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NATIONAL BUREAU OF STANDARDS REPORT

10 655

SPECIFICATIONS FOR RESINOUS FLOORING — REQUIREMENTS AND TEST METHODS

NBS

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
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NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT 4216448

December 7, 1971

NBS REPORT 10 655

SPECIFICATIONS FOR RESINOUS FLOORING – REQUIREMENTS AND TEST METHODS

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Sponsored by
Office of the Chief of Engineers, U. S. Army
Directorate of Civil Engineering, U. S. Air Force
Naval Facilities Engineering Command, U. S. Navy

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SPECIFICATIONS FOR RESINOUS FLOORING - REQUIREMENTS AND TEST METHODS

INTRODUCTION

At the request of the U. S. Army, Office of the Chief of Engineers (OCE), The Building Research Division (BRD) reviewed the Guide Specifications for Military Construction dealing with resinous flooring, described in Part 1 of the report. Since the Building Research Division had not investigated the properties of the resinous systems covered by these specifications, BRD requested a review by a technical committee of the American Society for Testing and Materials (ASTM). This is Committee C-3 on CHEMICAL-RESISTANT NONMETALLIC MATERIALS and includes Subcommittee S-4 on Monolithic Surfacings. Subcommittee S-4 has prepared TENTATIVE SPECIFICATION FOR RESINOUS CHEMICAL RESISTANT MONOLITHIC SURFACINGS, in the process of letter ballot for adoption as a Tentative Standard by the Committee. This Tentative Specification is described in Part 3 of this report. The OCE Guide Specifications are based on specifications by The National Terrazzo and Mosaic Association, Inc. (NTMA), described in Part 2 of this report. These NTMA specifications are based in turn on ASTM Standards, Federal Test Method Standard No. 406, military specifications, and private sources. The NTMA specifications for polyester terrazzo are based largely on Military Specification MIL-F-52505, while the Latex Terrazzo specification is derived from MIL-D-3134F.

The review of the OCE Guide Specifications by the ASTM C-3 Committee, Section 1.2 of this report, cited differences between values for physical properties in the Guide Specifications and those in their own Tentative Specification. In an attempt to resolve this conflict, BRD measured some of the important physical properties of two mixes of standard Ottawa sand and two flooring resins. One of these resins is an epoxy resin or prepolymer and a curing agent, a combination recommended by the manufacturer for monolithic surfacings. The manufacturer is one of the most important in petrochemicals and in epoxy resins and curing agents in particular. The other resin is a polyester resin with peroxide catalyst, also recommended by the manufacturer for monolithic surfacings.

1.0 Corps of Engineers Guide Specifications for Resinous Flooring. First Drafts

Drafts of four such specifications were sent to BRD 22 July 1970 with a letter explaining that these are used as a basis for preparing contract specifications for military construction projects. Comments on these specifications were submitted in a letter to Mr. Nyal Nelson, OCT, 12 August 1970. After the specifications had been reviewed by ASTM Committee C-3, their comments were transmitted in a letter to Mr. William Darnell 23 September 1970. The four OCE Guide Specificatons were approved April 1971 with minor changes but with the same references for physical properties.

1.1 Comments on Corps of Engineers Draft Guide Specifications

Comments submitted by BRD were as follows:

(1) The needs of the Services would be best served by a performance type specification for resinous floors, if such is practicable at the present time. An effort in this direction is the enclosed Draft No. 4, TENTATIVE SPECIFICATIONS FOR RESINOUS CHEMICAL RESISTANT MONOLITHIC SURFACINGS, prepared by ASTM Committee C-3, Subcommittee S-4, hereafter referred to as ASTM Specification.

(2) The four Corps of Engineers Specifications are redundant and should be combined into one specification. The four types of resinous flooring could then be specified as Types I, II, III and IV.

(3) The Corps of Engineers Specifications are based on the NTMA specifications, which give architectural and engineering details lacking in the ASTM specification. Also, explanations are given in the NTMA specifications for procedures and tests.

(4) In both the NTMA and ASTM specifications, different tests are used and different values required for different resin systems. In a performance specification, tests would be selected which correspond to performance requirements and acceptable values would be those required in service. For example:

(a) In the NTMA SPECIFICATION FOR EPOXY RESIN TERRAZZO, section 1.10 prescribes PERFORMANCE AND PROPERTIES OF EPOXY MATRIX (with no marble chips or fillers added). In the NTMA SPECIFICATION FOR POLYESTER RESIN TERRAZZO there are no such requirements for polyester matrix.

(b) In the NTMA SPECIFICATION FOR POLYESTER RESIN TERRAZZO, section 1.10 PERFORMANCE AND PROPERTIES prescribes curing time, shrinkage resistance, chemical resistance, fumigant resistance, abrasion resistance, hardness, porosity, accelerated weathering resistance, fungistatic and bacteriostatic resistance, ultraviolet light resistance, thermal shock resistance, and stain resistance, which are lacking in NTMA SPECIFICATION FOR EPOXY RESIN TERRAZZO, section 1.11, PERFORMANCE AND PROPERTIES OF EPOXY RESIN TERRAZZO, although some of these factors are found in section 1.10 PERFORMANCE AND PROPERTIES OF EPOXY MATRIX. On the other hand, a bond strength test is prescribed for epoxy resin terrazzo but not for polyester resin terrazzo. The impact resistance of epoxy resin terrazzo must be 16 foot pounds when tested by a two pound falling ball, while the polyester terrazzo is required to pass a Gardner impact test of 144 inch pounds. Why should one resin terrazzo be required to pass a more stringent or a different test than another?

(c) In the ASTM specification, compressive strength requirements vary from 4,000 to 10,000 psi depending on the type of resin, while flexural strength requirements vary from 750 to 1,500 psi.

1.2 Review of Guide Specification by ASTM

ASTM Committee C-3 would comment on only one of the four OCE Guide Specifications, INDUSTRIAL RESINOUS FLOORING. The others,

DECORATIVE RESINOUS FLOORING
CONDUCTIVE RESINOUS TERRAZZO FLOORING
CONDUCTIVE SPARKPROOF INDUSTRIAL RESINOUS FLOORING

were considered to be outside the scope of the Committee, limited to chemical resistant monolithic surfacings more than 1/16-inch or 60 mils thick. Comments of the Committee on GUIDE SPECIFICATION FOR INDUSTRIAL RESINOUS FLOORING were as follows, referring to numbered paragraphs or sections of the July 1970 draft:

1.1 The Subcommittee does not agree with the values for the physical properties in the NTMA Specification Details. Values recommended by the Subcommittee are found in Table 1 of the enclosed Draft No. 4, TENTATIVE SPECIFICATIONS FOR RESINOUS CHEMICAL RESISTANT MONOLITHIC SURFACINGS, March 10, 1970.

n, d 2. GENERAL. The question was raised as to temperature of storage but members agreed that epoxy resins, at least, are designed to be stored at temperatures as low as 50°F. However, the temperature should be at least 65°F. for installation.

2.1, 2.2, and n, d 3.5. Divider strips are not needed for industrial resinous flooring and if exposed to corrosive chemicals, may be detrimental.

3.1 Primer is not always required with epoxy flooring. The primer, if required, is not necessarily dry or cured before the resin surfacing is applied.

3.2 The term "thermosetting" is unnecessary since epoxy resins are all thermosetting. The degree of thixotropy of polyester resins is important and epoxy resins should have a degree of thixotropy.

3.3 The terms "catalyst" and "curing agent" are better than "catalyzer". Actually, peroxides used with polyester resins are initiators rather than catalysts, since they are not recoverable. Curing agents or hardeners used with epoxy resins are reactants, not catalysts, and are added in stoichometric amounts. However, "catalyst" and "curing agent" are terms used by the industry.

3.4 Cellulosic materials are not commonly used as fillers in resinous flooring compositions. The size 3/16-inch for filler seems fairly coarse. The maximum diameter of the aggregate must not be more than half the thickness of the surfacing, which is specified in 6.2 as from 3/16 to 5/16 inch.

3.6 and 3.7 Sealer is not needed in industrial resinous flooring and if sealer is used the flooring will not be non-slipping or non-yellowing.

5 A curing period of 28 days is adequate but ASTM recommends a shorter period.

6.3 It is necessary to add a thickener to the mix for coving.

NOTES, No. 5. Both epoxy and polyester surfacings should be suitable in areas where there are sources of heat. Sources of heat should be better defined, as the temperature, temperature differential, or cycling.

1.3 Guide Specifications Issued by the Corps of Engineers

The Corps of Engineers did not issue a Guide Specification on DECORATIVE RESINOUS FLOORING but issued an additional Guide Specification on RESINOUS TERRAZZO FLOORING. The four Guide Specifications issued April 1971 are:

CE 244.02, RESINOUS TERRAZZO FLOORING

CE 244.03, INDUSTRIAL RESINOUS FLOORING

CE 244.04, CONDUCTIVE RESINOUS TERRAZZO FLOORING

CE 244.05, CONDUCTIVE SPARKPROOF INDUSTRIAL RESINOUS FLOORING

Only those portions of the Guide Specifications relating to requirements and test methods will be discussed in this report.

1.3.1 OCE Guide Specification CE 244.02, RESINOUS TERRAZZO FLOORING

Reference to requirements and test methods: NTMA Specifications

Epoxy Resin Terrazzo (Section 2.3 of this report)

Polyester Resin Terrazzo (Section 2.4 of this report)

In 5.1 of CE 244.02: Epoxy flooring system: The epoxy matrix with no chips or fillers shall conform to PERFORMANCE AND PROPERTIES OF EPOXY MATRIX of Specification for Epoxy Resin Terrazzo except that the requirements of weight loss and dimensional change on the specimens subjected to the chemical resistance tests shall not apply. The epoxy matrix with aggregate and/or filler shall conform to PERFORMANCE AND PROPERTIES OF EPOXY RESIN TERRAZZO of Specification for Epoxy Resin Terrazzo.

In 5.2 of CE 244.02: Polyester flooring system shall conform to PERFORMANCE AND PROPERTIES of Specification for Polyester Resin Terrazzo.

In Section 2 of CE 244.02, storage of materials is specified at minimum temperature of 50°F. and installation temperature 60°F. Divider strips are specified, as this is not a specification for industrial or corrosion resistant flooring. Primer is specified but it is not required to be dry before application of the topping. Catalyzer or hardener is specified in place of catalyzer. Aggregate specified is a blend of marble chips consisting of a range of sizes up to and including an NTMA Standard No. 1 chip.

1.3.2 OCE Guide Specification CE 244.03, INDUSTRIAL RESINOUS FLOORING

Review of CE 244:03: Sections 1.1 and 1.2 of this report

Reference to requirements and test methods: NTMA Specifications

Epoxy Resin Terrazzo (Section 2.3 of this report)

Polyester Resin Terrazzo (Section 2.4 of this report)

In 5.1 of CE 244.03: Epoxy flooring system. The epoxy matrix with no chips or fillers shall conform to PERFORMANCE AND PROPERTIES OF EPOXY MATRIX of Specification for Epoxy Resin Terrazzo except that the requirements for weight loss and dimensional change on the specimens subjected to the chemical resistance tests shall not apply. The epoxy matrix with filler shall conform to PERFORMANCE AND PROPERTIES OF EPOXY RESIN TERRAZZO of Specification for Epoxy Resin Terrazzo except test specimens shall not be ground.

