentation in the spindle. Level the instrument. Start the motor and set for proper speed from the table below. Take periodic readings on 0-100 scale until a constant value is obtained. At higher speeds, it will be necessary to stop the indicating needle by using the clutch, then switching off the motor. Start the motor for the next reading before releasing the clutch. When a constant scale reading is obtained, convert the scale reading to poises by multiplying by the proper factor from the table below:

REPORT

The report shall include:

1. Complete identification of the material.
2. The viscosity in poises.
3. The temperature of the liquid at the time of testing
4. The viscometer spindle and speed used.
5. Date of testing.

	SPEED AND SPINDLE TO BE USED		
VISCOSITY, POISES	SPINDLE	SPEED	FACTOR
0.2-0.4	1	60	0.01
0.4-2.0	1	30	0.02
2.0-10	1	6	0.1
10-50	2	6	0.5
50-200	3	6	2.0
200-800	4	6	10.0
800-4,000	4	1.5	40.0
4,000-20,000	4	0.3	200.0

ADDENDUM 2

GEL TIME DETERMINATION

The gel time test is meant to be a fast and simple method of determining the general quality of the resinous cements. The resulting cure time does not bear a direct relationship to cure time of the resinous cements on the roadway surface.

Samples of both resinous cement components are conditioned at 77 ± 2°F. When the samples have reached 77 ± 2°F, the proper quantity of each component (A and B) is weighed into an unwaxed paper cup. The total sample shall weigh 60 ± 0.2 grams. The weight ratio of A to B shall be the proper ratio for the particular material being tested. The time is recorded and they are immediately mixed, stirring for three minutes with a wooden tongue depressor or equivalent, taking care to periodically scrape the walls and bottom of the cup and the stirrer. The sample is then set on a wood bench top, and probed every two minutes with a small stick starting twenty minutes from the time of mixing. The time at which a soft ball forms in the center of the container is recorded as the gel time.

ADDENDUM 3

TESTS FOR DETERMINING CLEANLINESS AND SOUNDNESS OF PORTLAND CEMENT SURFACES AND QUALITY AND ADHESION OF SEAL COATS OR THIN OVERLAY PAVEMENTS

SCOPE

This test is designed for use in the field or laboratory to develop quantitative data essential to the proper application and evaluation of resinous cement overlays. The following conditions can be tested:

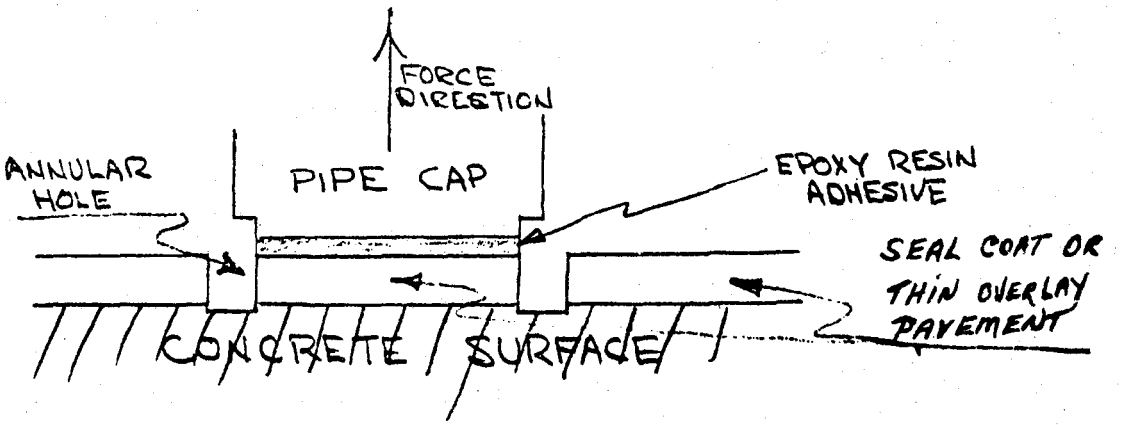
1. Adhesion of the finished seal coats or thin overlay pavements to concrete, soundness of the underlying surface and strength of the resinous cement.
2. Cleanliness of the concrete, which affects the adhesion of the seal coats or thin overlay pavements.
3. Soundness of the concrete surface, on which the thin overlay pavements or seal coats depends for support.

