Geopolymer for Protective Coating of Transportation Infrastructures

FINAL REPORT
September 1998

Submitted by

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In cooperation with

New Jersey
Department of Transportation
Division of Research and Technology
and
U.S. Department of Transportation
Federal Highway Administration

Disclaimer Statement

1. Report No. FHWA 1998-12	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Geopolymer for Protective Coating of Transportation Infrastructures		5. Report Date September 1998	
		6. Performing Organization Code CAIT/Rutgers	
7. Author(s) Dr. P. Balaguru		8. Performing Organization Report No. FHWA 1998-12	
9. Performing Organization Name and Address New Jersey Department of Transportation CN 600 Trenton, NJ 08625		10. Work Unit No.	
		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Federal Highway Administration U.S. Department of Transportation Washington. D.C.		13. Type of Report and Period Covered Final Report 06/27/1997 - 12/31/2000	
		14. Sponsoring Agency Code	
15. Supplementary Notes			

16. Abstract

    Surface deterioration of exposed transportation structures is a major problem. In most cases, surface deterioration could lead to structural problems because of the loss of cover and ensuing reinforcement corrosion. To minimize the deterioration, various types of coatings have been tried over three decades with different degrees of success. For successful long-term performance, the coating material itself should be durable, should bond well to the patent surface, and be compatible with parent surface in terms of expansion or contraction during temperature changes.

17. Key Words geopolymer, protective, coatings, reinforcement, corrosion, polymeric, polymer modified, cementitious		18. Distribution Statement	
19. Security Classif (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No of Pages 29	22. Price

Form DOT F 1700.7 (8-69)

Acknowledgements

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Introduction

Surface deterioration of exposed transportation structures is a major problem. In most cases, surface deterioration could lead to structural problems because of the loss of cover and ensuing reinforcement corrosion. To minimize the deterioration, various types of coatings have been tried over three decades with different degrees of success. For successful long-term performance, the coating material itself should be durable, should bond well to the parent surface, and be compatible with parent surface in terms of expansion or contraction during temperature changes. Currently, coating materials available in the market could be broadly classified into the following three categories, discussed in the following sections.

Polymeric Coatings

These coatings consist of polymeric or latex materials mixed with fillers. They could be very thin so as to penetrate existing cracks or thick to bridge small existing cracks. Polymers have a very high degree of impermeability and provide excellent bond during the initial application. The major problems associated with these types of coatings are, lack of vapor pressure release and stability under UV radiation. Release of fumes during application and curing and disposal of excess materials could also cause problems in certain instances. Polymeric coatings are also susceptible to fire. Past experience indicates that polymeric coatings delaminate at the interface due to damage of concrete adjacent to the polymer layer. Delamination could occur in the range of 5 to 15 years.

Polymer Modified Cementitious Coatings

A number of proprietary coatings are available in this category. The cement and filler content are adjusted to allow the release of vapor pressure. Pigments are added to improve the UV radiatiion. These coatings are found to be more durable than polymer coating. Issues relating to toxicity and fire are still to be resolved.

Cementitious Coatings

The inorganic cement coatings are compatible with concrete and do not have toxicity or UV degradation. The main problem is to obtain a fluid mix that can be used for coating with low water content. Curing the coatings is also a time consuming process. These coatings also have relatively high permeability. Therefore, cementitious coatings are not popular.

Current Research

The results reported in this report deals with the development of an inorganic matrix called Geopolymer, for use as a coating material. This matrix can be formulated with varying degrees of permeability to allow for release of vapor pressure. The coating can also be designed to provide a glossy surface to which paint will not stick. Therefore, the coating can also be used as a graffiti-resistant application in urban areas.

Properties of Geopolymer

Geopolymer is a potassium alumina-silicate matrix which is water based and has mechanical properties similar to portland cement concrete. Since the particle size of solids in the matrix is less than 0.5 μ m, the resin has low viscosity and can be applied as a very thin coating. The material had been investigated as a matrix for high strength advanced composites for aerospace, automobile, and infrastructure applications [1-5]. The following is the summary of properties that makes this matrix suitable for use as a coating for infrastructures.

- The matrix is water based and has no toxins. The excess material can be disposed of as ordinary waste and no fumes are generated during mixing, application, or curing.
- It bonds well with concrete, steel and wood, and has a bond strength of about 1.6 ksi. Carbon, glass, steel and ceramic fibers can be mixed to improve the mechanical properties.
- The basic color is white and hence pgiments can be added to obtain any desired color. UV radiation does not degrade the material.
- Alumino-silicate materials have been used as bricks for thousands of years with excellent durability performance. Therefore, the material is expected to be very durable. In addition, when used with portland cement concrete, a chemical bond is developed resulting in excellent interfacial bond properties.
- Fillers can be added to obtain a very hard surface that cannot be scratched even with steel. The composition can also withstand up to 1000° C and hence fire is not a problem.
- As mentioned earlier, a glossy finish can be obtained to provide a graffiti-resistant surface.
- The pure matrix has a compressive strength of 5 ksi, and a modulus rupture of about 1.2 ksi. Micro and short discrete fibers can be added to increase the modulus of rupture to 15 ksi and continuous fibers have been used to increase modulus of rupture to 70 ksi.

2

Research Program

The research program had three main components consisting of: (i) evaluation for durability, (ii) application techniques, and (iii) techniques for removal of graffiti. The following sections provide the pertinent details of the study and the results.

Evaluation for Durability

The durability tests were designed to evaluate both the performance of the coatings and the behavior of the interface. The first series consisted of accelerated degradation under wetting and drying using warm water. The second test was conducted for evaluating freezing and thawing resistance. A number of formulations were evaluated in order to obtain a variety of coatings based on surface hardness, surface finish, and economy.

Matrix Composition

The matrix consisted of a liquid component, three types of silicafumes, two types of fillers, two activators, two fiber types, water repellent agent, and addition of organic polymers. Three types of silica fumes provide various degrees of eonomy. The gray silicafume is the most economical, but white color cannot be achieved with this fume and therefore useful only for application where matching of color is not needed. The second fume is more economical than the first but contains 0.5 percent carbon, providing a light gray color.

Fillers provide different levels of hardness and economy. One activator provides rapid curing whereas the other one provides more working time (pot life). Carbon and organic fibers were used to improve the ductility of the matrix. Organic fibers provide more resistance to elongation but are susceptible to fire. However, since the fiber volume fraction is less than 0.5 percent, fibers do not emit fumes under fire. Water repellent agent and organic polymers were tried to obtain early strength and water resistance. Compositions without polymer require protection from rain or running water for 3 days. The combination of these variables resulted in 71 mixes, as shown in Table 1.