In 5.2 of CE 244.03: Polyester flooring system shall conform to PERFORMANCE AND PROPERTIES of Specification for Polyester Resin Terrazzo.

In Section 2 of CE 244.03, storage of materials is specified at minimum temperature of 50°F. and installation temperature 60°F. Metal divider strips are specified but plastic strips are to be substituted in acidic or alkaline conditions. Primer is specified but is not required to be dry before application of the topping. Catalyzer or hardener is specified in place of catalyzer, as in the original draft. The filler particle size is specified as not greater than 3/16 inch as in the original draft. Sealer is also specified as in the original draft but the non-yellowing requirement was eliminated. Curing time for the concrete is according to the manufacturer's recommendation. No provision for thickener appears in the requirement for cove base.

1.3.3 OCE Guide Specification CE 244.04, CONDUCTIVE RESINOUS TERRAZZO FLOORING

Reference to requirements and test methods: NTMA Specifications

Conductive Epoxy Resin Terrazzo (Section 2.1 of this report)

Conductive Polyester Resin Terrazzo (Section 2.2 of this report)

Latex Matrix Terrazzo (Section 2.5 of this report)

In 5.1 of CE 244.04: Conductive epoxy flooring system. The epoxy matrix with no chips or fillers shall conform to PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY MATRIX in NTMA Specification for Conductive Epoxy Resin Terrazzo. The epoxy matrix with aggregate and/or filler shall conform to the requirements of PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY TERRAZZO of Specifications for Conductive Epoxy Resin Terrazzo.

In 5.2 of CE 244.04: Conductive polyester flooring system shall conform to PERFORMANCE AND PROPERTIES of Specification for Conductive Polyester Resin Terrazzo.

In 5.3 of CE 244.04: Conductive latex flooring system shall conform to PERFORMANCE AND PROPERTIES of Specification for Latex Matrix Terrazzo and conductivity requirements of epoxy and polyester specifications above.

In Section 2 of CE 244.04, storage of materials is specified at minimum temperature of 50°F. and installation temperature 60°F. It is specified that plastic strips be installed "in locations indicated". Primer is specified but is not required to be dry before application of the topping, except for conductive latex flooring system, in which "the interval between priming and application of topping shall be in strict accordance with the manufacturer's recommendation". Aggregate specified is a blend of marble chips that consists of a range of sizes up to and including NTMA Standard No. 1 chip.

1.3.4 OCE Guide Specification CE 244.05, CONDUCTIVE SPARKPROOF INDUSTRIAL RESINOUS FLOORING

Reference to requirements and tests methods: NTMA Specifications

Conductive Epoxy Resin Terrazzo (Section 2.1 of this report)

Conductive Polyester Resin Terrazzo (Section 2.2 of this report)

Latex Matrix Terrazzo (Section 2.5 of this report).

In 5.1 of CE 244.05: Epoxy flooring system. The epoxy matrix with no chips or fillers shall conform to PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY MATRIX of Specification for Conductive Epoxy Resin Terrazzo except for the requirements for weight loss and dimensional change on the specimens subjected to the chemical resistance tests shall not apply. The epoxy matrix with aggregate and/or filler shall conform to PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY RESIN TERRAZZO of Specification for Conductive Epoxy Resin Terrazzo.

In 5.2 of OCE 244.05: Polyester flooring system shall conform to PERFORMANCE AND PROPERTIES of Specification for Conductive Polyester Resin Terrazzo.

In 5.3 of OCE 244.05: Latex flooring systems shall conform to PERFORMANCE AND PROPERTIES of Specification for Latex Matrix Terrazzo and shall meet the conductivity requirements in the Specifications for Conductive Epoxy Flooring Systems and Conductive Polyester Flooring Systems.

2.0 National Terrazzo and Mosaic Association (NTMA) Specifications

The following specifications were referenced in the OCE Guide Specifications, all from The National Terrazzo and Mosaic Association, Inc., 716 Church Street, Alexandria, Virginia 22314:

CONDUCTIVE EPOXY RESIN TERRAZZO

CONDUCTIVE POLYESTER RESIN TERRAZZO

EPOXY RESIN TERRAZZO

POLYESTER RESIN TERRAZZO

LATEX LATRIX TERRAZZO

Copies of these specifications may be obtained from the Association but for convenience, requirements and test methods are listed alphabetically under each specification. References have been corrected and updated.

2.1 NTMA Specification for Conductive Epoxy Resin Terrazzo

2.1.1 NTMA 1.10 PERFORMANCE AND PROPERTIES OF CONDUCTIVE EOPXY MATRIX (with no marble chips or fillers added)

	Requirement
Abrasion or wear resistance (Abrasive resistance), ASTM D968-51 (reapproved 1966), maximum	0.1 gram loss per 5 gals. silica sand
Chemical resistance, Federal Test Method Standard No. 406, Method 7011, 7 days immersion Reagents: Mineral oil, ASTM No. 3 oil, lard, isopropyl alcohol, ethyl alcohol, 10% hydrochloric acid, 30% sulfuric acid, 5% acetic acid, 0.025% detergent, 1% soap solution, 10% sodium hydroxide, distilled water	No effect
Compressive strength, ASTM D695-69 Specimen b, cylinder, minimum, psi	14,000
Flexural strength, ASTM D790-66	
Flexural yield strength, minimum, psi	6,500
Tangent modulus of elasticity, minimum	1×10^4
Hardness, ASTM D1706-61 (Discontinued in 1968 but can be found on page 564, Part 27, ASTM Standards, June 1967)	
Shore D Durometer	60-85
Barcol Impressor	55-80
Shrinkage, linear, ERF-64 (Epoxy Resin Formulators Test Method), maximum, inch per inch	0.001
Tensile elongation, ASTM D638-68, C die as in ASTM D412-68, 0.2 inch/min., minimum	5 percent
Tensile strength, ASTM D638-68, C die as in ASTM D412-68, 0.2 inch/min.,minimum, psi	4,000

2.1.2 NTMA 1.11 PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY TERRAZZO
(Epoxy resin mixed with marble chips)

	Requirement
Bond strength, "Field Test for Surface Soundness and Adhesion", Appendix, pages 1139-1141, Title No.59-43, "Guide for Use of Epoxy Compounds with Concrete", Journal of the American Concrete Institute, Proceedings, vol. 59, No. 9 (September 1962), Minimum tensile strength with 100% concrete failure, psi	300
Conductivity, Section 252, NFPA 56A, Standard for the Use of Flammable Anesthetics, 1971, National Fire Protection Association, with recently calibrated ohmmeter	Less than 1,000,000 and more than 25,000 ohms
Flammability, ASTM D635-68 Extent of burning, maximum	Self extinguishing 0.25 inch
Heat resistance (to elevated temperature), MIL-D-3134F, sections 3.10, 4.7.5	Will not slip or flow No softening
Impact strength, two pound ball falling on a 12 x 12 x 1/4 inch specimen bonded to concrete and ground to terrazzo finish, 16 ft. lbs.	No chipping or detachment No indentation
Indentation, MIL-D-3134F, sections 3.9, 4.7.4, 4 x 6 x 1/4 inch specimen ground to terrazzo finish	No indentation
Thermal coefficient of linear expansion, ASTM D-696-70, temperature range 12 - 140°F. maximum inch per inch per degree Fahrenheit	25×10^{-6}

2.2 NTMA Specification for Conductive Polyester Resin Terrazzo

2.2.1 NTMA 1.10 PERFORMANCE AND PROPERTIES

Abrasion resistance, MIL-F-52505 (MO), sections 3.7, 4.4.2.6, 1,000 cycles on abraser machine, loss of thickness, maximum	1 mil
Accelerated weathering resistance, MIL-F-52505 (MO), sections 3.11, 4.4.2.10, 300 hours accelerated weathering	No cracking, peeling, blistering, or loss of adhesion. Slight chalking or fading of color permitted

	Requirement
Chemical resistance, MIL-F-52505 (MO), sections 3.5, 4.4.2.4 Reagents: 4% hydrochloric acid, 4% sodium hydroxide, 5% formaldehyde, 25,000 ppm chlorine (Hypochlorite solution), 1:500 mercuric chloride solution	No change in color; no blistering, cracking, peeling, loss of adhesion
Conductivity, section 252, NFPA 56A, Standard for the Use of Flammable Anesthetics, 1971, National Fire Protection Association, with recently calibrated ohmmeter	Less than 1,000,000 and no more than 25,000 ohms
Curing time, MIL-F-52505 (MO), sections 3.3, 4.4.2.2, at 73±5°F, 40±10 percent relative humidity	within 18 hours
Flammability, Federal Test Method Standard No. 406, Method 2021	Rating of "self extinguishing"
Fumigant resistance, MIL-F-52505 (MO), sections 3.6, 4.4.2.5, cyclic exposure to formaldehyde or beta-propiolactone	No deterioration, as blistering, cracking, peeling, loss of adhesion
Fungistatic and bacteriostatic resistance, MIL-F-52505 (MO), sections 3.12, 4.4.2.11	Shall not support growth of fungus or bacteria
Hardness, MIL-F-52505 (MO), sections 3.8, 4.4.2.7, Hardness as defined, minimum	M85
Impact resistance, MIL-F-52505 (MO), sections 3.10, 4.4.2.9, Impact test machine, 144 inch-pounds force	No cracking, spalling, loss of adhesion
Porosity, MIL-F-52505 (MO), sections 3.9, 4.4.2.8, submersion in distilled water for 24 hours	No cracking, peeling, blistering, loss of adhesion
Gain in weight, maximum	8 percent
Shrinkage resistance, MIL-F-52505 (MO), sections 3.4, 4.4.2.1, 4.4.2.3, dried terrazzo	No cracking, spalling, ridging
Maximum shrinkage	1/32 inch in 12 inches
Stain resistance, MIL-F-52505 (MO), sections 3.15, 4.4.2.14, exposed for 24 hours to staining agent	Shall not retain a permanent stain

	Requirement
Thermal shock resistance, MIL-F-52505 (MO), sections 3.14, 4.4.2.13, 50 cycles immersion in chilled and boiling water at 2-minute intervals	Shall not crack, peel, blister, spall, or lose adhesion
Ultraviolet light resistance, MIL-F-52505 (MO), sections 3.13, 4.4.2.12, 48 hours exposure to 30 microwatts ultraviolet light	No chalking, cracking, peeling, blistering, or loss of adhesion

2.3 NTMA Specification for Epoxy Resin Terrazzo

2.3.1 NTMA 1.10 PERFORMANCE AND PROPERTIES OF EPOXY MATRIX (with no marble chips or fillers added)

Same as 2.1.1 under NTMA Specification for Conductive Epoxy Resin Terrazzo with the deletion of Conductivity and addition of Fading resistance, ASTM E188-70, Method A, 48 hours exposure	No discoloration or other physical changes

2.3.2 NTMA 1.11 PERFORMANCE AND PROPERTIES OF EPOXY RESIN TERRAZZO (Epoxy resin mixed with marble chips)

Same as 2.1.2 under NTMA Specification for Conductive Epoxy Resin Terrazzo except Conductivity requirement is deleted.