SUMMARY OF PROCEDURE

The test is carried out by bonding a pipe cap firmly to a resinous cement overlay on a Portland cement concrete roadway surface or directly to the roadway surface and applying a force which pulls it vertically away from the roadway. When the test is intended to determine the quality of the seal coat or thin overlay pavement, the pipe cap is bonded to an isolated island (created by a core drill) in the overlay or seal coat. When the test is intended to evaluate the cleanliness or soundness of a concrete surface, the pipe cap is bonded directly to that surface.

The sketch below illustrates that when the pipe cap is properly bonded to the seal coat or overlay the upward vertical force will result in one or a combination of the following types of failure:

1. Cohesion in the seal coat or thin overlay.
2. Adhesion between the seal coat or overlay and the concrete surface.
3. Cohesion of the concrete surface.



Thus, by inspection of the failed area after the test, it is possible to determine the weakest link in this chain. By calculating the stress required to cause this failure, it is possible to determine whether minimum standards are met.

Improper or unsatisfactory cleaning of the concrete surface is indicated by an adhesion failure between the adhesive and the Portland cement concrete surface. The pressure required to cause failure in the concrete surface indicates the relative strength of that surface and whether or not it will properly support a resinous cement overlay.

APPARATUS (see attached photographs and drawing)

1. Pipe cap and hook

   A pipe cap for 1-1/2-inch nominal pipe is faced smooth on a lathe and a shoulder cut to provide a 2-inch diameter surface in the smooth face. A hook 3-1/2 inches long is made by welding a J-shaped piece of 1/2-inch diameter steel rod to a 1-1/2-inch pipe plug. The hook can then be easily screwed into the pipe cap as shown in Figure 1.

2. Jack housing

   A jack housing 21 inches high is made from a 4-inch diameter thin wall pipe as shown in Figure 5. This housing positions the dynamometer and provides for the application of a upward vertical pull on the pipe cap. The equipment is not commercially available but can be made by most machine shops from the dimensions shown in Figure 1.

3. Dynamometer

   A maximum reading dynamometer(1) fitted with 1-inch diameter eyes is used to measure and record the force needed to remove the pipe cap from the surface.

EQUIPMENT AND MATERIALS

1. Coring drill bit

   When the tester is used to measure the adhesion of a resinous cement overlay to concrete, an island of overlay is isolated by using a core bit to cut through the overlay. This operation provides for more consistent value by eliminating the necessity to shear the overlay. A tungsten carbide tipped 2-3/4-in. core bit(2) is used to make the annular cut.

(1) Dillon model AN, 0-2500 lb. dynamometer, W. C. Dillon and Company, Van Nuys, California.
(2) New England Carbide Tool Company, Incorporated, Medford, Massachusetts.

2. Drill stand

A bench drill stand(1), which operates on the drill press principle as shown in Figure 3, positions the drill bit and holds the electric motor(2) which drives the drill bit.

3. Epoxy resin adhesive

Any high strength, fast-setting, epoxy resin adhesive(3) is used to bond the pipe cap to the surface to be tested.

4. Heating torch

A conventional gasoline blow torch or liquefied propane burner is used as a heat source to speed the cure of the adhesive.

5. Surface pyrometer

A portable 0-500°F pyrometer fitted with a surface measuring head is used to determine the temperature of the heated pipe cap.

6. Spatula

A metal spatula such as those sold for kitchen use is used to mix the epoxy resin adhesive and apply it to the pipe cap and the surface to be tested.

7. Wire brush

A clean oil-free wire brush is used to roughen up and clean (in conjunction with xylene) surfaces to which the epoxy resin adhesive must bond (pipe cap, cement, and resinous cement overlay).