Sample Preparation

Reinforced mortar plates, 12 x 12 in. and 0.5 in. thick were prepared using ASTM Type I cement, concrete sand, and welded wire mesh. These plates were used as parent surface for coating. The coating matrix was prepared using high shear mixture for the laboratory

3

investigation. The constituent materials could be easily mixed with propeller type mixers currently used for mixing paint.

All the ingredients were mixed for about one minute. Initially, the mixture is stiff and eventually mixes to a thick liquid that can be applied using brush, squeeze, or sprayer. In the laboratory, squeeze was used for the application. The surface becomes tack free after 2 hours. The samples were left at room temperature for at least 28 days before placing them in a wet-dry machine.

Curing Scheme

The coating can be cured at room temperature or at elevated temperatures of 80° or 150° C. At 150° C, the curing is 99 percent complete in 3 hours. At 80° C, 3 hour curing provides about 92 percent curing. At room temperature, the sample has to be protected from running water or direct rain for 3 days. After 24 hours, the samples are water resistent. However, running water could damage the surface by leaching out small amounts of activators.

Test Setup: Wetting and Drying

The test setup consisted of a stainless container for storing water, high velocity fan for drying, electronic switches to control wet and dry cycles and a mechanism to maintain the water temperature, Fig. 1. A special supporting system was fabricated to place the samples inside without touching each other.

The cylindrical storage chamber had a capacity of 150 liters and was fitted with a high velocity fan for the drying operation. Cold and hot water from the tap was mixed to obtain a water temperature of 50° C. The specimens were soaked for two hours after which the controller opened the valve for draining the water and turned on the fan to start the drying cycle. A drying cycle duration of 2 hours was chosen which provided a complete dry surface. At the end of the drying cycle, the outlet valve and the fan were switched off and the inlet valve was opened to fill the chamber. Soaking for 2 hours, drying for 3 hours, and filling and draining that took 1 hour, constituted a cycle time of 6 hours, resulting in 4 wet-dry cycles per day.

Wetting in warm water and drying with air provided a very corrosive environment, providing visible rust to steel bars in 3 or 4 cycles. All the fixtures were made of stainless steel or plastic. The water was not recirculated and hence any chemicals bleached from the samples did not influence the water quality for the subsequent cycles. Since the surface area of samples and the volume of chemicals that could leach was very small in a given 2 hour soaking cycle, it was assumed that the water quality was the same as the drinking water. The initial value of pH, which was about 6.8, did not change during the wetting cycle.

Test Setup: Freezing and Thawing

For freezing and thawing tests, the standard equipment specified for ASTM C 666 was used for this study. The samples were sealed in polyethelyne bags in order to conduct the tests in air. Since the parent concrete (mortar) was not air entrained, freezing and thawing was not done in water. Some of the parent concrete disintegrated even in this scheme, as discussed in the next section.

Test Results and Discussion

Both wetting and drying, and freezing and thawing tests were conducted up to 100 cycles. The results are presented in Tables 2 and 3. The samples were visually examined for surface condition, cracking and bond to parent concrete. Glossy and semi-gloss appearance indicate that the coating did not deteriorate. A careful review of the results lead to the following observations. As expected, wetting and drying provided more severe deterioration than freezing and thawing.

- Most samples had cracks. Very fine cracks are much less than the maximum crack width of 0.007 in. recommended by the American Concrete Institute for salt water exposure. If the widths are smaller than 0.007 in., very little damage is expected. The test results presented in this report confirm this hypothesis. However, it is always better to have no cracks. Nine samples had "no crack" condition. Addition of small amount of micro fibers or 3 mm long carbon fibers also eliminates cracking for other formulations.

- Four of the uncracked samples and a number of samples with very fine, and fine cracks had good bond. If the coatings could not be removed using knife edges, the bond was designated as good. It should be noted that the surface of the parent concrete was smooth. In practical applications, it is expected that the surfaces will be much rougher and hence provide better bond than reported in the laboratory study.

- Mixes with organic polymers are not recommended even though some of the formulations, specially mix 9, provides excellent performance. Addition of organic matrix makes the mixing and application process more complex.

Mixes 59 and 68 provided overall best performance. These mixes contain silicafume with 0.5 percent carbon and water repellent agent. Water repellent agent also acts as a plasticizer resulting in better mixing and dispersion. Fillers are needed to improve the durability. A minimum of 25 percent filler is needed for reducing or eliminating cracks. The amount of filler can be doubled or tripled without sacrificing workability, but the resistance to graffiti reduces with increase in filler content.

Addition of micro and/or short fiber improves the matrix performance. Since the cost of carbon fibers is rapidly decreasing, it is recommended to use 0.5 percent carbon fibers in all mixes.

5

These fibers do result in a gray shade and if this is not acceptable, 0.25 percent nylon micro fibers (6 mm long) can be used.

Application Procedures

The matrix with or without short fibers can be applied with brush, squeeze, or sprayer. Commercial spraying system shown in Fig. 2 was successfully used for spraying. The matrix can also be easily applied by brush. For smaller areas, it is recommended to use brush and for larger areas, sprayers can be used. The pot life is about 1 hour at 75° F. At higher temperatures, precautions should be taken to cool the constituent materials to prevent the reduction of working time.

The components can be mixed with the paddle mixers used for mixing paint. The tools can be cleaned with water. Special surface preparation is not needed. It is recommended to wet the parent surface to obtain saturated-surface dry condition.

If the surface is left to cure at room temperature, it should be protected from running water and direct rain for 3 days. If heating blankets are used to raise the temperature to 80° C for three hours, no further protection is needed. The surface can also be heated using direct flame after 24 hours. If the coating is cured with direct flame, further protection is not needed.

Graffiti Removal Techniques

The graffiti can be removed with water under pressure. However, it is recommended to use abrasion wheels for the graffiti removal. This equipment, developed for the removal of lead paint, has a vacuum attachment for collecting the dust. Essentially, the equipment grinds off the paint and the removed particles are collected in the bag. Since the coating has a very hard surface, the abrasion wheels will provide very efficient graffiti removal and the amount of waste collected will also be very small.

