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TABLE 1 — MIX COMPOSITIONS

	1	2	3
COARSE AGGREGATE	1506 Kg/m³	1427 Kg/m³	1352 Kg/m³
SAND	106 Kg/m³	101 Kg/m³	89 Kg/m³
CEMENT	275 Kg/m³	350 Kg/m³	279 Kg/m³
WATER	78.5 l/m³	110 l/m³	64 l/m³
POLYMER (SOLIDS)	14.2 Kg/m³		25 Kg/m³
SUPERPLASTICIZER		3.5 l/m³	
DENSITY	1930 kg/m³	1980 Kg/m³	1815 Kg/m³
ACCESSIBLE POROSITY	21 %	20 %	24.2 %

1: Spanish specimens with polymer
2: Spanish specimens without polymer
3: Dutch specimens with polymer

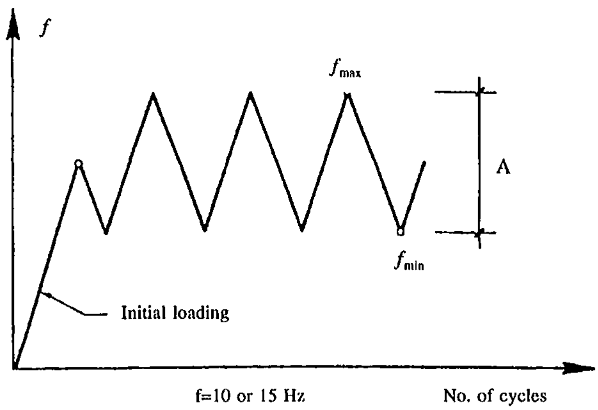

Fig. 1—Cyclic loading pattern

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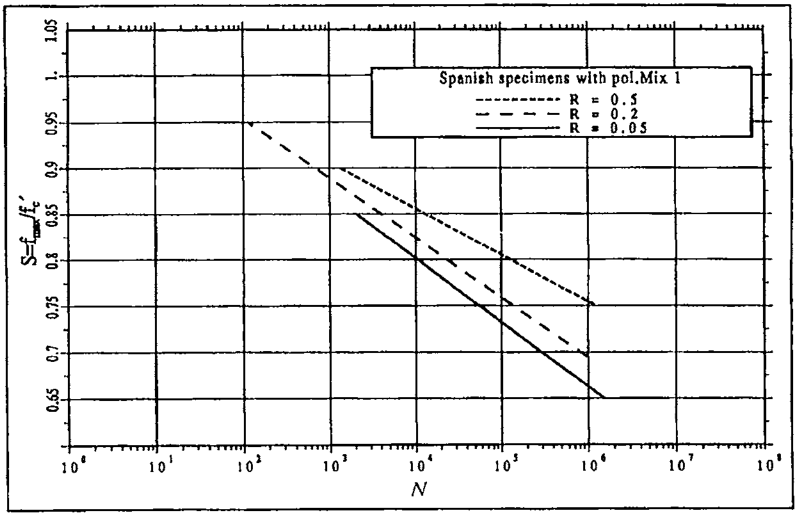

Fig. 2—*S-N* curves of Spanish polymer-modified porous concrete (mix 1) for three values of *R*

