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Expediency of Spray Waterproofing Application for Protection of Structural Concrete Elements against Environmental Agents

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Abstract *--- This experiment elaborates the appropriate protection of structural concrete elements against the environment agents. Construction is taking in to vibrant ways in which concrete is one of prime component to build the infrastructure both the vertical and horizontal constructions i.e., residential/commercial towers and longer highway bridges. Design/execution of concrete projects is considered to be one part of activity and the maintenance of built structures are another part of activity which is unremitting, cumbersome and also uneconomical as well to maintain the structures health condition. The environment agents are always keep attacking on the concrete surface and some of in which try to penetrate in to the concrete where the concrete is not dense enough or at the weaker areas, those penetrated environment agents such as carbon dioxide (CO_2), greenhouse gases, acid rains, alkaline and acidic soils, air pollution, contaminated water, radioactivity etc., are too dangerous to the concrete strength and cause for severe damage to the concrete by its chemical reaction within the concrete matrix since the concrete is made-up of chemical compositions (S-C-H gel). Those chemical compositions easily react with several environment agents and cause for concrete deterioration.*

The insulation is provided to the concrete with the spray waterproofing which is a simple method of applying a liquid agent all around to the concrete surface. The waterproofing agent goes on liquid but it dries into a flexible, impermeable membrane that any environment agents simply cannot get through and there is no chance of joins and gaps which are crucial for the waterproofing sprayed on any concrete surface. Spray waterproofing can be applied to just about any surface that may be vertical, horizontal, overhead, curved, pitched and various shaped surfaces as it gets bonds very well also swift to apply on the cleaned surface of concrete, masonry, stone, fiber cement, fiberglass, steel, tiles. The integrity of spray waterproofing confirms by conducting a pneumatic test oven an applied membrane.

Keywords *--- Concrete Protection, Sustainability of Concrete, Spray waterproofing, Environment Agents, Insulation of Concrete, Concrete deterioration.*

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I. INTRODUCTION

Concrete is a composite material which is made-up with fine aggregates, coarse aggregates, cement and water all these elements are obtained from the environment therefore it has the tendency of interaction with the environment agents [3] such as alkaline and acidic soils, air pollution, contaminated water, insects and pests. Mainly cement occupies the 15% of volume of concrete which is a pure chemical composition these chemical compositions easily react with the environment agents such as carbon dioxide (CO_2), greenhouse gases and radioactivity. It is essential to protect the concrete elements in-fact all the structural elements which are made with different materials other than concrete such as steel, wood, tiles, fiber concretes, wand another composite concrete surface etc.

There are several types of waterproofing materials available (cementious waterproofing, bitumen coating, bituminous membrane, PVC membrane, etc.) in the market but those have the certain limitations to install for example the [5] PVC membrane cannot be installed at overheads and the bitumen membrane has height restrictions and has jointing issues, cementious waterproofing has less life and not strong enough whereas the spray waterproofing [2] overcomes all the afore mentioned issues. The spray waterproofing [1] comes with primer coat as the primary application over the cleaned concrete surface next to adhesion test of concrete and then two coats of polymer with different color pigment and a silica aggregate broadcast over the wet polymer to receive the further material if any. The polymers become rubbery kind as it is left to dry usually 24 hours for each coat. The integrity of applied layers is confirmed by conducting numerous tests for concrete substrate, primer and wet & dry thickness of the membrane.

Aim **---** The current exercise aims to protect the structural concrete elements against the environment agents by insulating with spray waterproofing on its surface in order to increase the life span of concrete structure also for the other composite structures.

II. MATERIALS AND METHODOLOGY

The waterproofing system [8] shall be an elastomeric cold spray applied system based on methacrylate resins. The membrane system has the scope of various materials [4] used for spray waterproofing each material has its essential function at required zone namely Primer, two coat of dissimilar color Polymers, Broadcast Aggregate, Tack coat, Red sand Asphalt, Debonding tape, Expansion and Contraction joint pvc strip [9].

2.1. Surface Preparation

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All new concrete substrates should be a minimum of seven days old, minimum U2 concrete finish is recommended as shown in Fig.1 non U2 finish may be over coated but higher consumption rates may be required. The following requirements must still be adhered to all surfaces must be dry, and free from laitance, oil, grease, curing compounds, loose particles, friable matter, moss and algae growth as well as any other dirt. Where necessary mechanical surface preparation such as diamond grinding, vacuum blasting or grit blasting can be performed to provide a laitance free substrate. All blowholes and voids are to be repaired with an appropriate concrete repair material prior to application of the waterproofing system.

