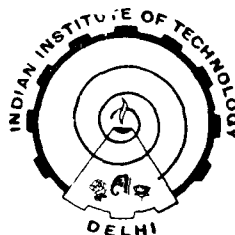


**STUDIES ON THE INTERACTION OF PHENOL—FORMALDEHYDE  
RESIN WITH AGGREGATE AND CEMENT—AGGREGATE COMPOSITES**

BY  
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A thesis submitted to the  
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for the Degree of  
**DOCTOR OF PHILOSOPHY**



**Centre for Materials Science and Technology**  
**INDIAN INSTITUTE OF TECHNOLOGY, DELHI**  
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*Dedicated*

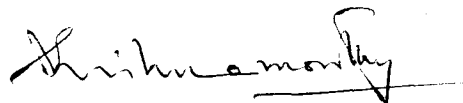
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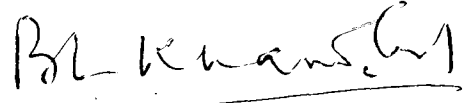
C E R T I F I C A T E

This is to certify that the thesis entitled, "STUDIES ON THE INTERACTION OF PHENOL-FORMALDEHYDE RESIN WITH AGGREGATE AND CEMENT-AGGREGATE COMPOSITES", being submitted by MR. RAVI KANT SOOD to the INDIAN INSTITUTE OF TECHNOLOGY, DELHI for the award of the degree of DOCTOR OF PHILOSOPHY in CENTRE FOR MATERIALS SCIENCE AND TECHNOLOGY, is a record of bonafide research work carried out by him under our guidance and supervision and has fulfilled the requirements for the submission of this thesis.

To our knowledge, the thesis has reached the requisite standard. The matter embodied in this thesis has not been submitted in part or full to any other University or Institution for the award of any degree or diploma.



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## A C K N O W L E D G E M E N T S

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## ABSTRACT

The thesis deals with the interactions which phenol-formaldehyde resin (a thermosetting resin) has with generally inert mineral aggregates, and with cement-aggregate composite, namely, concrete. These studies have been primarily carried out to assess as to whether such a resin can be used to develop a building material either in the form of polymer-impregnated concrete (PIC) or polymer-concrete (PC).

In this study, phenol-formaldehyde resins (both Novolac and Resol) have been used to develop PIC. The effect of various parameters has been studied to develop PIC which include type of resin, quality of cement and concrete, drying temperature for concrete, and cross-linking temperatures of impregnated resins.

The PIC thus developed has been assessed for compressive and tensile strengths, modulus of rupture, stress-strain behaviour, abrasion resistance, skid resistance and durability against distilled water, sea water and dilute solutions of sodium hydroxide, sodium chloride and magnesium sulphate for exposure upto five months.

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The PIC specimens having relatively low polymer loading of about 2.0 to 2.5% developed under 'optimum' conditions exhibit strength improvements by 2 to 3 times over unimpregnated concrete. The strength improvements and durability performance in identical conditions are better when Resol is used as an impregnant.

Studies to develop PC with the commercial phenol-formaldehyde resin (Novolac) have also been reported to assess the suitability of resin as a binder for the production of PC. The effect of several variables has been studied which include concentration of the original resin solution, the amount of cross-linking agent, cross-linking temperature and duration, sand-resin ratio, contents of silane (coupling agent) and microfiller. Under suitably 'optimized' conditions, the PC (mortar) exhibits good compressive and tensile strengths which are in the order of  $540 \text{ kg/cm}^2$ , and  $61 \text{ kg/cm}^2$  respectively, whereas for PC (10 mm maximum size aggregate), the values are  $620 \text{ kg/cm}^2$  and  $74 \text{ kg/cm}^2$  respectively.

The durability of PC (mortar) developed with and without silane coupling agent in various reagents as mentioned earlier has been studied for period upto five months. The studies indicated relatively better performance of the PC made with silane coupling agent

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than the PC made without the coupling agent. But durability to corrosive media such as tap water and distilled water, dilute solutions of sodium hydroxide and sulphuric acid, and sea water is not high.

Apart from strength properties, instrumental studies have also been carried out for the assessment of physical and chemical interactions between the resin and aggregate, and resin and cement-aggregate composites. The studies included infrared spectroscopy, X-ray diffraction and scanning electron microscopy.

The results have been interpreted to appreciate the nature of chemical interaction, probable bonding between the resin and the aggregate, and the influence of the curing reagents on the PIC and PC.

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