

DISCUSSION FORUM

Selection of polymers for repair and rehabilitation of RC structures

Mr P.K. Singha Roy writes

This has reference to the *Point of View* by Mr V.K. Singh published in the October, 2005 issue of your *Journal*¹. I would like to share my experience on the subject.

While specifying a polymer for repair/ retrofit/original work, it is not enough to suggest merely the generic type to which it should belong but also the properties expected out of it in use, that is, the functions it has to perform in the remaining service life of structure. Such properties

duly quantified from previous experience and published data with a reasonable margin should form the basis of an acceptance criteria. Only those products that meet this criteria during pre-qualification stage should be considered during tendering and successful vendor's supply during execution should be compared with the test reports of the pre-qualification samples for compliance. Batches of polymer not meeting this criteria within the specified tolerance of say 10 percent or so should be rejected. Only such

a stipulation can ensure discipline, consistency of quality and integrity of the supplier, as the deficiencies will be to his cost.

For this the client or his consultant has to make sincere efforts to write down and ensure a suitable specification for a particular situation/environment and not merely go by the recommendations of the manufacturer. This is a common practice in department like Atomic Energy where products are tested in in-house testing facilities or in other recognised third party laboratories on an on-going basis. Such provisions are incorporated in the supply tender. An example of a particular acceptance criteria for polymer coating established some 15 years ago, for a few property parameters, is given in *Table 1*².

It is suggested that similar exercise be done by the author for more reliable acceptance criteria for his job. It is found that the author has gone in for only one dosage rate as per manufacturer's recommendation and found wide variations. If he had tried testing with different dosages - say 10 percent more and 10 percent less - the variation would have been less. Has he tried this out? Did he refer back to the suppliers and ask them to explain the causes of the substantial deficiencies?

The author has mentioned some 18 parameters for test for performance evaluation, but tested for only 6 and that too only for mechanical properties and none on durability — for example, chloride-ion diffusion or carbonation. These could have given more surprises. It is better to reduce the number of parameters to make it more realistic to the situation/ environment and manageable for testing. For example, abrasion resistance or gas permeability is not required everywhere like permeability and compatibility.

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Table 1: Typical specification for a polymer coating

Test parameters	Method	Required property	
		Epoxy	Vinyl
Fineness of dispersion Hegman gauge	ASTM D 1210	P 5-7 F > 8	P 5-7 F > 8
Weight, kg/10 l	IS 101	P 12-15 F 10-14	P 12-15 B&F 10-14
No. of coats		P 1-2 F 3-4	P 2 B 2 F 2
Total DFT, microns	ASTM D 1974	400-450	400-450
Scratch hardness, kg	IS 101	F 1.5	F 0.5
Salt spray	IS 101	-	-
Corrosion protection in humidity	IS 101	-	-
Non-volatile, percent	IS 101	60-80	40-60
Viscosity fume of flow, s	IS 101	P 60-100 F 100-200	P 100-250 B 100-250 F 100-250
Abrasion resistance, loss mg/000 cycles	Tuber abramer CS to wheel 1 kg load	S<30	S<45
Rocker hardness	ASTM D 154	S>10	S>5
Practical adhesion (PS); Sandwich pull off technique	IS 04624	P>3500 S> 2500	P>1500 S> 1000
Tensile strength, kg/cm ²	ASTM D 2370	S>100	S>30
Percent elongation under load at the pointing break	ASTM D 2370	S>25	S>100
Water vapour permeability	ASTM D 1533	S<4	S<6
Flexibility on 1/8 inch (3 mm) marvel	ASTM D 1737	Pass method deformation crack, etc	
Impact resistance (Direct impact of 10.5 lb weight falling from 23 inch height)	DEF 1050	Pass	
Resistance to 8 different chemical solution, distilled water, 4 weeks detomised water, 4 weeks 2 percent nitric acid solutions, 4 weeks 5 percent NaOH solution, 4 weeks 5 percent teepol and petrol, 4 weeks Hot water @ 195°C-30 min Steam@psig. - 10 min	ASTM D 1304	Pass	
Accelerated weatherouater (500 hours)	IS 2932	Pass	
Air permeability coefficient	NFB method	< 8 × 10 ⁻⁵	< 8 × 10 ⁻⁵

Note: 1. P - Primer, B- Body, F - Finish, S - System (multicoat)

2. Only a few parameters excluding nuclear parameters are quoted above

Mr S.R. Saxena writes

This refers to the *Point of View* write-up by Mr V.K. Singh. I would like to share my views and would like to comment on the views of Mr Singh.