Summary and Recommendations

As expected, the alumino-silicate matrices shows excellent promise for application as a protective and graffiti-resistant coating. The coating provides a hard surface from which graffiti can be removed with abrasion wheels. Matrix can be formulated to provide durable coating, under wet-dry and freeze-thaw conditions. It is compatible with various concrete surfaces, steel, and wood as shown in Figs. 3 to 9.

6

The coating can be applied with brush or sprayers. It is compatible with concrete, steel, and wooden surfaces. Paint will not stick to the coating. The surface can be recoated only with the inorganic matrix.

The following are the two recommended compositions:

Composition 1	Liquid	100g
	Any Silica fume	135g
	Ground Sand	100g
	Activator	10g
	Latex	20g

Composition 2   Same as 1 except replace latex with water repellent.

In both cases, addition of 0.5 weight percentage of 3 mm long carbon fibers improve the performance further.

It is recommended to use the matrix for demonstration projects involving all three types of surfaces. Large piers and retaining walls in urban areas are the prime targets. This will further demonstrate the feasibility and performance of this chemical composition which has been in use for buildings over 800 years.

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TABLE 1

Mix Proportions

Sample ID	Liquid [g]	SiO$_2$ 1 [g]	SiO$_2$ 2 [g]	SiO$_2$ 3 [g]	Act. 1 [g]	Act. 2 [g]	Filler 1 [g]	Filler 2 [g]	777 [g]	Fiber 1 [%]	Fiber 2 [%]	Polymer Type	Polymer Content [%]	Water [g]
1	100	135			10		100			0.5				
2	100	135			10		100			1				
3	100	135			10		100				0.25			5
4	100	135			10		100				0.5			5
5	100	135			10		100				1			5
6	100	135			10		100			0.5		West 209	5	
7	100	135			10		100			0.5		West 209	5	5
8	100	135			10		100			0.5		West 209	10	
9	100	135			10		100			0.5		West 209	15	
10	100	135			10		100			0.5		Epondex	5	
11	100	135			10		100			0.5		Epondex	10	
12	100	135			10		100			0.5		Epondex	15	
13	100	135			10		100			0.5		3M Vinyl	5	
14	100	135			10		100			0.5		3M Vinyl	10	
15	100	135			10		100			0.5		3M Vinyl	15	
16	100	135			10		100			0.5		Evercoat	5	
17	100	135			10		100			0.5		Evercoat	10	
18	100	135			10		100			0.5		Evercoat	15	
19	100	135			10		100			0.5		West 207	5	
20	100	135			10		100			0.5		West 207	10	
21	100	135			10		100			0.5		West 207	15	
22	100	135			10		100			0.5		West 205	5	
23	100	135			10		100			0.5		West 205	10	
24	100	135			10		100			0.5		West 205	15	
25	100	135			10		100			0.5		West 206	5	
26	100	135			10		100			0.5		West 206	10	
27	100	135			10		100			0.5		West 206	15	
28	100	135			10		100					Latex	10 g	
29	100	135			10		100					Latex	20 g	
30	100	135			10		100					Latex	30 g	
31	100		135		10		100					Latex	20 g	
32	100		135		10		100					Latex	40 g	
33	100		135		10		100					Latex	60 g	
34	100			135	10		100					Latex	20 g	
35	100			135	10		100					Latex	40 g	
36	100			135	10		100					Latex	60g	

Liquid	Potassium Silicate
Activator 1	Calcium based oxide
Activator 2	Zinc based oxide
Filler 1	Ground sand
Filler 2	Ceramic powder
777	Water repellent
Fiber 1	Carbon fiber
Fiber 2	Polymeric fiber

TABLE 1 (cont'd)

Mix Proportions

Sample ID	Liquid [g]	SiO₂ 1 [g]	SiO₂ 2 [g]	SiO₂ 3 [g]	Act. 1 [g]	Act. 2 [g]	Filler 1 [g]	Filler 2 [g]	777 [g]	Fiber 1 [%]	Fiber 2 [%]	Polymer Type	Polymer Content [%]	Water [g]
37	100		135		10		50							
38	100		135		10		100							
39	100		135		10		200							
40	100			135	10		50							
41	100			135	10		100							
42	100			135	10		200							
43	100		135		10		50							
44	100		135		10		100							
45	100		135		10		200							
46	100		135		10		200							~5
47	100*			140	20		200							
48	100*			140	20		200			0.5				
49	100*			140	20		200			1				
50	100*			140	20		200			1				~5
51	100			135	5		50	0	10					
52	100			135	5		25	25	10					
53	100			135	5		0	50	10					
54	100			135	5	0	50		10					
55	100			135	2.5	2.5	50		10					
56	100			135	0	5	50		10					
57	100			135	5			50	10					
58	100			135	5			100	10					
59	100			135	5			150	10					
60	100	135			5			50	10					
61	100	135			5			100	10					
62	100	135			5			150	10					
63	100	135				5		50	10					
64	100	135				5		100	10					
65	100	135				5		150	10					
66	100			135	5	0	50		10					
67	100			135	5	0	50		10					
68	100			120+5MK	5	0	50		10					
69	100			135		5	50	0	10					
70	100			135		5	40	10	10					
71	100			135		5	30	20	10					

TABLE 2

Results After 100 Wet-Dry Cycles

Sample ID	Surface Condition	Crack Size	Crack Orientation	Crack Density	Bond
37	Flat	Very Fine	Random	High	Good
38	Flat	Very Fine	Random	Medium	Good
39	Flat	Very Fine	Random	Low	Good
40	Debonded				
41	Flat	Large	Random	High	Fail
42	Semi-Gloss	Medium	Random	High	Poor
43	Flat	Very Fine	Random	Low	Good
44	Semi-Gloss	Fine	Random	Medium	Fail
45	Flat	Fine	Random	Medium	Poor
46	Flat	None	N/A	N/A	Good
47	Chalky	Medium	Random	Medium	Fail
48	Flat	None	N/A	N/A	Fail
49	Semi-Gloss	None	N/A	N/A	Poor
50	Flat	None	N/A	N/A	Poor
51	Semi-Gloss	Very Fine	Random	Very Low	Good
52	Flat	Very Fine	Random	Very Low	Good
53	Semi-Gloss	Very Fine	Random	High	Poor
54	Flat	Very Fine	Random	Low	Good
55	Flat	Very Fine	Random	Low	Good
56	Chalky	Very Fine	Random	Low	Good
57	Gloss	Very Fine	Random	Very Low	Fair
58	Gloss	Very Fine	Directional	Very Low	Fair
59	Semi-Gloss	None	N/A	N/A	Good
60	Semi-Gloss	Very Fine	Random	Very Low	Good
61	Semi-Gloss	Very Fine	Random	Medium	Poor
62	Flat	Very Fine	Random	Low	Fair
63	Flat	Very Fine	Random	Low	Fair
64	Flat	Very Fine	Random	Very Low	Fair
65	Flat	Fine	Random	Low	Good
66	Semi-Gloss	Very Fine	Random	Medium	Fail
67	Flat	Very Fine	Random	Low	Poor
68	Flat	None	N/A	N/A	Good
69	Flat	Fine	Random	Medium	Good
70	Flat	Fine	Random	Medium	Poor
71	Flat	Very Fine	Random	Low	Good