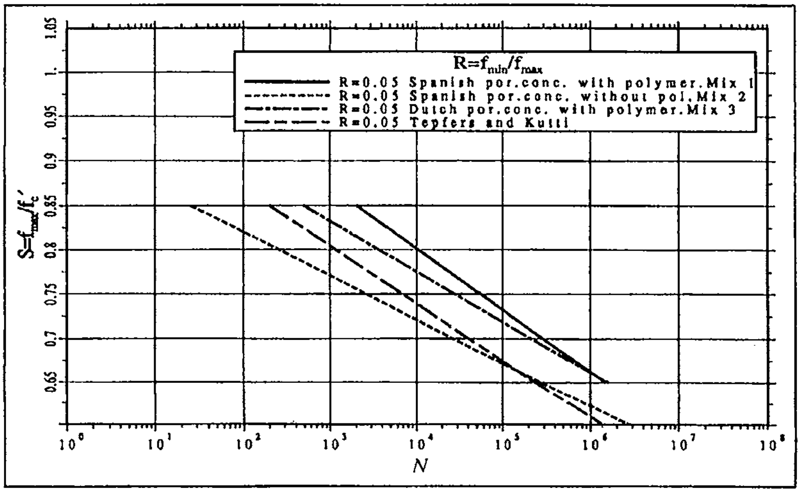

Fig. 3—*S-N* curves of polymer-modified porous concrete, porous concrete without polymer and plain concrete for R = 0.05

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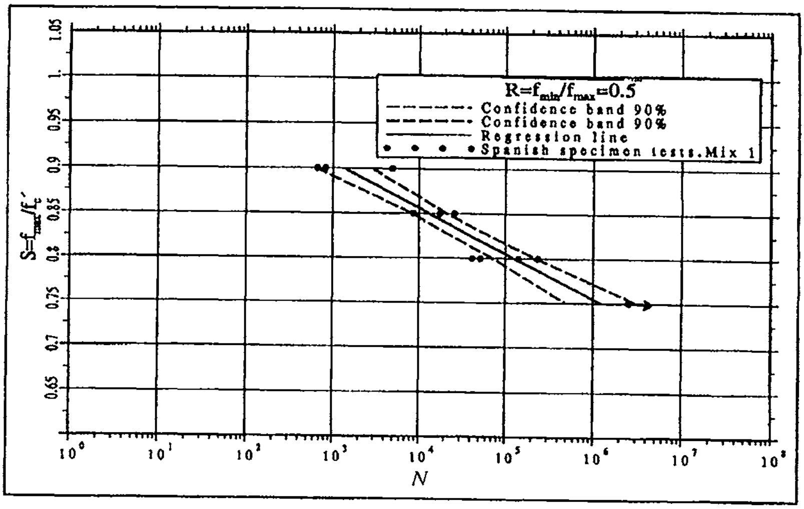

Fig. 4—90 percent confidence limits of *S-N* curve of Spanish polymer-modified porous concrete for $R = 0.5$

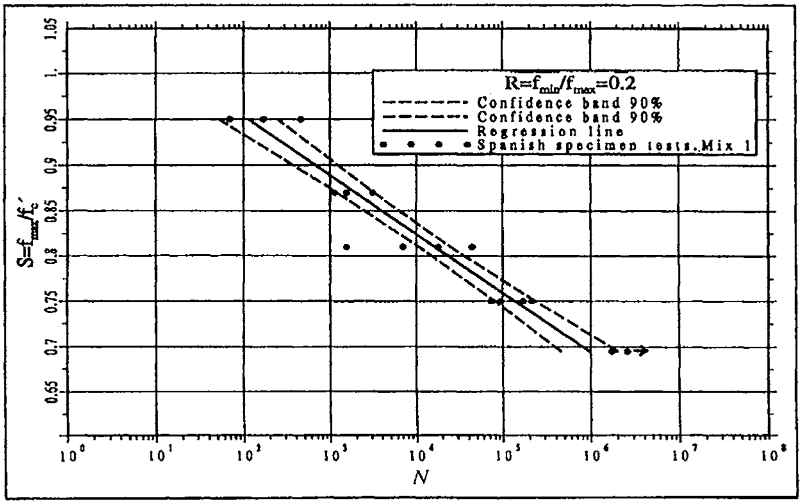

Fig. 5—90 percent confidence limits of *S-N* curve of Spanish polymer-modified porous concrete for $R = 0.2$