2.4 NTMA Specification for Polyester Resin Terrazzo

Same requirements as 2.2.1 under NTMA Specification for Conductive Polyester Resin Terrazzo except Conductivity requirement is deleted.

2.5 NTMA Specification for Latex Matrix Terrazzo

2.5.1 NTMA 1.10 PERFORMANCE AND PROPERTIES

Abrasion or wear resistance, MIL-D-3134F, sections 3.15, 4.7.10, Maximum wear	0.150 inch

	Requirement
Accelerated light and weather aging resistance, MIL-D-3134F, sections 3.21, 4.7.16	Surface shall show no appreciable change in color, signs of checking, cracking, or other deterioration
Adhesive strength, MIL-D-3134F, sections 3.19, 4.7.14, Initial adhesive strength, minimum, After aging and exposure, minimum	65 psi 95% of initial strength
Color, MIL-D-3134F, sections 3.5, 6.2	As specified
Corrosion resistance, MIL-D-3134F, sections 3.14, 4.7.9	Shall not soften or become detached from substrate
Fire resistance, MIL-D-3134F, sections 3.16 4.7.11, Rating of, minimum	Fire retardant
Fire and toxicity hazards, MIL-D-3134F, section 3.6, before and after setting	Shall not constitute an undue fire hazard. Fumes shall not be more toxic than those from ordinary paint.
Heat resistance (to elevated temperature), MIL-D-3134F, sections 3.10, 4.7.5	Shall not flow or slip in any part more than 1/16 inch, or soften
Impact resistance, MIL-D-3134F, sections 3.8, 4.7.3	No visible signs of chipping, cracking, or detachment
Impact shock resistance, MIL-D-3134F, sections 3.18, 4.7.13	No signs of chipping, cracking, or detachment
Indentation, MIL-D-3134F, sections 3.9, 4.7.4	No signs of cracking or detachment
Initial indentation	Less than 7 percent More than 1 percent
Odor, MIL-D-3134F, section 3.4, under ordinary service conditions	Free from objectionable odors

	Requirement
Oil resistance, MIL-D-3134F, sections 3.17, 4.7.12	
Maximum weight change	3 percent
Maximum volume change	2 percent
Resistance to moisture and temperature changes, MIL-D-3134F, sections 3.12, 4.7.7	No signs of cracking, separation, or corrosion
Slip resistance (non-slip properties), MIL-D-3134F, section 3.11, Factors of friction	Not less than those specified in Table 1
Water (moisture) absorption, MIL-D-3134F, sections 3.13, 4.7.8, maximum based on weight under normal atmospheric conditions	5 percent
Water resistance (Serviceability), MIL-D-3134F, sections 3.22, 4.7.17	No breaks, loss of adhesion, or other deficiency which would affect serviceability
Weight, MIL-D-3134F, sections 3.7, 4.7.2, in thickness of 1/4 inch, maximum	3.0 pounds per sq. ft.

Table 1. Requirements and Tests in The National Terrazzo and Mosaic Association (NTMA) Specifications

	Conductive Epoxy Resin Terrazzo 1/	Conductive Polyester Resin Terrazzo 2/	Epoxy Resin Terrazzo 3/	Polyester Resin Terrazzo 4/	Latex Matrix Terrazzo 5/
Abrasion or Wear resistance	M	T	M	T	T
Adhesion or Bond strength	T		T		T
Accelerated weathering resistance		T		T	T
Chemical resistance 6/	M	T	M	T	
Color					T
Compressive strength 6/	M		M		
Conductivity, electrical	T	T			
Corrosion resistance					T
Curing time 6/		T		T	
Fading resistance			M		
Fire resistance, flammability	T	T	T	T	T
Flexural strength 6/	M		M		
Flexural modulus of elasticity 6/	M		M		
Fumigant resistance		T		T	
Fungistatic, bacteriostatic resistance		T		T	
Hardness	M	T	M	T	
Heat resistance (to elevated temperature)	T		T		T
Impact resistance, strength	T	T	T	T	T
Impact shock resistance					T
Indentation	T		T		T
Odor					T
Oil resistance	M 7/		M 7/		T
Porosity		T		T	
Resistance to moisture and temperature changes					T
Shrinkage, linear 6/	M	T	M	T	
Slip resistance					T
Stain Resistance		T		T	

Table 1 - continued

	Conductive Epoxy Resin Terrazzo 1/	Conductive Polyester Resin Terrazzo 2/	Epoxy Resin Terrazzo 3/	Polyester Resin Terrazzo 4/	Latex Matrix Terrazzo 5/
Tensile elongation	M		M		
Tensile strength 6/	M		M		
Thermal coefficient of expansion 6/	T		T		
Thermal shock resistance		T		T	
Toxicity (Fire and toxicity hazards)					T
Ultraviolet light resistance		T		T	
Water (moisture) absorption 6/					T
Water resistance	M 7/		M 7/		T 8/
Weight					T

NOTES to Table 1

1. M refers to requirements under PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY MATRIX, section 2.1.1 of this report.

   T refers to requirements under PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY TERRAZZO, section 2.1.2 of this report.

2. T refers to requirements under PERFORMANCE AND PROPERTIES, section 2.2.1 of this report.

3. M refers to requirements under PERFORMANCE AND PROPERTIES OF EPOXY MATRIX, section 2.3.1 of this report. These are the same as those in Section 2.1.1 except for deletion of Conductivity and addition of Fading resistance. See Note 1.

   T refers to requirements under PERFORMANCE AND PROPERTIES OF EPOXY RESIN TERRAZZO, section 2.3.2 of this report. These are the same as those in section 2.1.2 except that Conductivity is deleted. See Note 1.

4. T refers to requirements in NTMA Specification for Polyester Resin Terrazzo, section 2.4 of this report. These are the same as those in section 2.2.1 except that Conductivity is deleted. See Note 2.

5. T refers to requirements under PERFORMANCE AND PROPERTIES, section 2.5.1 of this report.

6. Requirements included in ASTM C-3 Specification, part 3.0 and Tables 2 and 3 of this report.

7. Under Chemical resistance.

8. Under Serviceability.

3.0 Tentative Specification for Resinous Chemical Resistant Monolithic Surfacings of ASTM Committee C-3

The following is Draft No. 4 of the Tentative Specification, dated 31 March 1970, drafted by Subcommittee S-4 on Monolithic Surfacings of ASTM Committee C-3 on Chemical Resistant Non-Metallic Materials.

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SCOPE:

1. A - This specification covers the requirements for resin filled systems suitable for use as trowel or spray applied monolithic surfacings in areas where chemical resistance is required.

   Two types are covered -

   Type A - Surfacings where chemical resistance and moderate to heavy traffic are required. (Rigid systems)

   Type B - Surfacings where mild chemical resistance and severe thermal shock stability (or resistance) are required. (Flexible systems)

   B - Monolithic surfacings utilized as vessel linings are excluded from this specification.

DEFINITION:

2. A - Resinous Chemical-Resistant Monolithic Surfacings:

   As intimate mixture of a liquid resin-based material, hardening agent and filler system composed of properly selected and graded materials. These components are mixed at temperatures of 65°F. to 85°F. to form a trowelable or, in some cases, a sprayable mixture that hardens after placement of a minimum thickness of 60 mils. (approximately 1/16")

   B - Monolithic

   Monolithic as applied to surfacing in this usage refers to a continuous surfacing 60 mils in thickness or greater which cures in place and is applied over an existing or newly placed substrate and continuously bonded to the surface.

TYPES OF RESINS AND FILLERS:

3. A - The liquid resin base may be (1) epoxy resin, (2) polyester resin, or (3) other resinous material capable of forming chemical resistant surfacing material when mixed with a suitable hardening agent and filler.

   B - The fillers are usually of a siliceous or carbonaceous nature. The filler materials shall be selected to have adequate resistance to the particular chemicals to which they will be exposed when properly combined with the resin system.

C - The hardening agent may be of the reactive or catalyst type. It is usually supplied separately to be added to the resin prior to use in accordance with the manufacturer's recommendation. However, in some cases it may be incorporated in the powder in such a manner that it becomes effective when mixed with the resin. The service limitations of the cured system shall be defined by the manufacturer.

PHYSICAL REQUIREMENTS:

4. Resin-based monolithic surfacings prepared from these materials shall conform to the respective physical requirements prescribed in Table I.

GENERAL REQUIREMENTS:

5. The resin shall have a viscosity that will permit it to be mixed with the hardener and/or filler components by manual methods. The filler materials shall have properly graded particles that will permit application and finishing of the mixture to an acceptable surface at the minimum thickness prescribed by the manufacturer.

METHODS OF TESTING:

6. The properties enumerated in this specification shall be determined in accordance with the following methods:

A - Working life and setting time - Methods of Test for Working and Setting Times of Resinous Chemical-Resistant Mortars (ASTM Designation: C308)

B - Tensile Strength - Method of Test for Tensile Strength of Resinous Chemical-Resistant Mortars (ASTM Designation: C307)

C - Compressive Strength - Method of Test for Compressive Strength of Resinous Chemical-Resistant Mortars (ASTM Designation: C579)

D - Flexural Strength and modulus of elasticity (ASTM Designation: C580)

E - Shrinkage and coefficient of thermal expansion (ASTM Designation: C531)

F - Absorption and apparent porosity - Tentative method of test for absorption and apparent porosity of chemical-resistant mortars (ASTM Designation: C413)

G - Chemical Resistance (ASTM Designation: C267)

PACKAGING AND MARKING:

7. A - The hardener and/or filler shall be properly packaged to prevent deterioration in storage and shall be marked in such a manner to indicate clearly the resin with which they (it) are (is) to be used. The resin shall be packaged in suitable containers and market in such a manner that the hardener and/or filler materials with which it is to be used and the storage conditions required to prevent deterioration of the resin are clearly stated.

   B - In addition to the above information, packages may be marked at the discretion of the supplier and on his responsibility indicating that the product satisfies this specification.

REJECTION:

8. The resins, hardeners and/or fillers, or all, may be rejected if they or the surfacing mixture made therefrom fail to meet any of the requirements of this specification.