8. Xylene

Xylene is used to clean pipe cap and surfaces to which the epoxy resin adhesive must bond prior to the application of the adhesive. The solvent is also used for clean up.

9. Rags

Clean rags are required for solvent wiping the pipe cap and surfaces to be tested as well as for clean up.

(1) Model 60, Black and Decker, Towson, Maryland.
(2) Model 499, Black and Decker, Towson, Maryland.
(3) Most two package epoxy resin adhesives available in hardware stores are suitable.

10. Patching materials

After the tests are completed, it may be desirable to fill the small holes left in the roadway surface. A mixture of sand and the epoxy resin adhesive may be used unless it is desirable to closely match the color of the tested surface. In this latter case, suitable resinous cements and aggregates must be available.

CHOICE OF TEST SITES

It is important to locate areas for testing which are representative of the entire area in question. For instance, in evaluating the cleanliness of Portland cement concrete roadway surface, it will be necessary to run tests in the tire tracks, between the tire tracks, and along the gutters. Each of these areas may have a different type and degree of surface comtamination.

TEST PROCEDURE FOR EVALUATING SEAL COATS OR THIN OVERLAY PAVEMENTS

The drill and drill stand are set up on the overlay as indicated in Figure 2. A 2-inch annular hole is drilled through the coating and just down to the concrete base (see Figure 3). An isolated island of the seal coat or thin overlay pavements, 2 inches in diameter, is thereby created.

The pipe cap and the surface to which it will bend are then prepared for bonding with the epoxy resin adhesive. A wire brush and a clean cloth dipped in xylene are used alternately to remove all contaminants from the surfaces. The adhesive is applied to the overlay and to the pipe cap with a spatula. The epoxy resin manufacturer's mixing and application procedures should be followed carefully. (Heating the pipe cap before application of the epoxy resin adhesive, see Figure 4, facilitates spreading of the adhesive.) The pipe cap is then positioned on the isolated island in the roadway surface. The torch flame is directed into the well of the pipe cap in such a way that the flame does not reach the pavement. The pipe cap is heated to 275°F (the temperature is checked with a surface pyrometer), and under these conditions the adhesive will harden rapidly. The pipe cap is then allowed to cool to air temperature. Thirty minutes should be allowed for cooling or the pipe cap checked with a pyrometer to insure cooling process has been completed. Tests should not be conducted when roadway surface temperature is over 80°F.

When the pipe cap has reached air temperature, the testing apparatus is positioned over it. The lower hook is screwed into the threaded pipe cap and is connected to the lower loop in the lower portion of the dynamometer. The upper hook is screwed into the loading arm at the top of the cylindrical housing. The hook fits into the upper loop of the dynamometer. To apply the proper loading, the handle is rotated at a speed required to apply tension to the pipe cap at the approximate rate of 100 pounds every 5 seconds.

The upward vertical force applied to the pipe cap will result in one or a combination of the following types of failures:

1. Adhesion between epoxy resin adhesive and pipe cap.

2. Cohesion of epoxy resin adhesive.

3. Adhesion between epoxy resin adhesive and the thin overlay pavement or seal coat.

4. Cohesion in seal coat or thin overlay pavement.

5. Adhesion between seal coat or thin overlay pavement and concrete surface.

6. Cohesion of concrete surface.

Since the purpose of this test is to determine the stress required to cause failures of the types 4, 5 and 6, the test should be rerun if failures of types 1, 2 or 3 result. Continued failures in the adhesive or the bond of the adhesive indicate an improper adhesive or technique for applying the adhesive is being used. Failures of types 1 and 3 could be caused by improper cleaning of the pipe cap or the roadway surface prior to application of the adhesive.

Repeated failures of type No. 4 indicate poor quality of the seal coat or overlay or that the pipe cap has not been allowed to cool sufficiently before the tests are conducted.