Figure 1. Surface Preparation

2.2. Adhesion Test

Adhesion test is carried out by fixing a dolly 50mm diameter on prepared concrete substrate applying adhesive between dolly and concrete surface shall be a two component, flexible, methacrylate resin. Test is prepared on concrete surface using Elcometer adhesion testing applying minimum pull strength of 1 MPa and failure in concrete substrate as shown in Fig.2. This bond will need to be proven by tensile adhesion testing.

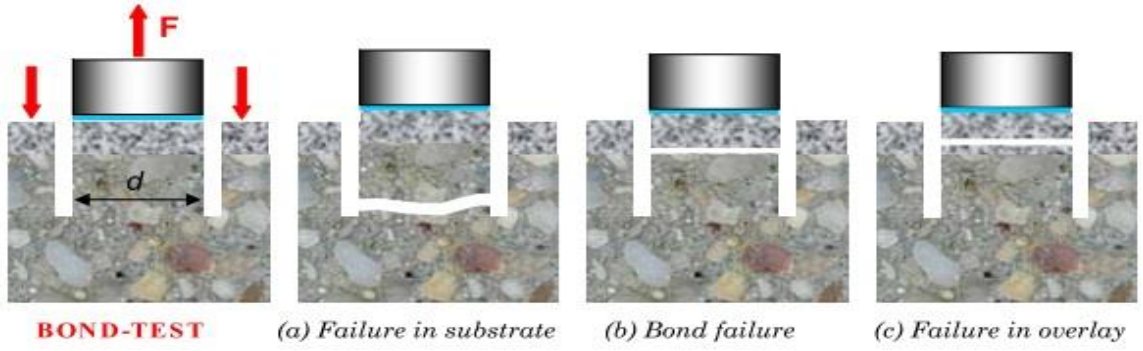

Figure 2. Adhesion (Pullout Dolly) Test

2.3. Primer

Primer contains 100% solid-component and elastomeric coating used to prime on concrete prior to the application of the membrane applied using plural spray equipment, providing a permanent bond between membrane and substrate. The solid composition of primer: Part-A is Isocyanic acid, polymethylenepolyphenylene ester (30-60%), Diphenylmethane (4,4') diisocyanate (30-60%), Propylene carbonate (13-30%), Reaction product of polymethylenepolyphenylene (3-7%) and the part-B contains with some other additives Polyetherpolyol (30-60%) Aminopropyltriethoxysilane (0.1-1%).

After confirming of surface preparation of concrete substrate and adhesion test and also the moisture content of concrete surface to be less than 5.0% the primer is to be applied over a concrete surface by mobilizing a spray equipment suitable for use with product as shown in Fig.3 and apply primer at 800 to 1000 square meter per barrel (180 liter) over surfaces to receive coating system. Default thickness is 2 mm on the deck surfaces and 1 mm on the abutment areas where primer is required and reapply primer if set more than 24 hours. Allow primer to go tack free before spraying membrane.

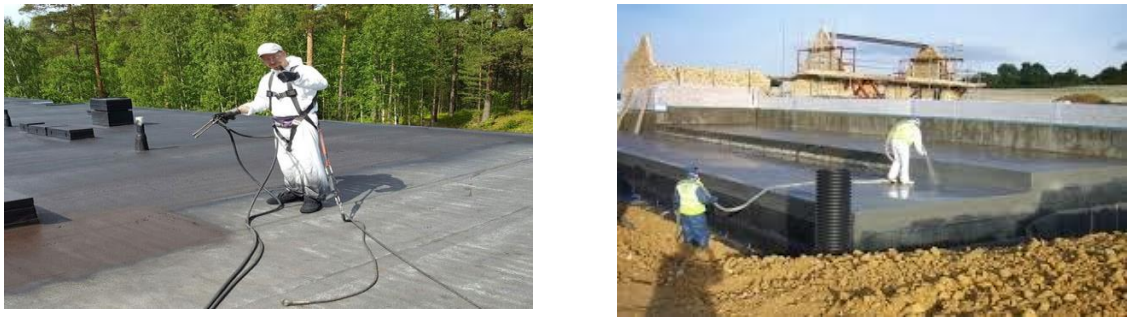

Figure 3. Application of Primer

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2.4. Waterproofing Membrane

Waterproofing membrane is combination of two coats of contrast color pigments of Part-A and Part-B. Part-A has the solid components of Isocyanates, reaction product of polyol with methylenediphenyl and diisocyanate(60-100%), Diphenylmethane(4,4') and diisocyanate(30-60%), Diphenylmethane(2,4') diisocyanate(13-30%), Isocyanic acid, polymethylenepolyphenylene ester(1-3%) and Part-B has the solid composition of Polyoxypropylenediamine (60-100%), Diethyltoluenediamine (DETDA)(13-30%), Glycerin poly(oxy -propylene) triamine (3-7%).