Table 2. Physical and Chemical Requirements in ASTM Specification

	EPOXY		POLYESTER		ASTM
	Type A	Type B	Type A*	Type B	Method
Working life, minutes, 73°F. (22.8°C.) minimum	30	30	30	30	C-308
Initial use time, hours, 73°F. (22.8°C.) minimum	--	--	--	--	--
Chemical exposure	Generally a minimum of 72 hours is required. Consult mfg. for specific chemicals and cure conditions.				
Traffic, light	24	24	16	16	--
Traffic, heavy	48	48	36	36	--
Service strength setting time, days, maximum	7	7	3	3	--
Tensile strength, minimum, psi, 7 days	1500	600	1500	600	C-307
Compressive strength, minimum, psi, 7 days	6000	4000	10,000	8000	C-579
Flexural strength, minimum, psi, 7 days	1500	750	1500	750	C-580
Flexural modulus of elasticity, minimum 7 days	0.5×10^6	0.25×10^6	1.0×10^6	0.5×10^6	C-580
Shrinkage % maximum (Note 1)	0.5	0.5	1.0	0.6	C-531
Coefficient of thermal expansion, maximum In./In./°F.	40×10^{-6}	40×10^{-6}	40×10^{-6}	40×10^{-6}	C-531
Absorption % maximum	1.0	2.0	1.0	2.0	C-413
Chemical resistance	Note 2	Note 2	Note 2	Note 2	C-267

Note 1: Values shown are for shrinkage after gellation.

Note 2: It should be noted that ASTM C-267 is an immersion test and will in many cases show more severe corrosion than will actually be attained by a monolithic system exposed only intermittently to corrosive environment on one exposed surface face. The manufacturer of the surfacings should be consulted as to chemical resistance.

*1000 psi for carbon filled surfacings.

Table 3. Comparison of Requirements[1/] Common to NTMA Specifications[2/] and the ASTM C-3 Specification [3/]

	Requirement
Chemical resistance	
NTMA Specification for Conductive Epoxy Resin Terrazzo 4/	No effect
NTMA Specification for Conductive Polyester Resin Terrazzo 5/	No change in color; no blistering, cracking, peeling, loss of adhesion
ASTM C-3 Specification	None given
Compressive strength	
NTMA Specification for Conductive Epoxy Resin Terrazzo 4/	14,000 psi
ASTM C-3 Specification	
Epoxy, Type A, rigid systems	6,000 psi
Epoxy, Type B, flexible systems	4,000 psi
Polyester, Type A	10,000 psi
Polyester, Type B	8,000 psi
Curing Time	
NTMA Specification for Conductive Polyester Resin Terrazzo 5/	within 18 hrs. at 73±5°F., 40±10% R.H.
ASTM C-3 Specification	
Initial use time, hours, 73°F., minimum	
Chemical exposure	72
Light traffic	
Epoxy, Type A or B	24
Polyester, Type A or B	16
Heavy traffic	
Epoxy, Type A or B	48
Polyester, Type A or B	36
Service strength setting time, days, maximum	
Epoxy, Type A or B	7
Polyester, Type A or B	3

Table 3 - continued

	Requirement
Flexural strength	
NTMA Specification for Conductive Epoxy Resin Terrazzo 4/	6,500 psi
ASTM C-3 Specification, minimum, after 7 days	
Epoxy, Type A	1,500 psi
Epoxy, Type B	750 psi
Polyester, Type A	1,500 psi
Polyester, Type B	750 psi
Flexural modulus of elasticity	
NTMA Specification for Conductive Epoxy Resin Terrazzo 4/	1×10^4
ASTM C-3 Specification, minimum, after 7 days	
Epoxy, Type A	0.5×10^6
Epoxy, Type B	0.25×10^6
Polyester, Type A	1.0×10^6
Polyester, Type B	0.5×10^6
Shrinkage	
NTMA Specification for Conductive Epoxy Resin Terrazzo 4/	0.001 in./in.
NTMA Specification for Conductive Polyester Resin Terrazzo 5/	1/32 inch in 12 inches
ASTM C-3 Specification, percent maximum, after gelation	
Epoxy, Type A or B	0.5
Polyester, Type A	1.0
Polyester, Type B	0.6
Tensile strength	
NTMA Specification for Conductive Epoxy Resin Terrazzo 4/	4,000 psi
ASTM C-3 Specification, minimum, after 7 days	
Epoxy, Type A	1,500 psi
Epoxy, Type B	600 psi
Polyester, Type A	1,500 psi
Polyester, Type B	600 psi

Table 3 - continued

	Requirement
Thermal coefficient of linear expansion	
NTMA Specification for Conductive Epoxy Resin Terrazzo 6/	25×10^{-6} in./in./deg. F.
ASTM C-3 Specification	
Epoxy and Polyester, Types A and B, maximum	40×10^{-6} in./in./deg.F.
Water absorption	
NTMA Specification for Latex Matrix Terrazzo 7/	5 percent under normal atmospheric conditions
ASTM C-3 Specification, percent maximum and apparent porosity	
Epoxy, Type A	1.0
Epoxy, Type B	2.0
Polyester, Type A	1.0
Polyester, Type B	2.0

NOTES to Table 3

1. For comparison of test methods, see Table 4.

2. See section 2.0 and Table 1 of this report.

3. See section 3.0 and Table 2 of this report. Requirements are for the finished product with fillers.

4. For matrix with no marble chips or fillers, section 2.1.1 of this report. Also included in Epoxy Resin Terrazzo, section 2.3.1. See Table 1.

5. For terrazzo with marble chips and fillers, section 2.2.1 of this report. Also included in Polyester Resin Terrazzo, section 2.4. See Table 1.

6. For terrazzo with marble chips and fillers, section 2.1.2 of this report. Also included in Epoxy Resin Terrazzo, section 2.3.2. See Table 1.

7. For terrazzo with marble chips and fillers, section 2.5.1 of this report. See table 1.

Table 4. Comparison of Test Methods[1/] in NTMA Specifications[2/] and the ASTM C-3 Specification [3/]

Chemical resistance

NTMA Specification for Conductive Epoxy Resin Terrazzo[4/]

Federal Test Method Standard No. 406, PLASTICS: METHODS OF TESTING, Method 7011, 7 days immersion
Reagents: Mineral oil, ASTM No. 3 oil, lard, isopropyl alcohol, ethyl alcohol, 10% hydrochloric acid, 30% sulfuric acid, 5% acetic acid, 0.025% detergent, 1% soap solution, 10% sodium hydroxide, distilled water

NTMA Specification for Conductive Polyester Resin Terrazzo [5/]

MIL-F-52505 (MO), FLOOR COATING, RESINOUS, MONOLITHIC, TROWEL TYPE (FOR WOOD AND CONCRETE FLOORS), Sections 3.5, 4.4.2.4
Reagents: 4% hydrochloric acid, 4% sodium hydroxide, 5% formaldehyde, 25,000 ppm chlorine (hypochlorite solution), 1:500 mercuric chloride solution

ASTM C-3 Specification

ASTM C267-65, Standard Method of Test for CHEMICAL RESISTANCE OF MORTARS. The test reagents shall consist of the reagents, solutions, or products to which the mortars are exposed in service. No reagents are specified.

Compressive strength

NTMA Specification for Conductive Epoxy Resin Terrazzo [4/]

ASTM D695-69, Standard Method of Test for COMPRESSIVE PROPERTIES OF RIGID PLASTICS, Specimen b, cylinder. (Size of specimen not specified but should be)

ASTM C-3 Specification

ASTM C579-68, Standard Method of Test for COMPRESSIVE STRENGTH OF CHEMICAL-RESISTANT MORTARS

Curing Time

NTMA Specification for Conductive Polyester Resin Terrazzo [5/]

MIL-F-52505 (MO), sections 3.3, 4.4.2.2, at 73±5°F., 40±10% relative humidity. Shall cure within 18 hours.

ASTM C-3 Specification: No reference

Flexural strength and modulus of elasticity

NTMA Specification for Conductive Epoxy Resin Terrazzo[4/]

ASTM D790-66, Standard Method of Test for FLEXURAL PROPERTIES OF PLASTICS (Detail specification should specify specimen size)

ASTM C-3 Specification

ASTM C580-68, Standard Method of Test for FLEXURAL STRENGTH AND MODULUS OF ELASTICITY OF CHEMICAL-RESISTANT MORTARS

Shrinkage

NTMA Specification for Conductive Epoxy Resin Terrazzo[4/]

ERF-64 (Epoxy Resin Formulators Test Method)

NTMA Specification for Conductive Polyester Resin Terrazzo[5/]

MIL-F-52505 (MO), sections 3.4, 4.4.2.1, 4.4.2.3, dried terrazzo. Concrete panels are prepared as in Method 2051, procedure C, Federal Test Method Standard No. 141a, PAINT, VARNISH, LACQUER, AND RELATED MATERIALS:METHODS OF INSPECTION, SAMPLING, AND TESTING. The panels are cured and then cleaned, dried, primed, and a 1/4-inch coating applied. After 48 hours drying the panels are examined for shrinkage, which should not be more than 1/32 inch in length or width. (No measurement procedure is described.)

ASTM C-3 Specification

ASTM C531-68, Standard Method of Test for SHRINKAGE AND COEFFICIENT OF THERMAL EXPANSION OF CHEMICAL-RESISTANT MORTARS

Tensile strength

NTMA Specification for Conductive Epoxy Resin Terrazzo[4/]

ASTM D-638, Standard Method of Test for TENSILE PROPERTIES OF PLASTICS, 0.2 inch/min., C- die as in ASTM D412-68, Standard Method of TENSION TESTING OF VULCANIZED RUBBER

ASTM C-3 Specification

ASTM C307-61, Standard Method of Test for TENSILE STRENGTH OF CHEMICAL-RESISTANT RESIN MORTARS (Will be discontinued in April 1972 unless Committee C-3 reapproves or revises it.)

Thermal coefficient of linear expansion

NTMA Specification for Conductive Epoxy Resin Terrazzo 6/

ASTM D696-70, Standard Method of Test for COEFFICIENT OF LINEAR THERMAL EXPANSION OF PLASTICS, temperature range 12-140°F., inch per inch per degree Fahrenheit. ASTM D696 recommends the range -30 to 30°C. unless the properties of the plastic are well known, as the possible change in coefficient at a certain temperature.

ASTM C-3 Specification

ASTM C531-68, Standard Method of Test for SHRINKAGE AND COEFFICIENT OF THERMAL EXPANSION OF CHEMICAL-RESISTANT MORTARS

Water absorption (Moisture absorption)

NTMA Specification for Latex Matrix Terrazzo 7/

MIL-D-3134F, DECK COVERING MATERIALS, 3.13, 4.7.8. Three specimens, 2 inches square by 1/4 inch thick, shall be prepared by applying the deck covering to oiled surfaces of steel plate, so that on drying the specimens will not adhere to the plates. Each specimen without the steel backing plate shall be weighed dry, dipped into tap water at room temperature, lightly wiped on all surfaces with a paper towel and again weighed to the nearest 0.1 gram. Immediately after weighing, the specimens shall be immersed in water (tap, at room temperature) for 24 hours, lightly wiped and again weighed. The percent gain in moisture shall be based on the weight of the dry specimen and the difference between the weight after 24 hours immersion and the weight after dipping and wiping.

ASTM C-3 Specification

ASTM C413-66, Standard Method of Test for ABSORPTION OF CHEMICAL-RESISTANT MORTARS

NOTES to Table 4

1. For comparison of requirements, see Table 3.

2. See Section 2.0 and Table 1 of this report.

3. See Section 3.0 and Table 2 of this report. Requirements are for the finished product with fillers.

4. For matrix with no marble chips or fillers, section 2.1.1 of this report. Also included in Epoxy Resin Terrazzo, section 2.3.1. See Table 1.