When the test is completed, the maximum tensile load developed before failure is recorded. Also recorded is the nature of the failure which is described by stating the percentage of the cross section of the break which reveals failure in the seal coat or overlay, in adhesion between the seal coat or overlay and concrete, and/or in the concrete roadway surface. Typical example of data recorded would be:

Maximum tensile loading - 545 pounds.
Type of failure - 85% concrete pavement, 10% adhesion, 5% overlay (or seal coat)

After the tests have been completed and the data recorded, the small holes created by the test plugs can be easily patched with a mortar made from the epoxy resin adhesive and sand or a mortar consisting of binder and sand.

PROCEDURE FOR EVALUATING SOUNDNESS OF PORTLAND CEMENT CONCRETE SURFACES

To test the surface soundness of concrete, a 4-inch by 4-inch area of surface is cleaned to remove contaminants which may prevent a good bond between the concrete and the epoxy resin adhesive. This is accomplished by alternately scrubbing with a wire brush and wiping with a clean rag dipped in xylene. Without cutting the annular hole as described in the above

procedure, the 1-1/2-inch pipe cap is bonded directly to the surface in the center of the 4-inch by 4-inch area. The test is then performed as described in the above procedure.

If the test results in failure in cohesion of the epoxy resin adhesive or any failure in adhesion, the test should be repeated. Repeated failures in adhesion or cohesion in the adhesive indicate improper adhesive or adhesive application techniques are being employed.

The maximum tensile load developed before failure is recorded.

PROCEDURE FOR TESTING CLEANLINESS OF PORTLAND CEMENT CONCRETE SURFACE

Without drilling an annular hole, a pipe cap is bonded directly to the previously cleaned concrete surface. Since the purpose of this test is to evaluate the cleanliness of a surface, no surface preparation shall be undertaken. The pipe cap is cleaned by alternately scrubbing with a wire brush and wiping with a clean cloth dipped in xylene. Adhesive is applied to the pipe cap and the concrete surface and the pipe cap positioned as in the above procedures. The test is then carried out as described above.

Failures in the bond between the pipe cap and the adhesive or cohesive failures in the adhesive nullify this test. As discussed above, repeated problems of this type indicate improper adhesive or adhesive application techniques.

When the test has been run, maximum tensile load is recorded. Also recorded is the percentage of failure occurring in the concrete and the percentage of adhesion failure.

PROCEDURE FOR TESTING IN A LABORATORY

When this test is used in the laboratory, a universal testing machine may be substituted for the jack housing and dynamometer. The test procedure can be used for evaluating the adhesion and relative tensile properties of resinous cement overlays. Substrates for the seal coats or overlays to be tested may be well cured Portland cement concrete, patio blocks of suitable strength, or other suitable materials.

CALCULATIONS AND RESULTS

The tensile load indicated on the dynamometer gauge is recorded. This is converted into unit stress (psi) according to the following formula:

$$\text{Tensile strength (psi)} = \frac{L}{A}$$

Where: L = tensile load
A = surface area (3.14 sq. in.)

Sample calculation:

Suppose a tensile load of 1,260 lbs. was observed on the dynamometer gauge. The surface area being 3.14 sq. in. we substitute in the above formulation.

$$\text{Tensile strength (psi)} = \frac{1260}{3.14}$$

$$\text{Tensile strength} = 401.3 \text{ psi}$$

As shown in Figure 6, the type failure as % of total area is also recorded.(1) The various type failures possible are defined as follows:

1. Adhesion failure - The bond between the island of resinous cement overlay on the concrete fails. No concrete on pipe cap.

2. Concrete failure - The failure caused by breaking in the concrete.

3. Cohesion failure - The failure due to the seal coat (or thin overlay pavement) separating between the pipe cap and the concrete base.

When this last method is to be used to evaluate the Portland cement concrete or mortar surface prior to the application of the seal coat or overlay, much the same procedure is followed.

(1) The test in Figure 6 resulted in "100% concrete failure". Another example of failure would be "75% concrete failure, 25% adhesion failure, and 5% cohesion failure.