During my previous tenure in Mumbai region, I was posted in Civil Maintenance Section of the Oil and Natural Gas Corporation (ONGC) and was looking after the maintenance of office and residential buildings. During the tenure, I was entrusted with the responsibility of providing suitable measures to structurally rehabilitate the existing ONGC buildings which had shown signs of disintegration and distress due to ageing, corrosion effect, and declining structural strength, etc.

After a thorough inspection and examination of the existing building by IIT, Mumbai, which conducted non-destructive testing including ultrasonic pulse velocity measurement tests on concrete members (slab, column, beam etc) and carried out analysis and evaluation thereof, structural repairs were suggested with the application of polymer modified mortar on the affected concrete members.

This was the first type of such work executed in ONGC's residential colonies in Mumbai and being a specialised work of its kind, had no useful reference in the existing PWD/BMC schedule of rates or the specifications. The solution was somewhere else, possibly in the literature on polymer mortar and I had to search for the useful information among the jargon of familiar and not-so-familiar terms and details. After carrying out literature search and extensive market research and study, I found myself more baffled and confused as to how to formulate the specifications and select appropriate materials and procedure of the repair process. This was because there was a vast difference in the type of technical literature available from different manufacturers and no two different companies spoke of its product in similar tone in terms of properties and test results though each of them claimed highly of their products. There were no comparable standards available for judging the worthiness of the chemical and suitability of application of the material to concrete structures.

Also, it was neither desirable nor appropriate to blindly adopt the specifications, nomenclature and application procedures of any particular brand available in the market unless it was supported with all due requisite technical

data confirming to the standard parameters and also the proven track record.

Taking into account of all these aspects along with the technical requirements of work as warranted at site, it was rather painstaking to carve out and finalise the details of the items which could be applicable for any brand of material and also meet the requirements of the work, since technical details from different companies sometimes gave even conflicting and confusing information.

I then approached and consulted an experienced professor in IIT, Powai and deliberated at length regarding the problems encountered along with the constraints and limitations of field engineers due to the norms and guidelines of works procedure and existing contract agreement provisions and also keeping in mind the evidently known practices of working agencies.

The professor suggested the introduction of the following main material parameters while framing the specifications:

- (i) solid content, not to be less than 40 percent
- (ii) specific gravity not more than 1.01
- (iii) pH not less than 8.50.

In addition, certain specific tests were also suggested for ascertaining the appropriateness of the chemical to be used during the repair process. Few such important tests mentioned were: pot life, adhesion to concrete, compressive strength (for polymer) and tensile strength, compressive strength, flexural strength (for polymer modified mortar).

Accordingly, the specifications of the work were formulated and the work got executed.

While sharing the concerns and viewpoint of author, I would like to raise following pertinent issues.

- (i) Since there are no standards /codes available on the subject, how any rational comparison can be made between the claimed and actual results/characteristics? As such the first need in the field as far as polymer modified mortar is concerned is of fixing the standardised parameters and accepted standards for performance criteria for different properties of the material which can then be compared any time with the actual results.

- (ii) There are very few reputed institutes/ laboratories which conduct such required tests. Further, the available facilities are not enough to conduct all the required tests.

- (iii) It is not clear how it is possible for a field engineer to carry out such tests and fix any particular brand prior to invitation of work, as no such procedure exists in ONGC. Further, fixing of any particular brand is not advisable so as not to impose any restriction on the agency for using any other suitable equivalent brand. Also, consistency and continuity of the same brand of material also needs to be ensured during the overall progress of work.

- (iv) The avenues available to ONGC civil engineers — or for that matter any civil engineer from client's side — within the confines of works' procedures and BDP guidelines for such type of proposed experiments at the initiation/tendering stage are limited. The best practice would be to evolve a performance criteria of limited and important tests and conduct these tests during pre-qualification and execution too.

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The author replies:

Reply to Mr P.K. Singha Roy

I would like to thank Mr P.K. Singha Roy for his keen interest in my write-up and tend to agree with the suggestions given for the selection of polymer brands for repair projects. I have gone through many published case studies of various rehabilitation works but found the characteristics like solid content/strengths of the PMM specified only in few cases. Mostly, the deterioration in concrete is discussed in more details and the procedures adopted for repairs are elaborated. Technical literature of some manufacturers does mention polymer properties but in actual use there are considerable of variations which make the selection of the specifications difficult. I agree that prior experience is extremely valuable for rehabilitation work especially when there are no BIS/CPWD specification available on the subject.