5. For terrazzo with marble chips and fillers, section 2.2.1 of this report. Also included in Polyester Resin Terrazzo, section 2.4. See Table 1.

6. For terrazzo with marble chips and fillers, section 2.1.2 of this report. Also included in Epoxy Resin Terrazzo, section 2.3.2. See Table 1.

7. For terrazzo with marble chips and fillers, section 2.5.1 of this report. See Table 1.

4.0 <u>Measurement by Building Research Division of Physical Properties of Resin Mixes:</u>

EPOXY RESIN MIX

750 grams epoxy resin

750 grams curing agent for same

4,000 grams graded standard Ottawa sand [1]

4,000 grams standard 20-30 Ottawa sand [2]

POLYESTER RESIN MIX

1,500 grams polyester resin

25 ml catalyst for same

4,000 grams graded standard Ottawa sand [1]

4,000 grams standard 20-30 Ottawa sand [2]

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1. Sect. 4, ASTM C109-64, Standard Method of Test for COMPRESSIVE STRENGTH OF HYDRAULIC CEMENT MORTARS (USING 2-IN. CUBE SPECIMENS)

2. Sect. 3, ASTM C190-70, Standard Method of Test for TENSILE STRENGTH OF HYDRAULIC CEMENT MORTARS.

4.1 Compressive strength

Compressive strength measurements were performed on the two resin mixes in 4.0 with the molds (par. 2(e)), preparation (par. 7), and testing procedure (par. 12(c)) described in ASTM C109-64, Standard Method of Test for COMPRESSIVE STRENGTH OF HYDRAULIC CEMENT MORTARS (USING 2-IN. CUBE SPECIMENS). The resin mixes were placed in the molds as in ASTM C579-68, Standard Method of Test for COMPRESSIVE STRENGTH OF CHEMICAL-RESISTANT MORTARS. Tests were performed at the indicated time intervals and the values are recorded in Table 4 and Figure 1.

Table 4. Compressive Strength of Epoxy and Polyester Resin Mixes

Time, Days after casting*	Compressive Strength			
	EPOXY RESIN MIX		POLYESTER RESIN MIX	
	psi	MN/m^2	psi	MN/m^2
1	2,194	15,128	5,438	37,495
2	2,881	19,864	7,500	51,713
6	3,313	22,843	8,800	60,676
30	3,877	26,732	9,225	63,606

*For time after gelation or initial set, subtract one day, as the resin mixes set about one day after casting.

Two conclusions are obvious from examining Table 4 and Figure 1. One is that the polyester resin mix has a much higher compressive strength than the epoxy resin mix and the other is that it takes about 30 days for the compressive strength of either resin mix to reach equilibrium. This raises the question as to the proper curing time at which compressive strength should be measured.

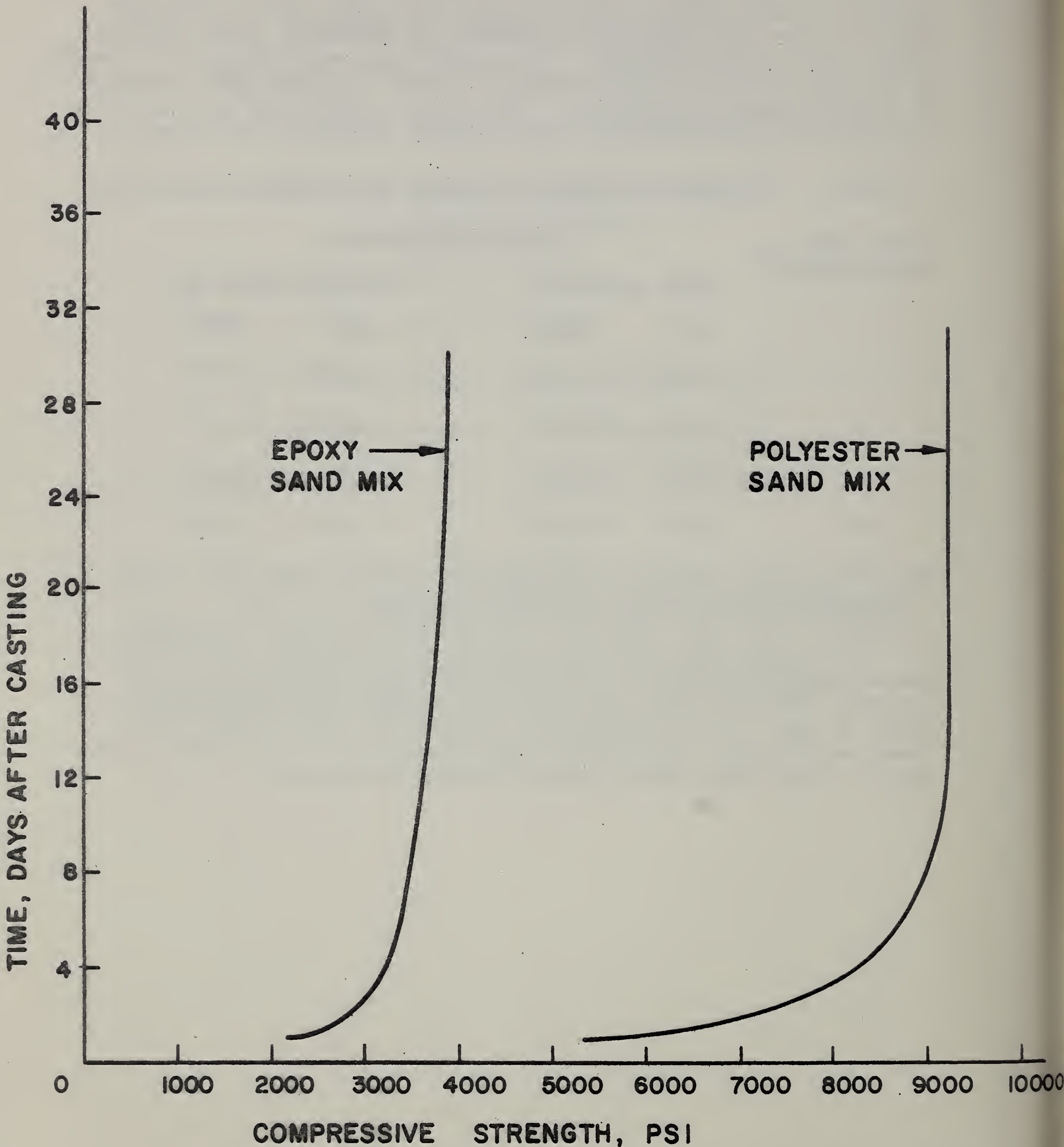

Figure 1. Change in Compressive Strength of Resin Mixes on Curing

4.2 Shrinkage on curing and coefficient of thermal expansion

Bars of resin mixes as in 4.0, 1 inch square by 10 inches between studs, were made as in ASTM C531-68, Standard Method of Test for SHRINKAGE AND COEFFICIENT OF THERMAL EXPANSION OF CHEMICAL-RESISTANT MORTARS. Molds (Figure 1) and measurement equipment (Figure 3) are described in ASTM C490-70, Standard Specification for APPARATUS FOR USE IN MEASUREMENT OF LENGTH CHANGE OF HARDENED CEMENT PASTE, MORTAR, AND CONCRETE. The standard bar used as an effective gage length of 10 inches.

$$\text{Percent shrinkage} = \frac{L_o - L}{L_o} \times 100, \text{ where}$$

L_o = Original length (length of standard bar), in inches

L = Length as measured during or after cure, in inches

Since $L_o = 10$,

Percent Shrinkage = 10 x (Shrinkage in inches as observed by dial readings)

Shrinkage of the resin bars is recorded in Table 5 and Figure 2.

Table 5. Percent Shrinkage of Resin Mixes on Curing[1]

Time, Days after Casting[2]	Percent Shrinkage	
	EPOXY RESIN MIX[3]	POLYESTER RESIN MIX[4]
2	0.0189	0.0177
6	0.0322	0.0312
30	0.0469	0.0402
92	0.0547	0.0453

1. Original length is length 1 day after casting

2. For time after gelation or initial set subtract one day.

3. Average of measurements on four bars.

4. Average of measurements on three bars. One bar showed an abnormally high shrinkage and there must have been an error in the initial length.

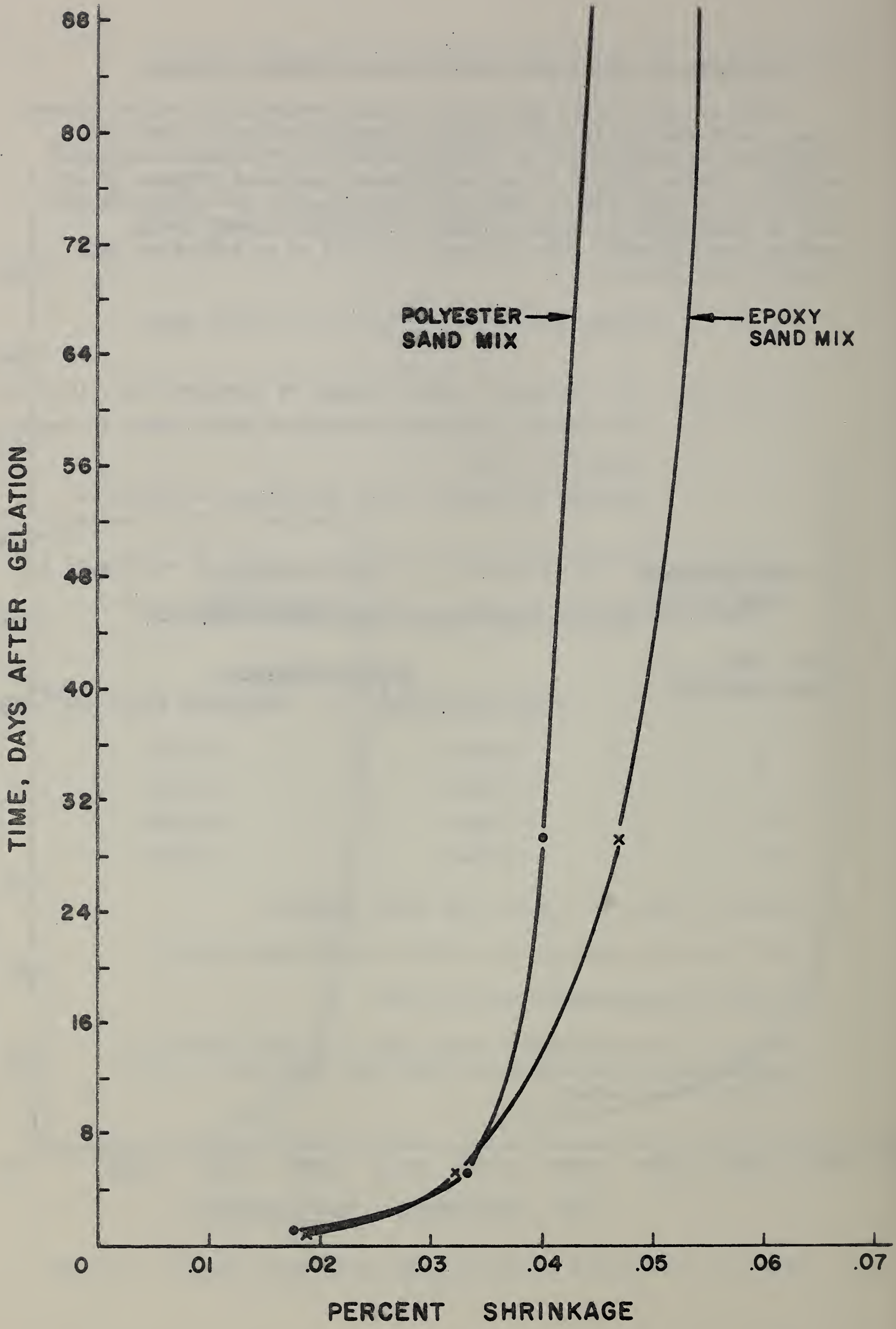

Figure 2. Shrinkage of Resin Mixes on Curing

There seems to be little difference between shrinkage of the epoxy and the polyester resin mix on curing. It appears that curing of neither resin mix was complete after 30 days, as some additional shrinkage occurred after 92 days.