TABLE 2 (cont'd)

Results After 100 Wet-Dry Cycles

Sample ID	Surface Condition	Crack Size	Crack Orientation	Crack Density	Bond
1	Gloss	Large	Random	High	Poor
2	Gloss	Medium	Directional	Medium	Fair
3	Chalky	Medium	Directional	High	Good
4	Chalky	Large	Directional	High	Good
5	Chalky	Fine	Random	Medium	Good
6	Gloss	Fine	Random	High	Good
7	Semi-Gloss	Fine	Random	High	Good
8	Gloss	Fine	Random	High	Good
9	Semi-Gloss	None	N/A	N/A	Good
10	Gloss	Large	Random	High	Good
11	Semi-Gloss	Fine	Random	Medium	Fair
12	Semi-Gloss	Very Fine	Random	Medium	Fair
13	Gloss	Medium	Random	Medium	Good
14	Gloss	Fine	Random	Low	Good
15	Gloss	Fine	Random	High	Good
16	Semi-Gloss	Medium	Directional	High	Good
17	Gloss	Medium	Random	Medium	Good
18	Gloss	Fine	Random	Medium	Fair
19	Semi-Gloss	Very Fine	Random	Medium	Good
20	Semi-Gloss	Very Fine	Random	Low	Good
21	Segregated	None	N/A	N/A	Good
22	Semi-Gloss	Very Fine	Random	Low	Poor
23	Flat	Fine	Random	Medium	Poor
24	Flat	None	N/A	N/A	Poor
25	Semi-Gloss	Fine	Random	Medium	Poor
26	Flat	None	N/A	N/A	Fair
27	Segregated	None	N/A	N/A	Poor
28	Gloss	Large	Random	Medium	Fair
29	Gloss	Medium	Random	High	Fair
30	Gloss	Medium	Random	Medium	Fair
31	Flat	Very Fine	Random	Low	Good
32	Flat	Medium	Random	Medium	Poor
33	Flat	Fine	Random	Low	Fair
34	Semi-Gloss	Very Fine	Random	Very Low	Good
35	Flat	Large	Random	High	Fail
36	Semi-Gloss	Very Fine	Random	Low	Good

11

TABLE 3

Results After 100 Freeze-Thaw Cycles

Sample ID	Surface Condition	Crack Size	Crack Orientation	Crack Density	Bond	Water Damaged
1	Sample Destroyed					*
2	Sample Destroyed					*
3	Sample Destroyed					*
4	Sample Destroyed					*
5	Sample Destroyed					*
6	Semi-Gloss	Large	Random	Low	Good	*
7	Semi-Gloss	N/A	N/A	N/A	Good	*
8	Semi-Gloss	N/A	N/A	N/A	Good	*
9	Semi-Gloss	N/A	N/A	N/A	Good	
10	Semi-Gloss	N/A	N/A	N/A	Good	
11	Semi-Gloss	N/A	N/A	N/A	Good	
12	Semi-Gloss	N/A	N/A	N/A	Good	
13	Semi-Gloss	N/A	N/A	N/A	Good	
14	Semi-Gloss	N/A	N/A	N/A	Good	
15	Semi-Gloss	N/A	N/A	N/A	Good	
16	Semi-Gloss	N/A	N/A	N/A	Good	
17	Semi-Gloss	N/A	N/A	N/A	Good	
18	Semi-Gloss	N/A	N/A	N/A	Good	
19	Semi-Gloss	N/A	N/A	N/A	Good	
20	Semi-Gloss	N/A	N/A	N/A	Good	
21	Segregated	N/A	N/A	N/A	Good	
22	Semi-Gloss	N/A	N/A	N/A	Good	
23	Flat	N/A	N/A	N/A	Good	
24	Flat	N/A	N/A	N/A	Good	
25	Semi-Gloss	N/A	N/A	N/A	Good	
26	Flat	N/A	N/A	N/A	Good	
27	Segregated	N/A	N/A	N/A	Good	
28	Gloss	Medium	Random	Medium	Good	
29	Gloss	N/A	N/A	N/A	Good	
30	Gloss	Fine	Random	Low	Good	
31	Flat	N/A	N/A	N/A	Good	
32	Flat	N/A	N/A	N/A	Good	
33	Flat	N/A	N/A	N/A	Good	
34	Sample Destroyed					*
35	Sample Destroyed					*
36	Sample Destroyed					*

12

TABLE 3 (cont'd)

Results After 100 Freeze-Thaw Cycles

| Sample ID	Surface Condition	Crack Size	Crack Orientation	Crack Density	Bond	Water Damaged
37	Flat	Fine	Random	High	Poor	*
38	Flat	Fine	Random	High	Poor	*
39	Flat	N/A	N/A	N/A	Poor	*
40	Semi-Gloss	Fine	Random	Medium	Poor	*
41	Semi-Gloss	Fine	Random	Medium	Poor	*
42	Semi-Gloss	Fine	Random	Medium	Poor	*
43	Sample Destroyed					*
44	Sample Destroyed					*
45	Sample Destroyed					*
46	Sample Destroyed					*
47	Semi-Gloss	Large	Random	Very High	Poor	*
48	Semi-Gloss	Large	Random	Low	Poor	*
49	Semi-Gloss	Large	Directional	Very Low	Fair	*
50	Sample Destroyed					*
51	Gloss	Medium	Random	Low	Good	
52	Gloss	Fine	Random	Low	Good	
53	Gloss	N/A	N/A	N/A	Good	
54	Sample Destroyed					*
55	Sample Destroyed					*
56	Sample Destroyed					*
57	Debonded					*
58	Semi-Gloss	Fine	Directional	Very Low	Good	*
59	Semi-Gloss	Fine	Directional	Very Low	Good	*
60	Gloss	Very Fine	Random	Low	Poor	
61	Gloss	Fine	Random	Medium	Good	
62	Gloss	Very Fine	Random	Low	Good	
63	Gloss	Fine	Random	Low	Good	
64	Gloss	Fine	Random	High	Good	
65	Semi-Gloss	Large	Random	High	Good	
66	Gloss	Very Fine	Random	Low	Good	
67	Gloss	Very Fine	Random	Medium	Fair	
68	Gloss	Very Fine	Random	Very Low	Good	
69	Gloss	Large	Random	High	Poor	*
70	Gloss	Medium	Random	Medium	Poor	*
71	Gloss	Medium	Random	Medium	Fair	*