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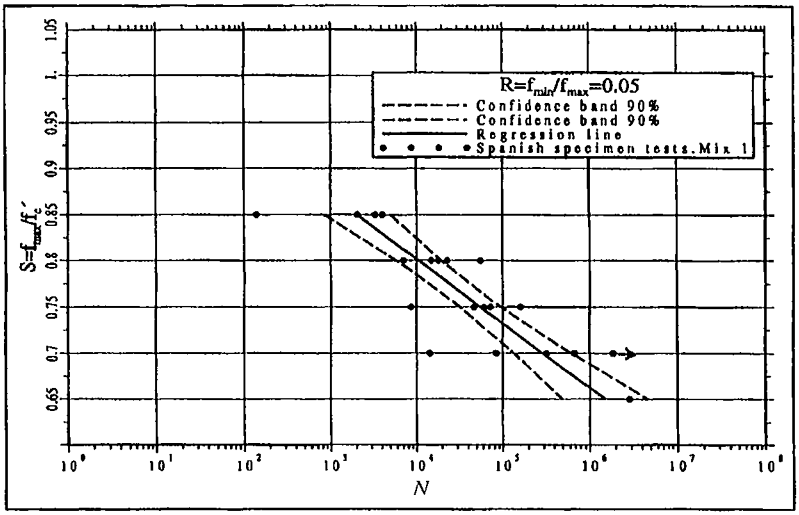

Fig. 6—90 percent confidence limits of *S-N* curve of Spanish polymer-modified porous concrete for $R = 0.05$

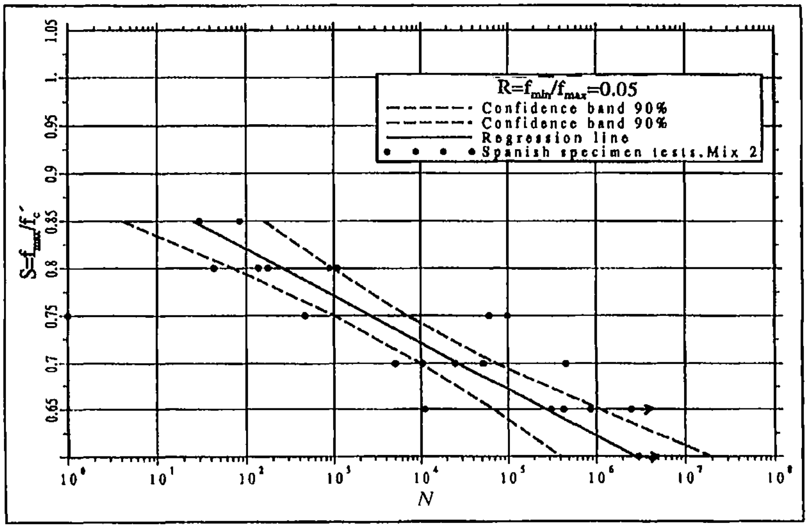

Fig. 7—90 percent confidence limits of *S-N* curve of Spanish porous concrete without polymer for $R = 0.05$

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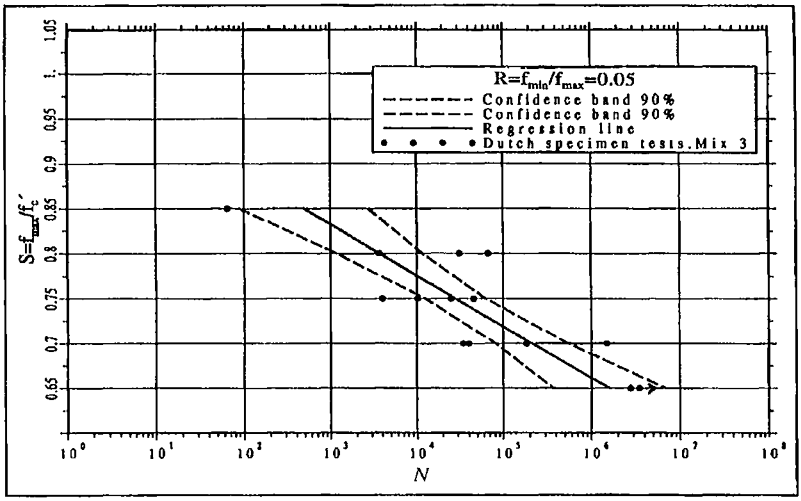