Coefficient of thermal expansion was measured on the bars used for the shrinkage measurements on the 92nd day. The particular studs used were as in ASTM C490-70 Standard Specification for APPARATUS FOR USE IN MEASUREMENT OF LENGTH CHANGE OF HARDENED CEMENT PASTE, MORTAR, AND CONCRETE, 13/16 inch long, of AISI Type 316 stainless steel. According to the Metals Handbook, vol. 1, page 423, 8th ed., the mean coefficient of thermal expansion of this type of stainless steel is 9×10^{-6} in./in./deg. f.

As described in ASTM C531-68,

$$C = \frac{Z - Y - W}{T(W - X)}$$, where

C = linear coefficient of thermal expansion, per deg. F.

Z = length of bar, including studs at elevated temperature, inches

Y = length of stud expansion, inches = X x T x k, where
k = linear coefficient of thermal expansion per deg. F. of the studs

W = length of bar, including studs at lower temperature, inches

T = temperature change, deg. F.

X = length of the two studs at the lower temperature, inches

For the measurement the bars were conditioned in the room at 22.5°C. The elevated temperature was that of the oven or 99.5°C. The temperature change T = 77.0°C. = 138.6°F.

The observed increase in length, average of three bars, when the polyester bars were placed in the oven at 99.5°C. overnight,

$Z - W = 0.01581$ inch

$X = 2 \times 13/16$ inch $= 2 \times 0.8125 = 1.625$ inch for the two studs

$W - X = 10.0000 - 1.6250 = 8.3750$ inch (0.2127 m)

$T = 138.6°F$ (77°C.)

$Y = 2 \times 9 \times 0.8125 \times 138.6 \times 10^{-6} = 0.00203$ inch

$Z - Y - W = 0.01581 - 0.00203 = 0.01378$ inch (0.0003500 m)

$C = \dfrac{0.01378}{138.6 \times 8.3750} = 11.87 \times 10^{-6}$ inch/inch/deg. F. (21.37×10^{-6} m/m/deg. C.) polyester resin mix.

An attempt was made to measure the coefficient of thermal expansion of the epoxy resin mix but the epoxy resin bars shrunk considerably after placing in the oven overnight at 99.5°C., the shrinkage amounting to 0.160 percent, based on the length of the bars after 92 days curing (See Table 5 and Figure 2). The observed shrinkage was at least partly due to the noticeable bending which occurred in the bars. Apparently the epoxy resin mix is not stable to a temperature of 100°C.

A final set of length measurements was made on the resin bars after the measurements of thermal coefficient of expansion. These measurements were made at room temperature (22.5°C.) The average of measurements on four bars of epoxy resin mix was calculated as 0.340 percent shrinkage, based on the original length (See Table 5 and Figure 2). The corresponding value for the polyester resin mix, based on measurement of three bars, was 0.0946 percent shrinkage. The heat distortion of the epoxy bars would be expected to be reflected in a permanent apparent shrinkage. However, the polyester bars were not distorted by heat and expanded normally. The additional shrinkage of the polyester bars indicates that further curing takes place during the heating period. Apparently heat has some effect on both resin types and this may be a characteristic of epoxy and polyester resins when cured at room temperature, a necessity for resin mixes used in so-called seamless floors or monolithic surfacings. This may be a basic weakness of this type of flooring.

4.3 Flexural strength and Flexural modulus of elasticity

Bars of the resin mixes described in 4.0, 1 inch square by 10 inches long, were made as in ASTM C580-68, Standard Method of Test for FLEXURAL STRENGTH AND MODULUS OF ELASTICITY OF CHEMICAL-RESISTANT MORTARS. After 19 days curing, the bars were tested using equipment described in Figure 3, ASTM C348-69, Standard Method of Test for FLEXURAL STRENGTH OF HYDRAULIC CEMENT MORTARS. The span, L, of the test equipment is 119 mm or 4.685 inches, instead of 9 inches or 22.86 cm as in par. 6.2 of ASTM C580-68. No equipment with 9-inch span was available. Otherwise the procedure of ASTM C580-68 was followed as closely as practicable. Crosshead speed was 0.5 cm/min. (0.19 inch/min.).

Flexural strength was calculated from the formula

$$S = \frac{3PL}{2bd^2}, \text{ where}$$

S = stress of midspan in lb/in^2

P = load in lbs. at moment of break

L = span, inches = 4.685 inches

b = width of beam = 1 inch

d = depth of beam = 1 inch

For the epoxy resin mix, as described in 4.0, the average breaking load for four bars was 339 lbs. (1,508 N), from which the flexural strength, S was calculated to be 2,383 psi. (16,431 MN/m^2)

For the polyester resin mix, as in 4.0, the average breaking load for four bars was 475 lbs. (2,113 N) and the flexural strength, S was 3,338 psi. (23,016 MN/m^2).

Flexural modulus of elasticity or tangent modulus was calculated from the formula

$$E_B = \frac{L^3M}{4bd^3}, \text{ where}$$

E_B = modulus of elasticity in bending, in $lb./in.^2$

L = span, inches

b = width of beam tested, inch

d = depth of beam tested, inch

M = slope of the tangent to the steepest initial straight-line portion of the load-deflection curve in lb./inch of deflection

The slopes of the load-elongation curves were determined graphically on the original chart as the tangent of the steepest part of the curve just before each bar broke. The average slope for four bars of epoxy resin mix was 15,199.4 lb/inch, from which it was calculated that the flexural modulus $E_B = 0.391 \times 10^6$ lb./in.^{2} (2.696×10^9 N/m^2). The average slope for four bars of polyester resin mix was 20,756 lb./inch, from which the calculated $E_B = 0.53 \times 10^6$ lb./in.^{2} (psi) (3.654×10^9 N/m^2).

4.4 Tensile strength

Tensile strength of the epoxy and polyester resin mixes described in 4.0 was measured as in ASTM C307-61, Standard Method of Test for TENSILE STRENGTH OF CHEMICAL-RESISTANT RESIN MORTARS. Six specimens of each type of resin mix were tested in a load-strain testing machine with crosshead speed of 0.5 cm/min. (0.19 in./min.). Tests were made in each case 19 days after casting the briquets of resin mix. Based on the average values obtained from six specimens, the tensile strength of the epoxy resin mix was 1,336 lb./in.^{2} (psi) (9,212 MN/m^2) and the tensile strength of the polyester resin mix was 1,905 psi (13,135 MN/m^2).

4.5 Comparison of BRD values with values of physical properties in ASTM specification

As already described in part 3.0 of this report, the Tentative Specification for Resinous Chemical Resistant Monolithic Surfacings of ASTM Committee C-3 covers two types of resin systems and includes epoxy and polyester resins. One resin system is called Type A and is intended for "Rigid systems" for surfacings where chemical resistance and moderate to heavy traffic are required. The other resin system is called Type B and is intended for "Flexible systems" for surfacings where mild chemical resistance and severe thermal shock stability or resistance are required. Values for physical properties are shown in Table 2 of this report, in section 3.0, which describes the ASTM Specification.

Values found by the Building Research Division (BRD) for physical properties of typical epoxy and polyester flooring resin mixes are recorded in section 4.0, Tables 4,5, 6 and 7, and Figures 1 and 2. In Tables 6 and 7 these values are compared with values in the ASTM Specification. Tables 4 and 5 and Figures 1 and 2 show the curing characteristics of the two resin mixes investigated by BRD. This is relevant to the "Service strength setting time" requirement in Table 2.

Table 6. Physical Properties of Epoxy Resin Mix Recommended by ASTM and Found by BRD
(In customary units. See Table 6a for SI units)

Physical Property	Value specified by ASTM C-3 Committee[1]		Value found by BRD[2]
	Type A, Rigid	Type B Flexible	
Compressive strength[3,4], psi	6,000	4,000	3,877
Percent shrinkage on curing[4,5]	0.5	0.5	0.0469
Coefficient of thermal expansion [5,6], inch/inch/deg. F.	40×10^{-6}	40×10^{-6}	Unstable[5]
Flexural Strength [7,8], psi	1,500	750	2,383
Flexural modulus of elasticity[7,8], psi	0.5×10^{6}	0.25×10^{6}	0.391×10^{6}
Tensile strength[8,9], psi	1,500	600	1,336

1. Values in Tables 2 and 3, part 3.0 of this report. These values are to be based on measurements on resin mixes which have been cured for 7 days.

2. Values for EPOXY RESIN MIX, described in part 4.0 of this report.

3. For BRD value see part 4.1 of this report.

4. BRD value based on measurements on specimens cured for 30 days.

5. For BRD value see part 4.2 of this report

6. BRD value based on measurements on bars used for shrinkage measurements after 92 days curing.

7. For BRD value see part 4.3 of this report.

8. BRD value based on measurements on specimens cured for 19 days.

9. For BRD value see part 4.4 of this report.

Table 6a. Physical Properties of Epoxy Resin Mix in SI Units*
(See Table 6 for customary units)

Physical Property	Value specified by ASTM C-3 Committee		Value found by BRD
	Type A, Rigid	Type B Flexible	
Compressive strength, MN/m^2	41,370	27,580	26,732
Percent shrinkage on curing	0.5	0.5	0.0469
Coefficient of thermal expansion, m/m/deg. C.	72×10^{-6}	72×10^{-6}	Unstable
Flexural strength, MN/m^2	10,343	5,171	16,431
Flexural modulus of elasticity, N/m^2	3.4×10^9	1.7×10^9	2.696×10^9
Tensile strength, MN/m^2	10,343	4,137	9.212

*Footnotes same as Table 6

Table 7. Physical Properties of Polyester Resin Mix Recommended by ASTM and Found by BRD

Physical Property	Value specified by ASTM C-3 Committee[1]		Value found by BRD[2]
	Type A, Rigid	Type b, Flexible	
Compressive strength[3,4], psi	10,000	8,000	9,225
Percent shrinkage on curing [4,5]	1.0	0.6	0.0402
Coefficient of thermal expansion [5,6], inch/inch/deg. F.	40×10^{-6}	40×10^{-6}	11.87×10^{-6}
Flexural strength[7,8], psi	1,500	750	3,338
Flexural modulus of elasticity[7,8], psi	1.0×10^{6}	0.5×10^{6}	0.53×10^{6}
Tensile strength[8,9], psi	1,500	600	1,905

1. Values in Tables 2 and 3, part 3.0 of this report. These values are to be based on measurements on resin mixes which have been cured for 7 days.