13
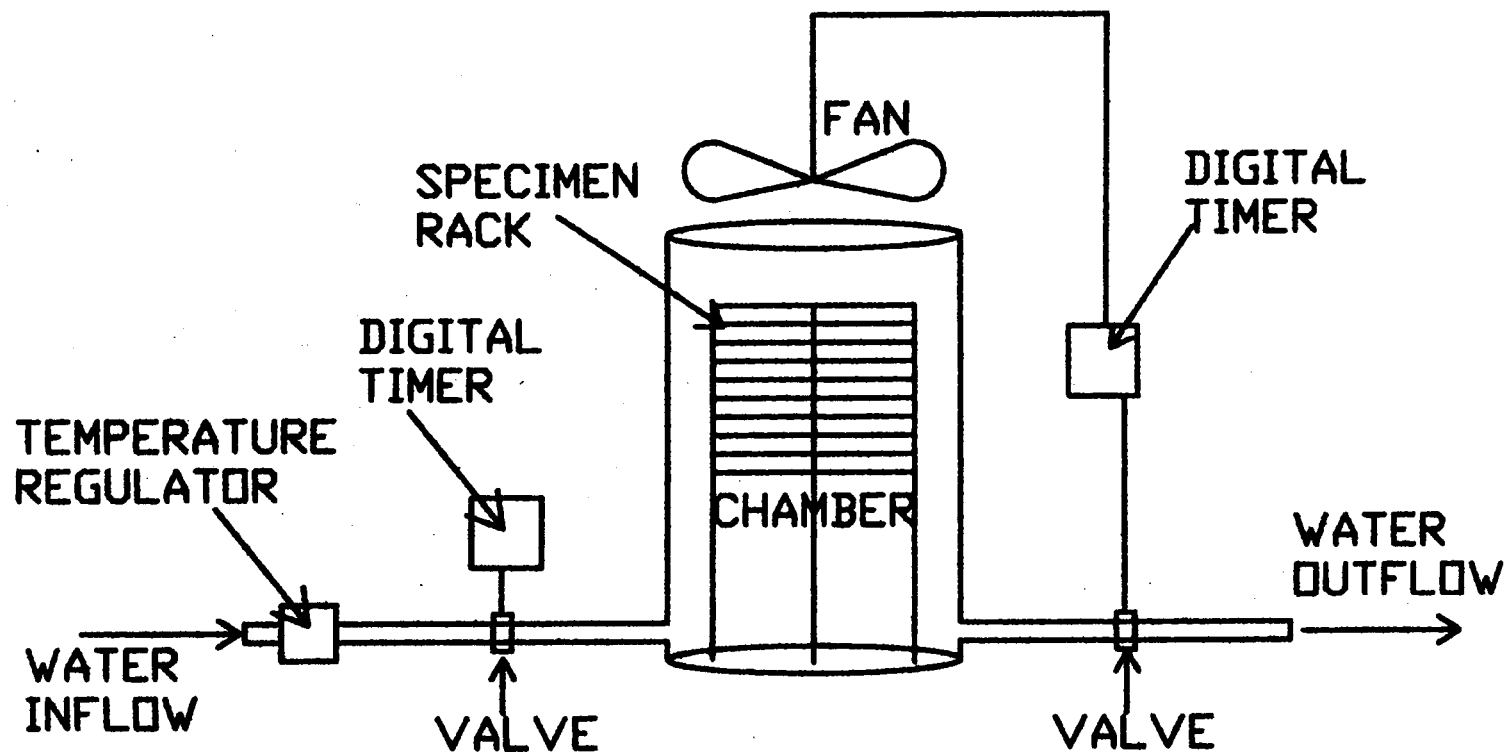
Fig. 1.   Wet-Dry Test Setup
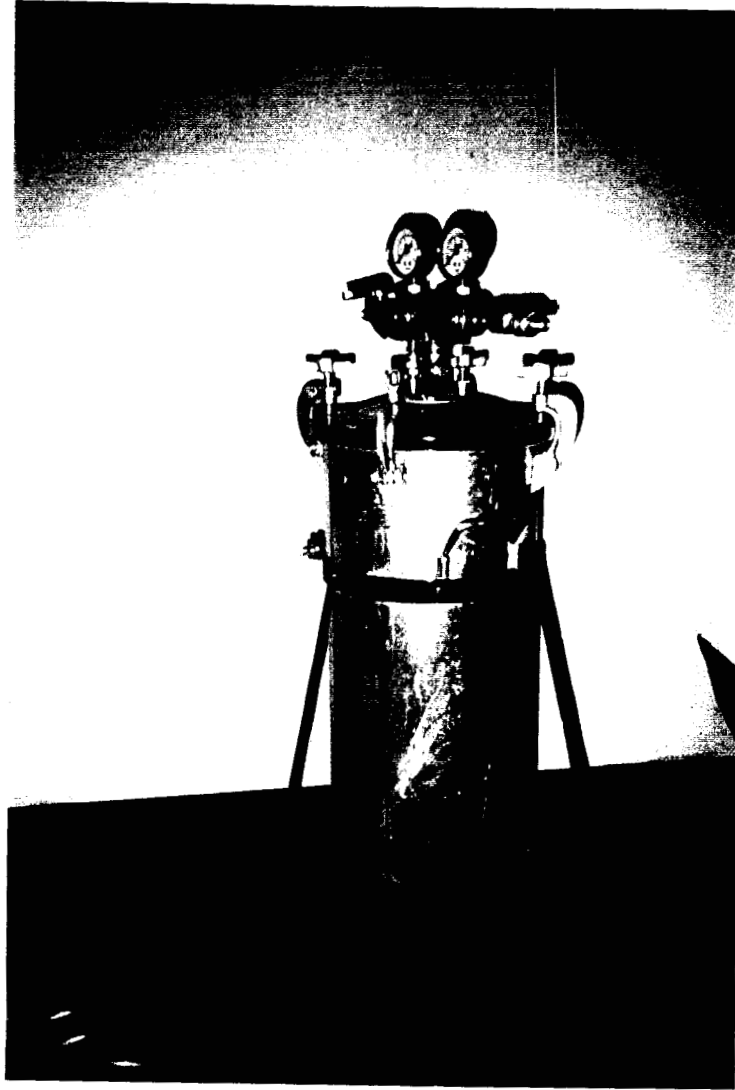
Fig. 2 (a). Spray system used for demonstration.
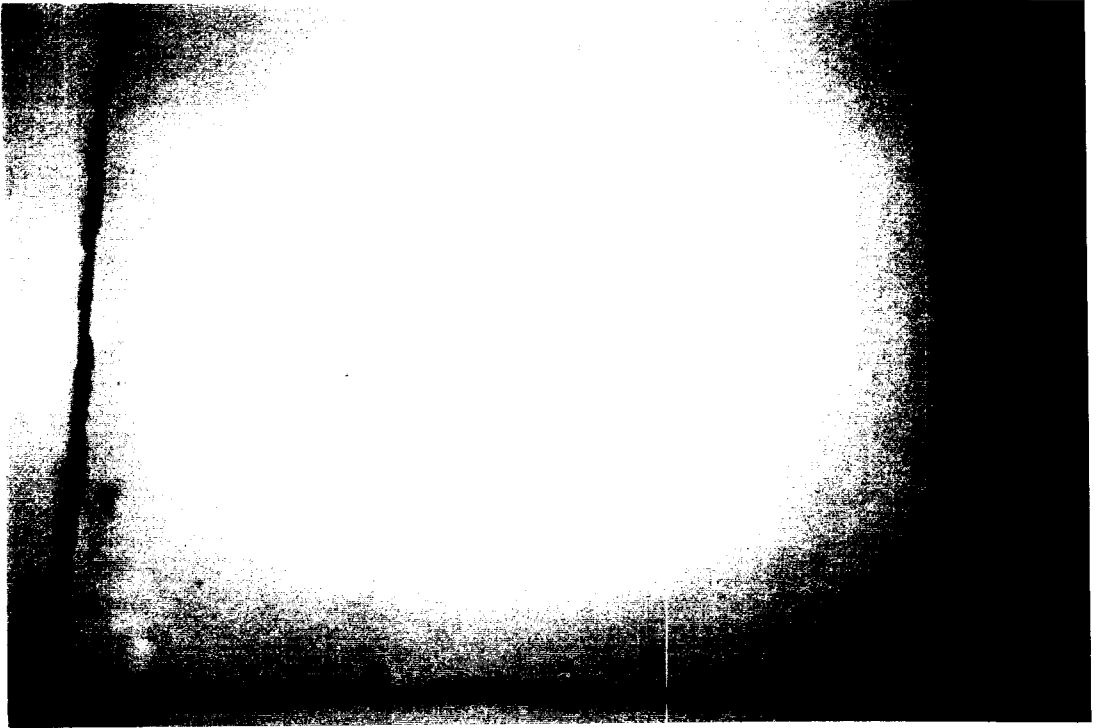
Fig. 2 (b). Setup for field mixing.

