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INFLUENCE OF NATURAL RUBBER LATEX ON PERMEABILITY OF FIBRE REINFORCED HIGH-PERFORMANCE CONCRETE

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Abstract: In order to achieve durable concrete, there are two important aspects to be considered which are durability and impermeability. To increase the demand for Natural Rubber Latex Modified Fibre reinforced High Performance Concrete (NRLMFRHPC) produced with locally available materials such as cement , Fine aggregates , coarse aggregates, Metakaolin and Crimped Steel fibers, the concrete should be made impermeable. In the present investigation, NRLMFRHPC has been produced with locally available aggregates and mineral admixture (Metakaolin) and Natural Rubber Latex based NRLMFRHPC mixes were designed by absolute volume method. The specimen of size 100mm diameter and 50mm depth were cast and cured for 28 days and then tested for durability by using "Rapid Chloride Ion Permeability Test (RCPT), to assess the permeability characteristics of NRLMFRHPC. The experimental results indicate that Natural Rubber Latex can be utilized in producing durable Fiber Reinforced High-Performance-Concrete. The various results which indicate the effect of Steel Fibers and Natural Rubber Latex on the permeability characteristics of high-performance-concrete are presented in this paper to draw useful conclusions.

Keywords: Metakaoline, Natural Rubber Latex, Steel Fibers, Sodium Chloride (NaCl), Sodium hydroxide (NaoH), High Performance Concrete**.**

I. INTRODUCTION

The durable concrete depends on permeability which again depends on its pore structure. W/B ratio is the fundamental for durability of concrete. When we discuss about the durability of concrete, the discussion starts with respect to permeability.The concrete should be made gas tight or water tight by closing the pores present in the concrete. The purpose of incorporation of polymers into the concretes is to make the concrete impervious . The incorporation of polymers in to the concretes began in the twentieth century .[Ramakrishnan, 1992;Jaigang et al, 2005]. The inclusion of synthetic polymer latexes ,[Walters, 1987] in the concrete has come in to the practice for making the concrete more durable. The test which is used in wide range of applications is Rapid Chloride Ion Permeability Test (RCPT). Standard testing procedures are in AASHTO T 277 or ASTMC 1202. The RCPT is performed by monitoring the amount of electricity which passes through a cylindrical specimen having the dimensions of 100mm diameter and 50 mm in height/thick in 6 hours. A voltage of 60 V DC is maintained through out the period of test. One end is immersed with 3.0% salt (NaCl) solution and other end in 0.3 M sodium hydroxide (NaOH) solution. Based on the charge passing through the specimen, a quantitative permeability of concrete is arrived.

The other major factor for deterioration of concrete is chemical attack. The concrete which is exposed to environment, get affected with the factors such as sulphates and acids. Chang et al, [2001] addressed the harmful effect of marine climate on durability of concrete structures built in coastal areas and reported that it is important to know the methodology to achieve high strength and durable concrete in order to avoid formation of cracks in the structural member. According to Nawy [2001], deterioration, long-term poor performance and inadequate resistance to hostile environment which led to accelerated research into the microstructure of cements matrix resulting into more elaborate codes and standards.

The usage of polymers as a modifier in recent concrete structures a strategy in improving microstructure and enhancing the durability of Concretes and cement mortars. The usage of Natural Rubber Latex as a polymer into the concrete is for better durability. Previous studies indicate that the incorporation of natural Rubber latex in to the concretes upto certain percentages improves the compressive strength also. One of the popular polymer which is

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suitable and naturally available is rubber latex. The durability of concrete decreases due to the transportation of aggressive substances from the surrounding environment followed by physical and chemical actions in its internal structure. The transport of aggressive gases and or liquids into concrete depends on its permeation characteristics. As the permeation of concrete decreases its durability performance, in terms of physio-chemical degradation, increases. Therefore, permeation of concrete is one of the most critical parameters in the determination of concrete durability in aggressive environments. Permeability is a measure of the ease with which the substances are transported due to a pressure differential, while sorptivity and absorption/ porosity (saturation methods) are measures of absorption characteristics of concrete.

The High performance concretes can be evaluated in terms of resistance to chloride ion permeability. The durability of metakaolin based Natural Rubber Latex based Modified Fiber Reinforced High Performance Concrete (NRLMFRHPC) can be evaluated by conducting the Rapid Chloride Ion Permeability Test (RCPT). The details of experimentation conducted to evaluate the chloride ion permeability of different NRLMFRHPC mixes are presented in this paper.