The membrane shall be a two component 100% reactive methacrylate waterproofing membrane applied in two coats of contrasting color [6]. The membrane is cold applied using a proportioning spray pump system each coat of membrane shall be applied to a minimum dry film thickness of l-2.mm in order to produce a minimum total membrane dry film thickness of 3mm. Wet film thickness checks will be carried out every 2 m^2 to ensure that the correct thickness is being applied. One coat system or two coat systems of the same color is not entertained.to avoid the confusion between applications of two coats. Provide spray equipment suitable for use with product. Spray membrane over primed surfaces at 90 square meter per barrel (180 liter) by using a reactor pumping. If the gradient of the highway bridge exceeds 4.5%, or there are areas where severe braking is anticipated or challenging geometry the application rate is increased to 1 mm more thickness of the dry film.

Where the system Is to be fully bonded to the substrate, a minimum of one tensile adhesion test Is to be carried out every 50 m^2 Prior to the application of the membrane, subject to a minimum of six tests for each structure being treated before application of the second coat the fully cured surface of the first coat shall be examined and any visible defects rectified [7]. Only after the first coat inspection may the second coat as of a contrasting color, is applied as shown in Fig.4. Following the application of the second coat of membrane the membrane will be checked to confirm its integrity by performing electrical holiday detection tests over the full surface area of waterproofing. The density of the applied cured membrane must be greater than 1.10g/cm^3

Figure 4. Application of Membrane (Part-A & Part-B)

2.5. Broadcast Aggregate

Immediately apply broadcast aggregate at 1 to 2 kg per square meter to achieve minimum 70% coverage rate after confirming of the two coats of spray waterproofing membrane when the second or top coat is wet to receive the broadcast aggregate [10]. The size of the broadcast aggregate is 2.0 mm to 4.75mm as shown in the Fig.5. This broad aggregate helps to create the strong bonding between the spray waterproofing membrane and protection layers which comes over the membrane for example plain concrete, screed concrete and asphalt etc.

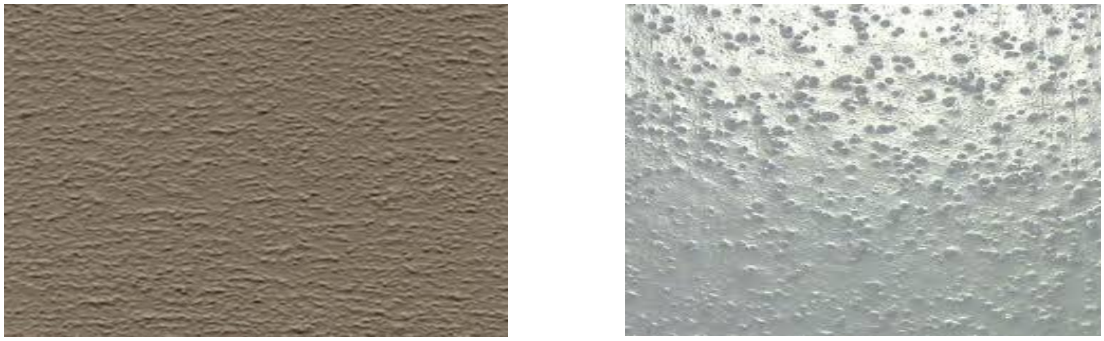

Figure 5. Broadcasting of Aggregate over the Membrane (Part-B)

2.6. Tack Coat

Apply tack coat at 115 square meter per barrel (180 liter) cement may be lightly broadcast into top of tack coat to prevent tire/track pickup of tack coat during asphalting as shown in Fig.6.

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Figure 6. Tack coat application over the Membrane (Part-B)

2.7. Red-Sand Asphalt

20 mm thick red sand asphalt is laid over the spray waterproofing membrane prior to the asphalt concrete in order to melt protect of membrane from asphalt heat while paving as shown in Fig.7.

Figure 7. Tack coat application over the Membrane (Part-B)

2.8. Sealants at Expansion & Contraction Joints

Special arrangement is made with compatible material at expansion, contraction and induced crack zones (shown in Fig.8) of concrete which seals the concrete as like as flat surface which acts more flexible to the static and dynamic actions of concrete due to temperature, weather affects and fatigue loadings.