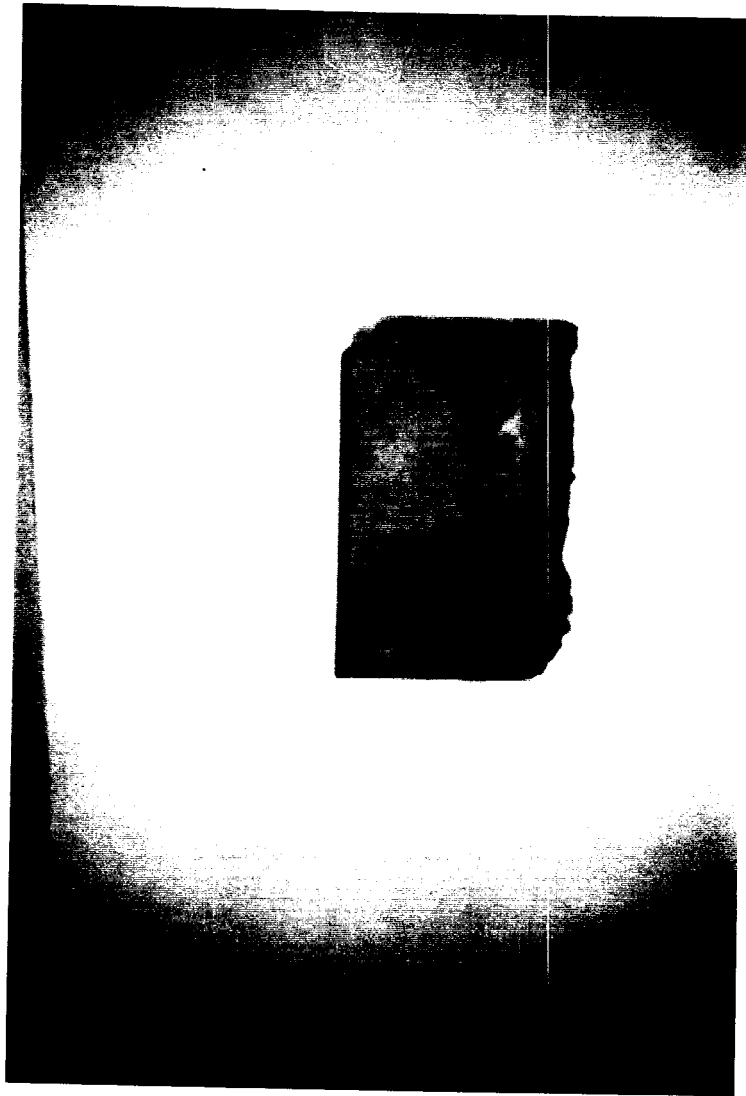Fig. 3. Coating on smooth concrete surface.