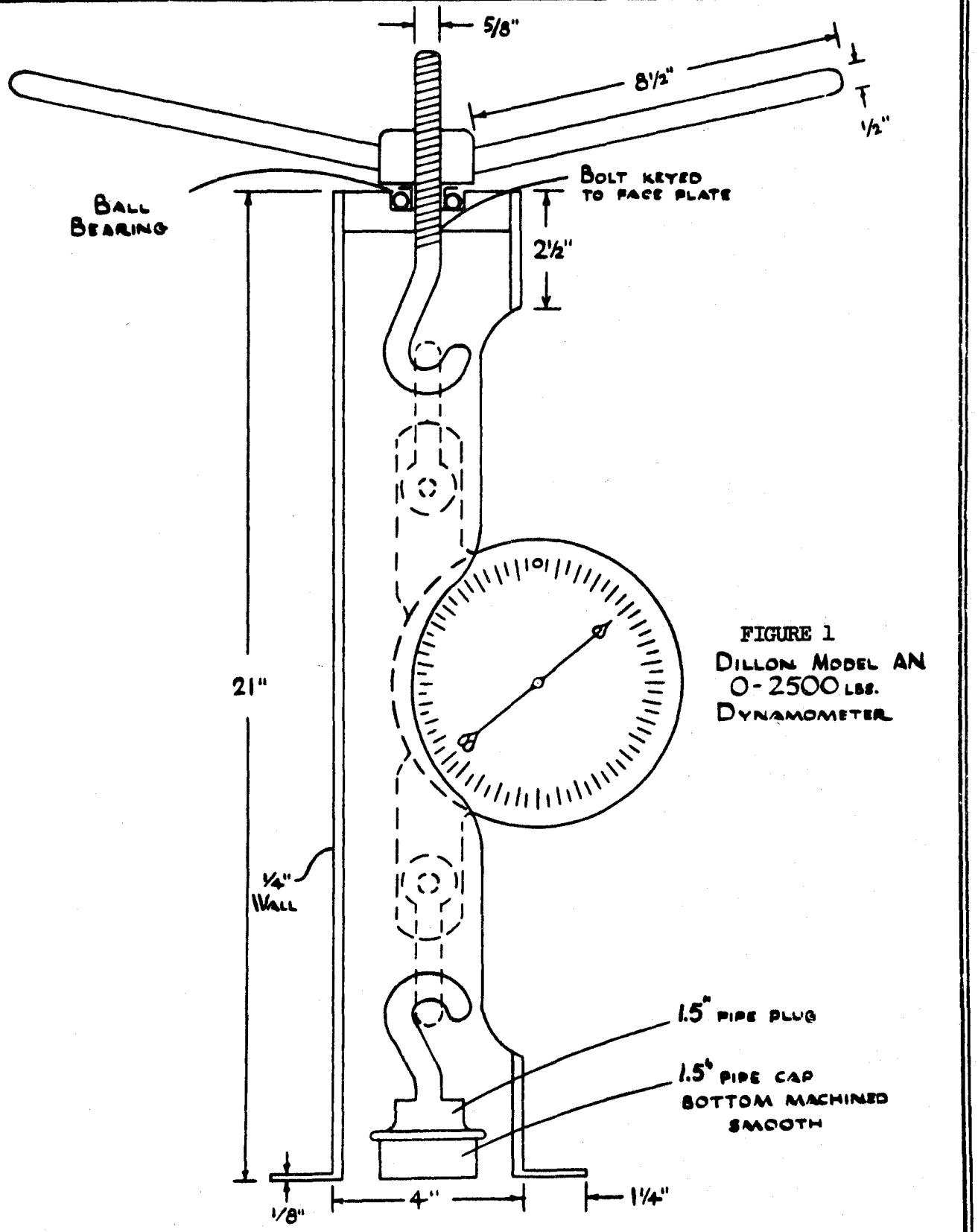


FIGURE 1
DILLON MODEL AN
0-2500 LBS.
DYNAMOMETER

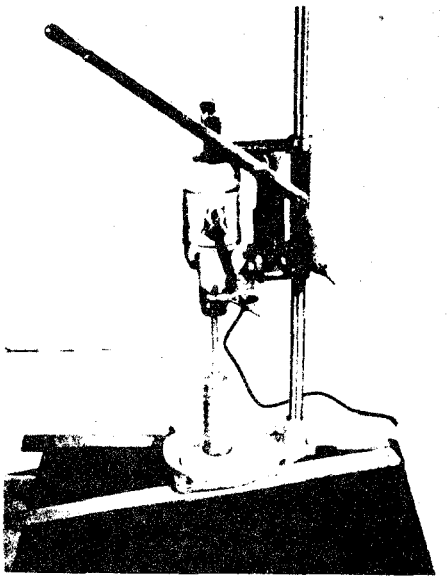


FIG.2 CORE DRILL USED TO CUT THROUGH OVERLAY PRIOR TO TESTING.

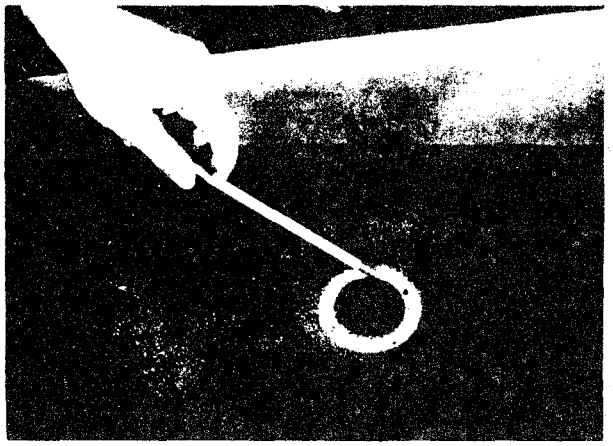


FIG.3 ISOLATED TEST AREA OF RESINOUS OVERLAY.