In the private sector, the rehabilitation work is executed through experienced consultants. In the public sector, the use of

in-house expertise is encouraged from project planning to execution stage. In the latter case, it becomes difficult to proceed in the absence of BIS / CPWD specifications. Due to time constraints it becomes difficult to do prior testing of various products for freezing the specification in the tender. Therefore, in order to facilitate the selection of polymer and decide specifications with confidence, the performance evaluation of some brands of polymers has been carried out and reported for guidance. I had strongly emphasised that manufacturers' brochures and literature should provide detailed and reliable information for the guidance of the users so that suitable and realistic specifications may be designed for the works.

I had also done evaluation by testing some brands at dosages higher than the recommended ones. Initially, it showed upward trend but after a particular dosage, some strengths started showing downward trend. At lower dosages the strengths were found less than those found at recommended dosages. These discrepancies were discussed with the representatives of some manufacturers but without much satisfactory replies.

There are eighteen properties for which tests on polymers can be done. All these were mentioned for the guidance of engineers. I fully agree that in practice, only limited number of tests may be done. For repairs by PMM, solid content is the main characteristic besides bond strength, tensile strength, flexural strength and compressive strength etc. for effective structural repair of concrete structures. For coatings, especially the waterproofing products, permeability is specially important. While concluding the write-up, I had specifically mentioned that one should select only those parameters for testing which are more important for a particular job.

Reply to Mr S.R. Saxena

I am also thankful to Mr S.R. Saxena for taking a lot of interest in my write-up. He has aptly brought out the difficulties faced by the field engineers in using the latest know-how for rehabilitation of structures. I appreciate the pains taken by him in applying appropriate technology for durable repairs in Mumbai..

The aim of my paper was to highlight the difficulties faced by engineers in adopting appropriate repair technology and need for updating product brochures/ literature of manufacturers so that complete

and reliable information is made available to all for suitable material selection.

Incidentally, I would also like to share the following information on the subject with the readers.

- An ACI report gives some typical physical properties of acrylic latex admixture³. They include: solid content 46-48 percent, pH value 8.8-10, specific gravity 1.06.
- Japanese Institute of Standards⁴ recommends total solids to be not less than 35 percent (with ± 1.0 percent deviation in the value specified by the manufacturer), compressive strength to be not less than 9.8 MPa, flexural strength not less than 3.9 MPa, adhesion strength not less than 0.98 MPa. I feel that the latter value is quite on the lower side for adoption in our repair projects.
- In 2003, the Central Public Works Department (CPWD) has released a *Handbook on repair and rehabilitation of RCC buildings*⁵. It is a comprehensive, informative and extremely useful guide on various deterioration processes, non-destructive testing, repair strategies, specifications, terms and conditions of tender and quality control procedures. In the item of PMM repair, the minimum compressive strength required at 28 days is mentioned as 20 N/mm², 25 N/mm² and 30 N/mm². It has also recommended meeting the bond strength requirement of ASTM C 1059. As per this specification slant shear bond strength value should be 1250 psi (8.62 N/m²).

Reference No. 3 mentioned in my write-up is an excellent guide for selection of repair material properties. In this write-up performance evaluation of some brands of polymers has been done. Based on this data, available literature and condition of the structures to be repaired, detailed specification may be framed for a project.

I firmly believe that it is the responsibility of manufacturers to get their products tested as per ASTM and BS standards from standard laboratories and report the results in their product brochures for guidance of the user. The engineer-in-charge can cross check some basic properties like solid content, compressive

strength, flexural strength, tensile strength and shear bond strength. This can be done in any standard concrete testing laboratory before specifying in tenders.

I appreciate that due to shortage of time for preparation of estimates, it is difficult to carry out pre-qualification for recommendation of a particular brand in tender. As per CPWD guidelines, minimum three brands with comparable prices, satisfying our requirements may be mentioned in tender specification. The suggestion for keeping sufficient time for project completion so as to carry out detailed testing of polymers is highly appreciated. There are no time schedules recommended for repair and rehabilitation works in CPWD manual or other publications. It should be carefully decided keeping in mind the possible constraints so that time over-run problems may not arise. Prior experience is very important. Testing of materials after award of the contract is to be done for quality control and assurance only. In my opinion, it is important to firm up the polymer specifications before tendering to avoid contractual problems at a later date.

I would like to clarify that the tests reported were carried out while approving acrylic and SBR polymer for repair of a structure in Ahmedabad and are not directly related with my Ph.D research. I would hesitate to discuss ONGC works procedure and BDP guidelines in ICJ but feel that we can definitely do prior testing of new innovative products for adopting latest technology, if needed, as per BDP for the benefit of Corporation.

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