Fig. 4. Coating on hollow-cor block (porous concrete).
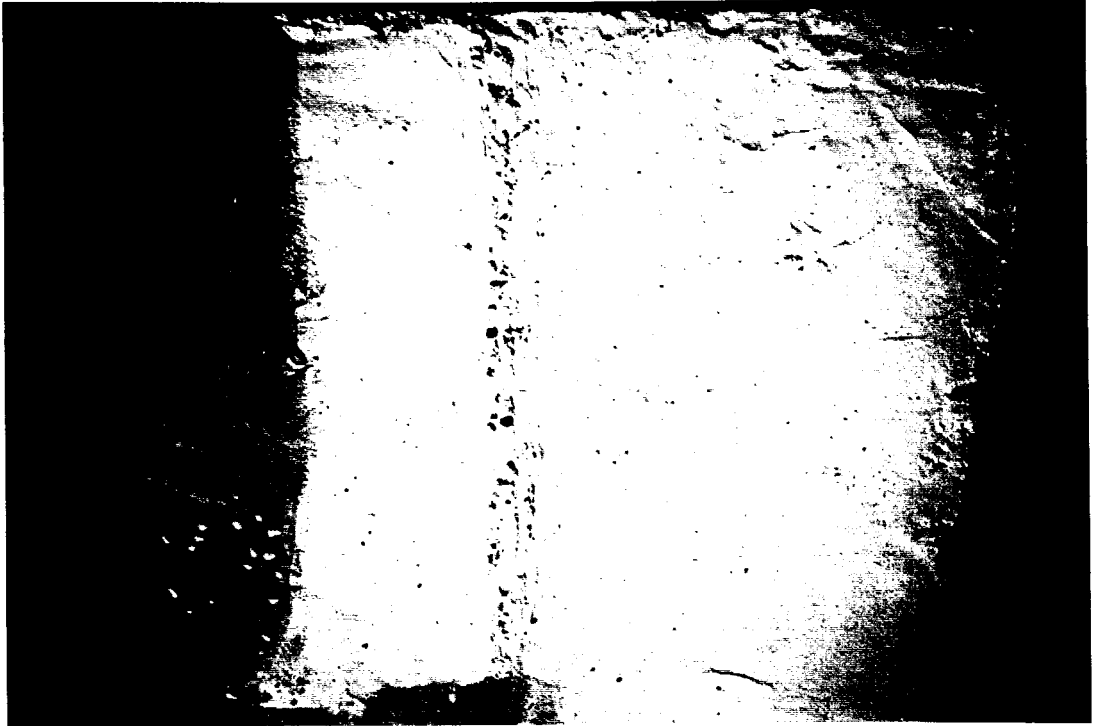
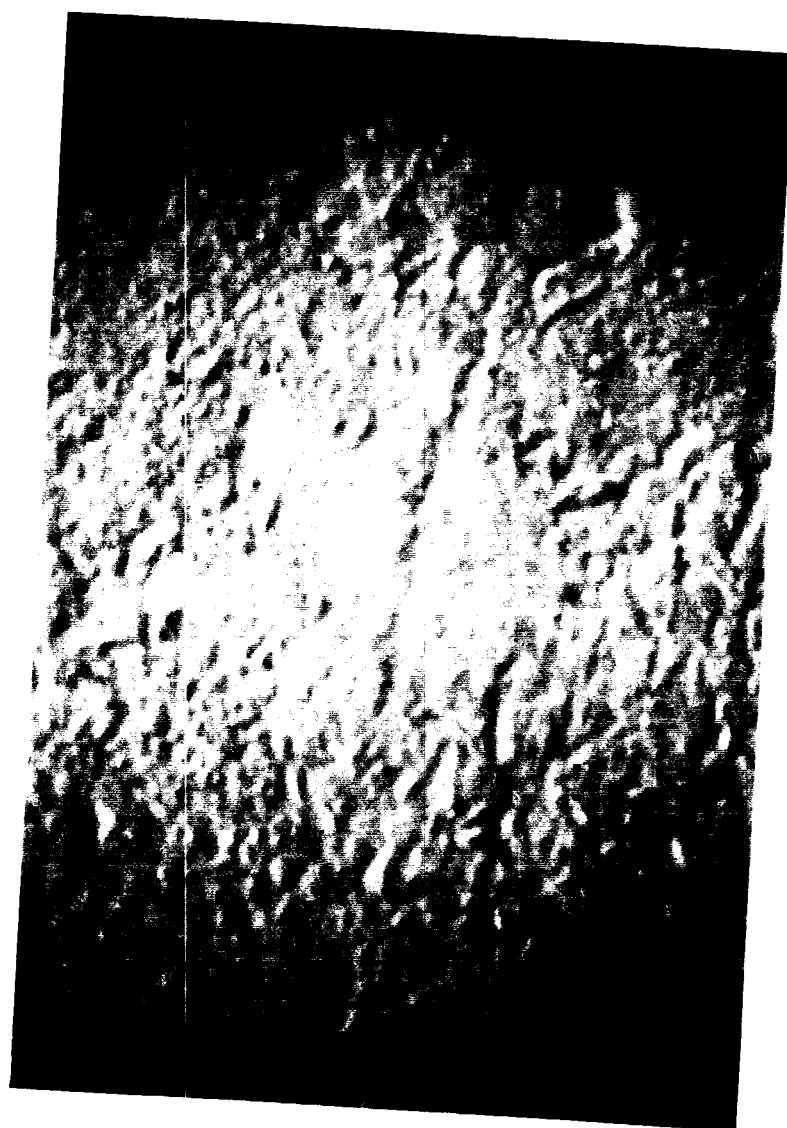Fig. 5. Coating on large concrete block, application by paint brush.