Fig. 8—90 percent confidence limits of *S-N* curve of Dutch polymer-modified porous concrete for $R = 0.05$

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SP 166-8

A New Family of Latexes for Portland Cement

by Lou A. Kuhlmann

Synopsis: A new family of latexes has been developed for use in portland cement that has a minimum film-formation temperature (MFFT) well above working temperature, eliminating the two major drawbacks of latex-modified mixtures: formation of a crust on the surface, and difficulty in cleaning tools. Instead of coalescing to form a film, as do the typical latex modifiers for portland cement, these latex particles maintain their shape as spheres. Of the several formulations studied, two are reported here: a styrene polymer and a methyl methacrylate polymer - both carboxylated. In addition to extensive laboratory testing of both polymers, two field trials with the styrene latex formulation were conducted. These laboratory and field studies demonstrated that film formation is not necessary for latexes to contribute to the performance of portland cement mixes. The data from these studies are encouraging, but also revealed that much more work needs to be done to fully understand the capabilities and limitations of this family of latexes.

Keywords: Latex; methyl methacrylate; permeability; polymer concretes; portland cement; styrene; temperature

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INTRODUCTION

Latexes currently used for modifying portland cement contribute many property improvements to mortar and concrete. Many different polymers are used to make these latexes, but all have one thing in common: a minimum film-formation temperature (MFFT) less than 50°F, meaning that they form a film at normal working temperatures. It is the formation of this film that is generally understood to be critical to the performance of these latexes in portland cement and responsible for the property improvements in the hardened mortar and concrete. This film-formation is also the cause of the two drawbacks associated with latex-modified mixtures - crusting of the surface as it dries and difficulty in cleaning tools and equipment.

A new family of latexes has been developed for use in portland cement that has a MFFT considerably above room temperature. The result is a latex-modified mixture that does not form a film at working temperatures, thus overcoming the crusting and cleaning problems. Thus, mixtures with these latexes are easier to finish than the normal latex-modified mixtures. In addition, use of these materials in ready-mixed concrete, a feature not practical with normal latexes, has been demonstrated. The mortar and concrete properties - workability, air content, compressive strength, bond strength, permeability and durability - were equivalent to, or better than, quality concrete. One formulation had several properties that were better than normal latex-modified mixtures.

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LABORATORY PROCEDURES

The following test methods were used in this study:

A. Mortar

1. Workability - Flow, ASTM C 230
2. Compressive strength - ASTM C 109
3. Air Content - ASTM C 185, paragraph 10

B. Concrete

1. Slump - ASTM C 143
2. Air Content - ASTM C 231
3. Compressive strength - ASTM C 39
4. Bond strength - tensile bond test as described in ACI Materials Journal, July-Aug, 1990, pp. 387-394
5. Flexural strength - ASTM C 78
6. Permeability - ASTM C 1202
7. Freeze/Thaw - ASTM C 666, Procedure B

The mixture proportions and curing schedule are given in Table 1. (This curing schedule will be identified as 'normal' in this paper.) Exceptions are noted on the tables and graphs. The air contents shown in Figures 2 & 8 were calculated from mortar density, according to ASTM C 185. Table 2 lists the properties of the two experimental latexes and the styrene-butadiene (S/B Control) latex used in this study. (Use of the word 'latex' in the terms 'latex content' and 'latex/cement', means the latex polymer, or solids.)

EXPERIMENTAL STYRENE LATEX

ACI's State-of-the-Art Report on Polymer-Modified Concrete (1) describes what occurs when particles in film-forming latexes change from the emulsion to a film in cured portland cement mixes. This film is visible in photographs taken at high magnification. Similar photographs of cured mortar made with a non film-forming latex clearly show the

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