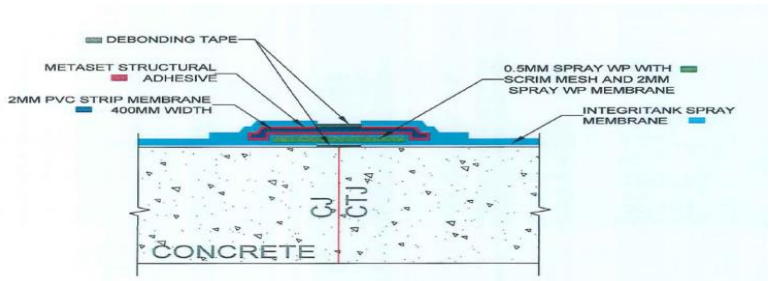

Figure 8. Arrangement of joint sealant at Expansion and Contraction Joints

2.9. Application Temperature

The ideal temperature for installation or application of the any spray waterproofing materials is as low as -20ºC to as high as +50ºC.

III. RESULTS & DISCUSSION

The spray waterproofing membrane materials application is done as stipulated and controlled the quality and other parameters as required and the applied materials practical tests with the pertain equipment that is Pullout dolly or adhesion test as shown in Table.1, moister meter test, wet film thickness test by gauge scale as shown in Fig.9 and Table.2, dry film thickness by Vernier caliper as shown in Fig.10 and Table.2 and holiday spark test for identifying pin holes on the dried membrane are carried out as shown in Fig.11

Table 1. Adhesion Test Observations

Test No.	Adhesion Strength (MPa)	Avg. Result (MPa)
1	1.2	1.06
2	1.0	
3	0.98	

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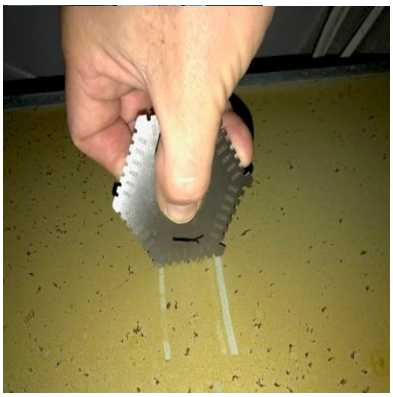

Figure 9. Wet film thickness testing

Figure 10. Dry film thickness testing

Figure 11. Holiday spark testing

Table 2. Wet Film Thickness Observations (Part-A & Part-B)

Test No.	Thickness (mm)	Avg. Result (mm)	Test No.	Thickness (mm)	Avg. Result (mm)
Part-A			Part-B		
1	3.2	3.28	1	3.1	3.1
2	3.4		2	3.2	
3	3.25		3	3.0	

Other mechanical and technical properties [11-25] are sound as the membrane doesn't allow any environment agent [2] either that is vapor form, air form or liquid state, therefore the concrete health is sustainable for longer period. Table 3 show the test values which are confirmed as per the pertain codes.

Table 3. Physical Properties of the Membrane

S. No	Property	Value
1	Minimum Thickness	2mm Min. @ 2kg/ Sq.m
2	Specific gravity	> 1.10 g/cc @ 23°C
3	Elongation	>80% - <150%
4	Tensile Adhesion Strength	Concrete Surface >0.7 MPa Steel Surface >2.0 MPa PVC Surface > 2.0 MPa
5	Water Vapor Transmission	< 4g/ Sq.m/day
6	Tensile Strength	>9 MPA
7	Tear Strength	>60 N/mm
8	Shore Hardness	> 40
9	Water Penetration	Zero
10	Static Crack Bridging	>2 mm
11	Dynamic Crack Bridging	> 1 mm
12	Abrasion	H22 wheel @ 1000 cycle <0.60g

IV. SAFETY PRECAUTIONS

No significant harm to environment where the work is executed in the closed area & Workers wear complete PPE (personal Protective Equipment with respirators) as shown in Fig.12. Mask protected surfaces prior to spray applications and erect spray curtains and partitions as required.

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Figure 11. Personal Safety Protection crew

V. CONCLUSIONS

The current project exercise is demonstrating that the spray water proofing with prime, two coats of membrane is more efficient than any other waterproofing membrane as of now. The spray waterproofing membrane has long-lasting as age as c2ncrete leads to avoid of maintenance of structural concrete elements and membrane as well. It is economical even when comparing the maintenance of damaged concrete due to environment agent effects and also applied membranes itself. This kind of spay waterproofing is suitable for all the type of composite structural elements to insulate and protecting form the environment agents and other nature proxies.

The method is applicable for all varieties of structures with different shapes since the material is in liquid state when applied and later become flexible rubber membrane there is easy and possible to apply at the sharp corners and champers of the structures. The spray waterproofing has the possibility to wrap the whole structures in it and make the structures contactless to any substance such as water, wind, environment agents and earth elements and animal fats, natural and artificial oils, acids, alkalis, and various industrial salts

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