2. Values for POLYESTER RESIN MIX, described in part 4.0 of this report.

3. For BRD value see part 4.1 of this report.

4. BRD value based on measurements on specimens cured for 30 days.

5. For BRD value see part 4.2 of this report.

6. BRD value based on measurements on bars used for shrinkage measurements after 92 days curing.

7. For BRD value see part 4.3 of this report.

8. BRD value based on measurements on specimens cured for 19 days.

9. For BRD value see part 4.4 of this report.

Table 7a. Physical Properties of Polyester Resin Mix in SI Units*
(See Table 7 for customary units)

Physical Property	Value specified by ASTM C-3 Committee: Type A, Rigid	Type B, Flexible	Value found by BRD
Compressive strength, MN/m^2	68,950	55,160	63,606
Percent shrinkage on curing	1.0	0.6	0.0402
Coefficient of thermal expansion, m/m/deg. C.	72×10^{-6}	72×10^{-6}	21.37×10^{-6}
Flexural strength, MN/m^2	10,343	5,171	23,016
Flexural modulus of elasticity, N/m^2	6.9×10^9	3.4×10^9	3.7×10^9
Tensile strength, MN/m^2	10,343	4,137	13,135

* Footnotes same as Table 7

5.0 Conclusions and recommendations

Most of the values for physical properties for the epoxy and polyester resin mixes reported in section 4.0 were close to those in the ASTM C-3 Specification. However, much lower values were reported in section 4.0 for percent shrinkage and coefficient of thermal expansion and it is hard to understand why such high values were specified by ASTM Committee C-3. Also hard to explain is the low value specified by ASTM C-3 for flexural strength, especially for the flexible type of resins. The tensile strength values for the flexible type of resins in the ASTM Specification are also low, although this may not be of practical importance. The most serious question is the lack of heat stability of the epoxy resin mix reported in 4.0 in which the epoxy resin would not withstand a temperature of 100°C. Epoxy resins are already regarded by the Corps of Engineers as being unstable to heat. Another characteristic of the resin mixes which we found, as shown in Tables 4 and 5 and Figures 1 and 2, is that curing is not complete after 7 days as inferred from the ASTM specification for "service strength setting time" in Table 2. In Table 2 the setting time for epoxy is required to be 7 days and for polyester resin only 3 days. However, our findings, as in Tables 4 and 5 and Figures 1 and 2, indicate that polyester resin requires about 10 to 20 days to cure and epoxy resin about 20-40 days, depending on wehterh compressive strength of percent shrinkage is used as the criterion.

Not only is there a lack of agreement between the ASTM C-3 Specification and our measurements but the ASTM C-3 Specification does not agree with the NTMA Specifications. This can be seen from an examination of Table 3. The test methods also differ, as shown in Table 4.

Another question about the ASTM C-3 Specification is the lack of detail for the chemical resistance requirement. Details are given for chemical resistance requirements and tests in the NTMA specifications but these differ for epoxy and polyester resins. For details see Table 4. Table 4 shows other differences between the ASTM C-3 specifications and the various NTMA specifications in requirements common to ASTM and NTMA. Table 1 shows how few of the NTMA tests are included in the ASTM C-3 specification and that not all the NTMA specifications include the same tests. Also NTMA requirements appear sometimes under the matrix and sometimes under the finished terrazzo.

A liaison should be established between the U. S. Army Corps of Engineers, the National Bureau of Standards, ASTM Committee C-3 and The National Terrazzo and Mosaic Association. We propose that the Building Research Division of the National Bureau of Standards act as the liaison and try to reach an agreement on specifications for resinous flooring. We should like to cooperate in making whatever tests and measurements are necessary to establish these specifications. We should also like to base the specifications on physical properties relevant to performance or end use as much as possible, using our field experience as a guide and performing whatever field observations and tests are necessary for this purpose.

As a starting point we have drawn up and present the following:

PROPOSED SPECIFICATION FOR RESINOUS MONOLITHIC SURFACINGS

TABLE OF CONTENTS

1. SCOPE AND CLASSIFICATION

1.1 <u>Scope</u>. This specification covers materials, requirements, surface preparation, and installation applying to resinous monolithic surfaces to be applied to concrete slabs.

1.2 <u>Classification</u>. Resinous monolithic surfacings shall be of the following types and classes and with or without special requirements, in any combination as specified.

Type I - Thin-set Terrazzo Flooring

Type II - Industrial Resinous Flooring

Class 1 - Latex or Resin emulsion Matrix

Class 2 - Polymer Matrix

Subclass a - One component Polymer Matrix

Subclass b - Two component Polymer Matrix

Special requirement - Conductive

Special requirement - Sparkproof

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on data of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

FEDERAL (INTERIM)

L-F-001641, FLOOR COVERING TRANSLUCENT OR TRANSPARENT VINYL SURFACE WITH BACKING

MILITARY

MIL-D-3134F, DECK COVERING MATERIALS

MIL-D-52505 (MO), FLOOR COATING, RESINOUS, MONOLITHIC, TROWEL TYPE (FOR WOOD AND CONCRETE FLOORS)

STANDARDS

FEDERAL TEST METHOD STANDARDS

No. 141a, PAINT, VARNISH, LACQUER AND RELATED MATERIALS: METHODS OF INSPECTION, SAMPLING, AND TESTING

No. 501a, FLOOR COVERINGS, RESILIENT, NONTEXTILE: SAMPLING AND TESTING

OTHER PUBLICATIONS

National Terrazzo and Mosaic Association, Inc. (NTMA), Terrazzo; Specifications, Details, Technical Data (1970)

National Fire Protection Association (NFPA), 56A, Standard for the Use of Inhalation Anesthetics, 1971

American Society for Testing and Materials (ASTM) Standards:

C307-61, Standard Method of Test for TENSILE STRENGTH OF CHEMICAL-RESISTANT RESIN MORTARS

C531-68, Standard Method of Test for SHRINKAGE AND COEFFICIENT OF THERMAL EXPANSION OF CHEMICAL-RESISTANT MORTARS

C579-68, Standard Method of Test for COMPRESSIVE STRENGTH OF CHEMICAL-RESISTANT MORTARS

C580-68, Standard Method of Test for FLEXURAL STRENGTH AND MODULUS OF ELASTICITY OF CHEMICAL-RESISTANT MORTARS

D412-68, Standard Method of TENSION TESTING OF VULCANIZED RUBBER

D638-68, Standard Method of Test for TENSILE PROPERTIES OF PLASTICS

E84-68, Standard Method of Test for SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS

E188-70, Recommended practice for OPERATING ENCLOSED CARBON-ARC TYPE APPARATUS FOR LIGHT EXPOSURE OF NONMETALLIC MATERIALS

E303-69, Standard Method of Test for MEASURING SURFACE FRICTIONAL PROPERTIES USING THE BRITISH PORTABLE TESTER

ASTM Special Technical Publication (STP) No. 422, "Symposium on Fire Test Methods - Restraint and Smoke", Atlantic City, N.J., 1966

3. REQUIREMENTS AND TEST METHODS

3.1 Qualification. Monolithic surfacing materials furnished under this specification shall be a product which has been tested and passed the qualification tests specified herein.

3.2 Materials. Monolithic surfacing materials shall consist of matrix and aggregate, corresponding to the desired type and class. Other ingredients may be added for the desired color or to fulfill special requirements. Dry materials other than aggregate shall be factory blended and properly proportioned for mixing with the liquid components. Primer, sealer, and grout shall be supplied as required. Materials shall be delivered to the job site in the manufacturer's original unopened package with the manufacturer's name, brand name, and type and class description clearly marked thereon. Materials to meet special requirements shall have the words CONDUCTIVE or SPARKPROOF marked thereon. Materials shall be stored at a temperature not lower than 50 degrees F. for at least 24 hours before installation. Materials when properly mixed, installed, and cured at room temperature shall produce a monolithic surfacing which meets the requirements of this specification.

Primer shall be supplied if recommended by the manufacturer of the surfacing materials. When used according to the manufacturer's instructions, the primer shall bond with the concrete subfloor and with the monolithic surfacing. Sealer shall be supplied if recommended by the manufacturer. When applied to the monolithic surfacing, sealer shall dry within 18 hours and shall form the surface which shall comply with the requirements of this specification. Grout shall be supplied for Type I, Thin-set Terrazzo Flooring, in an amount sufficient to fill in holes, cracks, and depressions in the floor after the first grinding.

3.2.1 Aggregate, Type I. The aggregate shall consist of a blend of marble chips of a range of sizes up to and including NTMA Standard No. 1 chip.

3.2.2 Aggregate, Type II. The aggregate shall be of suitable size for application in 3/16 to 5/16 inch thickness and the maximum diameter shall not be more than half the thickness of the surfacing. It shall be capable of installation with a feather edge.

3.2.3 Finishing, Types I and II. All monolithic surfacings shall be suitable for application with a trowel and shall be capable of finishing by steel trowel on the day of application.

3.2.4 Finishing, Type I. Thin-set terrazzo flooring shall be suitable for finishing with a terrazzo grinder after the specified curing period.

3.2.5 Matrix, Class 1. Matrix shall consist of liquid synthetic rubber latex or resin emulsion and dry mix to be furnished in separate containers, properly proportioned and clearly labelled.

3.2.6 Matrix, Class 2, subclass a. Matrix shall consist of liquid polymer or prepolymer with or without solvents, which shall cure when properly mixed with the other ingredients and installed, within the curing time specified.

3.2.7 Matrix, Class 2, subclass b. Matrix shall consist of two components, which shall be in separate containers, properly proportioned and clearly labelled. One component shall be a liquid polymer or prepolymer and the other component a curing agent, catalyst, or initiator, which shall cure the polymer when properly mixed with the other ingredients and installed, within the curing time specified.

3.2 Application. Monolithic surfacings in the colors, of the types and classes indicated, and with special requirements as specified, shall be applied to the areas shown on the drawings. A temperature of at least 65 degrees F. shall be maintained from 48 hours before installation until one week after installation. Adequate ventilation shall be provided to remove any volatile fumes. Finished work of other trades shall be protected from damage during installation.

3.4 Workmanship. The techniques of mixing, application, and finishing shall be of such quality that the monolithic surfacing shall meet the requirements of this specification.

3.5 Test requirements. The finished monolithic surfacing and samples submitted shall meet test requirements as in Table 1.