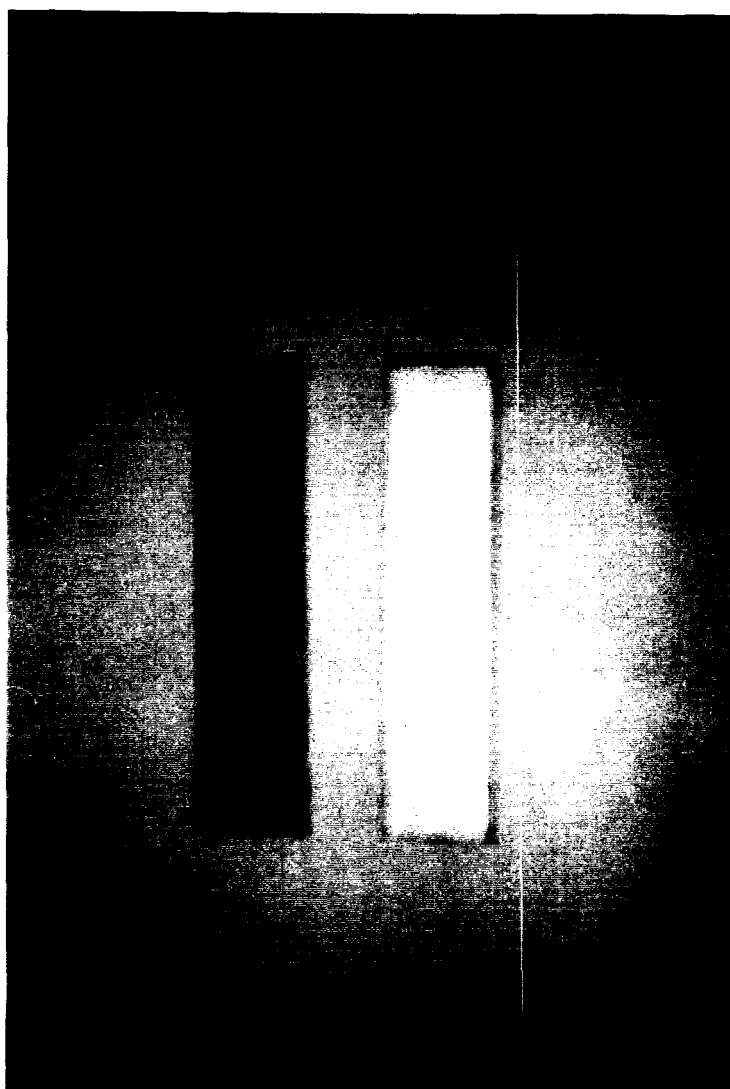Fig. 6.   Coating on concrete wall, application by sprayer.

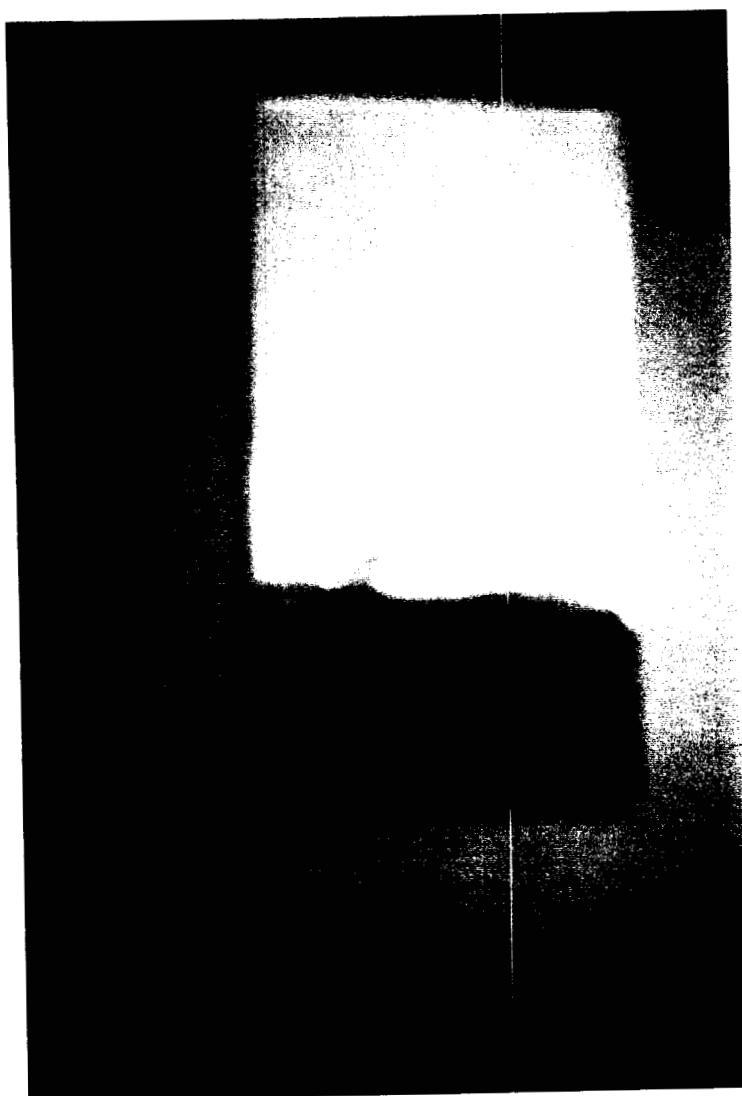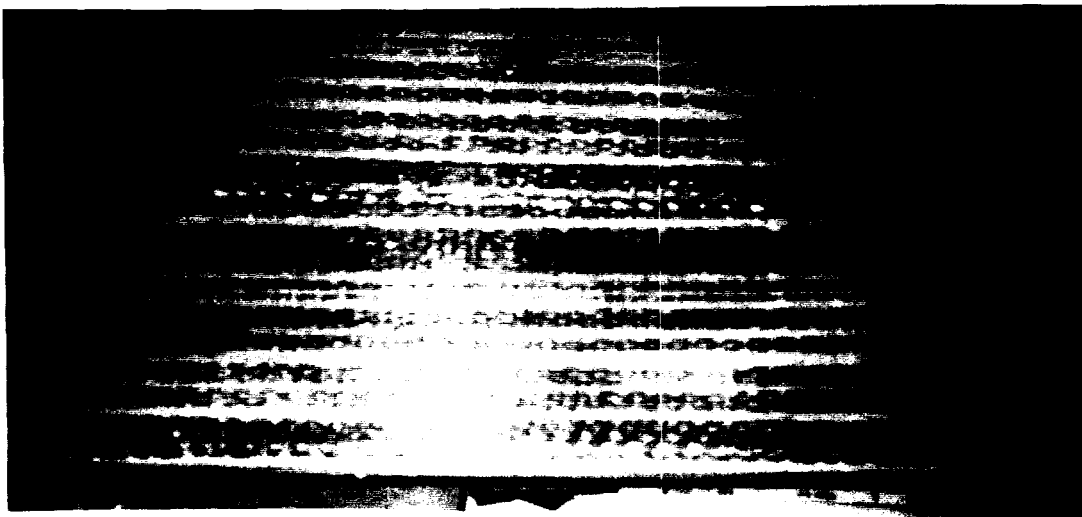Fig. 7.   Coating on steel plates.

Fig. 8. Coating on wood.

Fig. 9. Coating on wood with csrbon reinforcement.