In order to achieve the durable and high strength concretes a detailed experimental investigation on Metakaolin based Natural Rubber Latex Modified Fiber Reinforced High Performance Concrete (NRLMFRHPC) has been conducted.. Metakaolin is used as a mineral admixture; Natural rubber latex polymer is used as an additive. In the production of HPC polymer based chemical super plasticizers are generally used to improve the flow properties and to reduce the water-binder ratio. However in the present work, it is proposed to use the naturally available polymer i.e. Natural Rubber Latex (NRL) in the production of HPC and steel fibers of an aspect ratio 50 are added to improve the strength and ductility. The physical properties of each material which are used in the research program are presented.

II. EXPERIMENTAL PROGRAM

In order to study the behavior of Natual Rubber Latex Modified Fibre Reinforced High Performance Concrete (NRLMFRHPC) and also to understand the influence of natural rubber latex and steel fibres on permeability of Metakaoline based NRLMFRHPC, a total number of 81 mixes have been tried. In all the mixes the same type of aggregate i.e. crushed granite aggregate, river sand has been used. The proportion of cement, sand and aggregate has been maintained same for all mixes. These relative proportions have been obtained by absolute volume method. Ordinary Portland cement of 53 Grade from a single batch has been used. The test program consisted of conducting Rapid Chloride Ion Permeability Test (RCPT) on cylindrical specimens and to evaluate permeability.

A. Materials

1) Cement: Ordinary Portland cement of 53 grades conforming to ISI standards has been procured and the properties of the cement are investigated in the laboratory. The cement satisfies the requirements as per I.S 12269-1987.

2) Fine Aggregate: The locally available river sand conforming to grading zone-II of IS 383-1970 has been used as Fine Aggregate. The Specific Gravity of fine aggregates is 2.69 with a fineness modulus of 2.77.

3) Coarse Aggregate: The locally available crushed granite material has been used as coarse Aggregate. The Specific Gravity of coarse aggregate is 2.76 and Fineness modulus is 6.99

4) Steel fibers (S.F): Fiber is a small piece of reinforcing material which has certain characteristic properties. It can be either circular or flat. Plain concrete possesses a very low tensile strength ,limited ductility and little resistance to cracking internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of micro cracks leads to brittle fracture of the concrete. Although every type of fibers are suitable in cement and concrete not all of them can be effectively and economically used. Each type of fiber has its own characteristic properties and limitations. The fibers which could be used in the concretes are Steel fibers(s.f), polypropylene, nylon, asbestos, coir, glass and carbon. In this investigation crimped steel fibers have been used. The Diameter of fibers is 0.6-mm and the Aspect ratio is 50.

5) Natural Rubber latex (NRL): The Natural Rubber latex is collected from ASSOCIATED LATEX (INDIA) LIMITED having its Administrative Office at P.B. NO.1117, Beach Road, Calicut. The properties of Natural Rubber Latex are presented in Table 1

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Table I Physical properties of Rubber latex

S.No	Property	Rubber latex
1	Colour	White
2	Total Solid Content (% By Weight)	61.5 Max
3	Dry Rubber Content (% By Weight)	60 Min
4	Non Rubber solid content	1.50 Max
5	KOH Number	0.55 Max
6	Ammonia content , NH3 %	0.70 Max
7	Mechanical stability time	600 TO 1200
8	Volatile Fatty Acid Number	0.10 Max
9	Magnesium Content	8
10	P_H	10.4 Min
11	Coagulum Content , % By Mass	0.01 Max
12	Sludge Content, % By Mass	0.01 Max
13	Copper content As PPM	5
14	IRON content As ppm	8
15	Particle size of Rubber latex	0.2 μm
16	Specific Gravity of Rubber latex	0.94

6) Metakaolin: The mineral Admixture Metakaolin is obtained from VADODARA IN GUJARAT, INDIA. The Metakaolin is in conformity with the general requirements of pozzolana. The Specific Gravity of Metakaolin is 2.6 and its average particle size is 1.5 um The Specific surface area is 15 m2/gm. The pozzolonic reactivity of Metakaolin is 1050 mg of Ca (oh) 2/

7) Water: Clean potable fresh water, which is free from concentration of acid and organic substances, has been used for mixing the concrete.