Table 1. Test Requirements for Monolithic Surfacings[1]

Property of Surfacing	Test Requirement	Test Method Reference
Abrasion or Wear Resistance[3]	No break through at any point	3.6.1
Adhesion or Bond Strength	300 psi minimum tensile strength with 100 percent concrete failure	3.6.5
Aging or Accelerated Weathering Resistance[3]	No cracking, peeling, blistering, loss of adhesion after 300 hours	3.6.7
Chemical Resistance	No change in color; no blistering, cracking, peeling, loss of adhesion when tested with specified reagents	3.7
Compressive Strength[3,4]	4,000 psi	3.6.9.1
Conductivity, electrical	Less than 1,000,000 and more than 25,000 ohms	3.6.10
Curing time[2]	Within 18 hours	3.6.7
Defects in Appearance or Surface Defects	Shall conform to requirements in 3.8	3.8
Fading Resistance	No discoloration or other physical changes after 48 hours exposure	3.6.6
Fire Safety[3,4]	Flame spread rating 200 Maximum specific optical density of smoke generated 450 (flaming test only)	3.6.9.3
Flexural strength[3,4]	2,000 psi	3.6.9.4
Flexural modulus of elasticity[3,4]	0.5×10^6	3.6.9.4
Hardness	Hardness as defined, minimum M85	3.6.7
Heat resistance[3,4]	No shrinkage or distortion	3.6.9.5

Table 1 - continued

Property of Surfacing	Test Requirement	Test Method Reference
Impact resistance	No cracking, peeling, blistering, loss of adhesion from 144 inch-pounds force	3.6.7
Indentation	Not more than 0.015 inch after 10 minutes at 73°F.	3.6.2
Odor	Free from objectionable odors	3.6.8
Resistance to microorganisms (Fungistatic, Bacteriostatic Resistance)	Shall not support growth of fungus or bacteria	3.6.7
Shrinkage, linear[3,4]	0.5 percent maximum after gelation or setting	3.6.9.5
Slip Resistance	More than 45 BPN units	3.9
Sparking resistance (friction)	Shall not produce a spark	3.10
Stain resistance	Shall not retain a permanent stain	3.6.7
Tensile elongation[3,4]	Minimum 5 percent	3.6.4
Tensile strength[3,4]	1,500 psi	3.6.9.6
Thermal coefficient of expansion[3,4]	Maximum 40×10^{-6} inch/inch/deg. F.	3.6.9.5
Thermal shock resistance	Shall not crack, peel, blister, spall, or lose adhesion	3.6.7
Volatility[3,4]	Loss of volatile materials shall not exceed 1 percent	3.6.3
Water absorption	Maximum 5 percent	3.6.8
Water Resistance	See Chemical Resistance	

Table 1 - continued

NOTES to Table 1

1. Tests to be performed after 30 days curing except as otherwise indicated.

2. Note 1 does not apply.

3. Test cannot be performed on finished monolithic surface

4. Test cannot be performed on panels submitted as in section 4.

3.6 References in Table I to test methods

3.6.1 Federal Specification L-F-001641, 3.3.3.4

3.6.2 Federal Test Method Standard No. 501a, Method 3211

3.6.3 Federal Test Method Standard No. 501a, Method 9211

3.6.4 NTMA Specification for Conductive Epoxy Resin Terrazzo,
1.10 PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY MATRIX

Tensile elongation, ASTM D638-68 with C die as in ASTM D412-68

3.6.5 NTMA Specification for Conductive Epoxy Resin Terrazzo,
1.11 PERFORMANCE AND PROPERTIES OF CONDUCTIVE EPOXY TERRAZZO

Adhesion or Bond Strength, Journal of the American Concrete Institute, vol. 59, No. 9, pages 1139-1141 (September 1962)

3.6.6 NTMA Specification for Epoxy Resin Terrazzo,
1.10 PERFORMANCE AND PROPERTIES OF EPOXY MATRIX

Fading Resistance, ASTM E188-70, Method A

3.6.7 NTMA Specification for Conductive Polyester Resin Terrazzo,
1.10 PERFORMANCE AND PROPERTIES

Aging or Accelerated Weathering Resistance, MIL-F-52505 (MO), 3.11, 4.4.2.10

Curing Time, MIL-F-52505 (MO), 3.3, 4.4.2.2

Hardness, MIL-F-52505 (MO), 3.8, 4.4.2.7

Impact resistance, MIL-F-52505 (MO), 3.10, 4.4.2.9

Resistance to microorganisms (Fungistatic and bacterio-static resistance), MIL-F-52505 (MO), 3.12, 4.4.2.11

Stain resistance, MIL-F-52505 (MO), 3.15, 4.4.2.14

Thermal shock resistance, MIL-F-52505 (MO), 3.15, 4.4.2.14

3.6.8 NTMA Specification for Latex Matrix Terrazzo,
1.10 PERFORMANCE AND PROPERTIES

Odor, MIL-D-3134F, 3.4

Water (moisture) absorption, MIL-D-3134F, 3.13, 4.7.8

3.6.9 ASTM Standards and other publications as follows:

3.6.9.1 ASTM C-579-68

3.6.9.2 ASTM E84-68

3.6.9.3 ASTM STP 422

3.6.9.4 ASTM C580-68

3.6.9.5 ASTM C531-68

3.6.9.6 ASTM C307-61

3.6.10 Section 252, NFPA 56A

3.7 Chemical Resistance. The monolithic surfacing may be specified resistant to acid, alcohol, alkali, detergent, or oil in the invitation for bids or request for proposals. In such cases the surfacing shall be tested according to Method 6011, Federal Test Method Standard No. 141a with reagents specified in Method 9311, Federal Test Method Standard No. 501a

Product specified as resistant to	Reagent, Method 9311 paragraph
Acid	3.6.2
Acetic acid	3.6.1
Sulfuric acid	3.6.2
Alcohol	3.6.5
Alkali	3.6.3
Detergent	3.6.4
Oil	3.6.6, 3.6.7, 3.6.8, 3.6.9, 3.6.10

3.8 Defects in Appearance or Surface Defects. The finished monolithic surface and panel submitted shall have a smooth, level, even surface free from blisters, cracks, holes, protruding particles, and embedded foreign matter. The color and finish of the surfacing shall match the panel submitted. The product shall be rejected for any surface defect which will seriously affect serviceability or appearance.

3.9 Slip Resistance. Surfacing shall be tested for slip resistance according to ASTM E303-69 but with a dry surface.

3.10 Sparking Resistance. Surfacing shall be tested for sparking resistance by stroking the floor vigorously with a 12 inch hardened steel file in a 3 foot arc. The test shall be performed for each 80 square feet of floor area. Tests shall be made in a darkened space and only when the relative humidity of the atmosphere within the space does not exceed 50 percent.

4. QUALITY ASSURANCE PROVISIONS

4.1 Unless otherwise specified in the invitation for bids or request for proposal the supplier is responsible for the performance of all tests in 3.5. The government reserves the right to perform any of these tests or any inspections where such tests and inspections are deemed necessary to assure supplies and services conform to prescribed requirements. This applies to qualification tests, preparation of subfloor, and installation. Tests may be performed by the government on panels or unmixed ingredients submitted as samples.

4.2 Qualification tests shall be performed at a laboratory satisfactory to the procuring officer. Qualification tests shall consist of the tests specified in 3.0 and Table 1.

4.3 Samples and test data: Prior to delivery of the materials to the job site, the following samples shall be submitted for approval:

Monolithic surfacing:	Two 12- by 12- inch sample panels of each type finish or color combination
	Sufficient unmixed ingredients to provide for the application of 9 square feet in area and one-fourth inch (approximate) in thickness
Divider strips, as required:	Two 6-inch lengths of each type

Finished surfacing shall match the approved samples in color and texture. Samples shall be accompanied by certified test reports from an approved laboratory showing that the monolithic surfacing has been tested within the last 12 months and meets the requirements specified herein.

4.4 Descriptive data. Manufacturer's printed instructions for proportioning, mixing, surface preparation, application, and finishing, including the recommended type and installation methods for divider strips, shall be furnished.

5. PREPARATION OF CONCRETE SUBFLOOR

The monolithic surfacing shall not be installed until the concrete slab has cured for at least 28 days. The concrete subfloor to receive surfacing shall be swept clean and shall be free of paint, wax, oil, grease, concrete curing agents, or other materials that could affect the bonding or the smoothness of the surfacing to be applied. After cleaning, the concrete surface shall be etched with a 10 percent hydrochloric acid solution applied by mopping or brooming. The acid shall be allowed to remain on the surface approximately 10 minutes or until bubbling ceases. Surfaces shall then be thoroughly washed with clean water to remove all acid and shall be allowed to dry. Cracks or uneven areas shall be patched or repaired in a manner and with materials recommended by the manufacturer.

6. INSTALLATION: Except as otherwise specified herein all work shall be in strict accordance with the manufacturer's printed instructions.

6.1 Qualification of flooring contractor. Installation shall be performed by qualified mechanics under the direction and supervision and with the responsibility assumed by a flooring contractor with not less than three years of satisfactory experience in monolithic surfacing applications. Any terrazzo grinding shall be likewise performed by qualified mechanics through a contractor with at least three years satisfactory experience in this work.

6.2 Shop drawings. Where required, the contractor shall submit drawings showing the placement of any strips that may be required, including expansion, base and border strips, and locations for various types of monolithic surfacings.

6.3 Priming concrete slab. When recommended by the manufacturer of the surfacing materials, primer shall be applied to the surface after acid etching and thorough drying in a manner to insure coverage to the entire surface without flowing or collecting in depressions. The interval between priming and application of surfacing shall be in strict accordance with the manufacturer's recommendations.

6.4 Strips of the type and size agreed on between supplier and purchasing officer shall be placed as in the drawings.

6.5 Bases shall be cove-type, cast-in-place with 1-inch radius cove and shall be 4 or 6 inches high as specified in the invitations to bids or request for proposals.

6.6 Finishing - Type I - Thin-set Terrazzo Flooring. After the surfacing has cured for seven days the entire exposed surface shall be mechanically ground with a terrazzo grinder according to accepted trade practices. After grinding the surfacing shall be cleaned to remove all grinding debris. Grout shall then be applied, working well into pinholes and voids. Material for this purpose shall be as recommended by the manufacturer and described in the printed instructions. After the grout has cured, the surface shall be ground with a No. 120 or finer stone to a smooth, uniform polished surface. After final grinding, surfaces shall be washed with a neutral cleaner and rinsed with water.

6.7 Finishing - Type II - Industrial Resinous Flooring. The surfacing shall be steel troweled to a uniform smooth finish. After curing according to the manufacturer's recommendation, a sealer coat shall be applied if recommended by the manufacturer.

6.8 Protection of Finished Floor. The finished flooring shall be protected by a covering of heavy duty building paper before foot traffic is permitted. Boardwalks shall be placed over flooring in areas where subsequent building operations might damage the floor.

6.9 Electrical Resistance Test - Conductive Flooring. Between 30 and 45 days after installation of conductive monolithic surfacing, the flooring shall be tested as in 3.6.10.

6.10 Spark Resistance Test - Sparkproof Flooring. Between 30 and 45 days after installation of sparkproof monolithic surfacing, the flooring shall be tested as in 3.10.