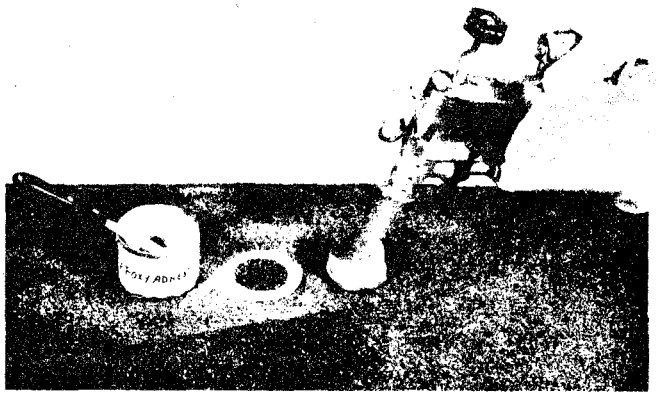


FIG. 4 BONDING THE PIPE CAP TO THE TEST AREA.

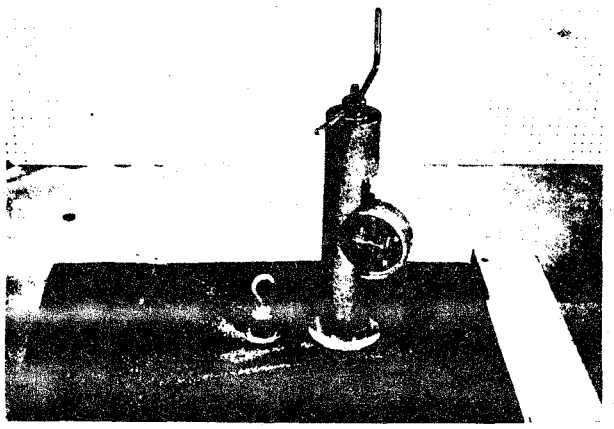


FIG. 5 TENSILE TEST UNIT USED TO PULL PIPE CAP FROM THE SURFACE.

FIG. 6 PIPE CAP AFTER PULLING SHOWING AGGREGATE SPLIT DURING FAILURE OF THE CONCRETE.