III. FABRICATIONS AND CASTING

Cylinders were cast in steel moulds of 100 mm dia and 50 mm height for every mix. The cement, sand and Metakaolin were mixed thoroughly by manually. Then steel fiber is added to the above mixture. For all test specimens, moulds were kept on table vibrator and the concrete was poured into the moulds in three layers by tamping with a tamping rod and the vibration was effected by table vibrator after filling up the moulds. The moulds are kept in vibration for one minute and it was maintained constant for all the specimens. Three cylinders were cast for each mix.

IV. CURING

The moulds were removed after 24 hours and the specimens were kept immersed in a clear water tank. After curing the specimens in water for a period of 28 days the specimens were removed out and allowed to dry under shade

V. RESULTS AND DISCUSSION

A. Effect of water-binder ratio on chloride permeability

The variation of chloride ion permeability with W/B ratio for metakaolin based NRLMFRHPC mixes is presented in Figures

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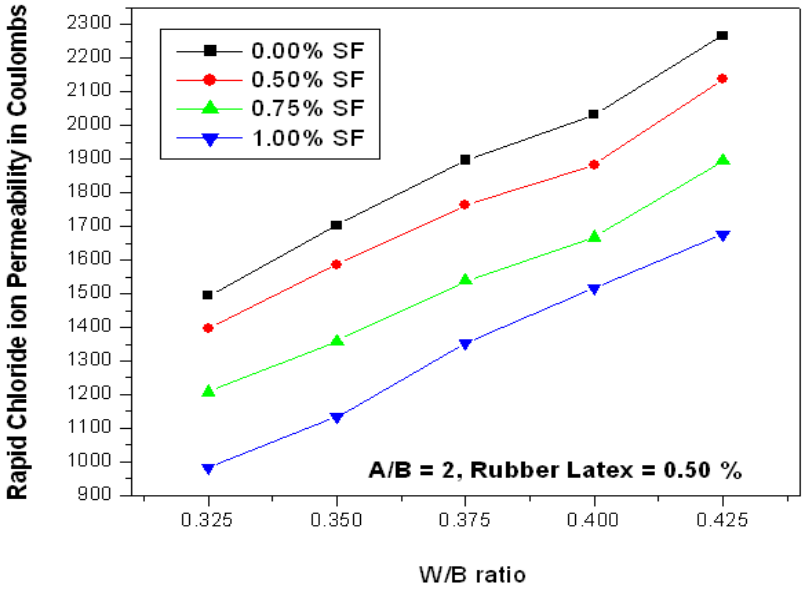

Fig. 1 Variation of Rapid Chloride Ion Permeability with W/B ratio

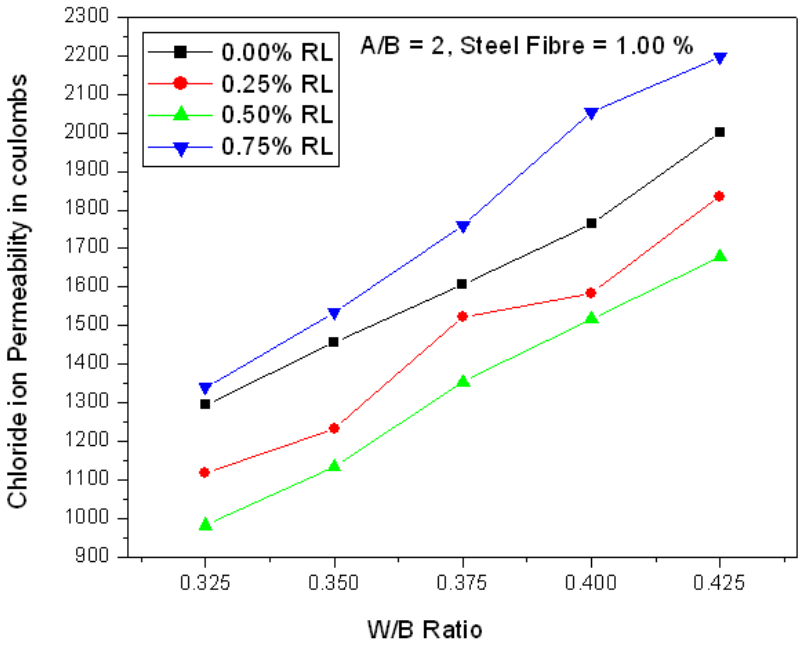

Fig. 2 variation of percentage of rubber latex with the water Binder ratio

From the Figures 1 & 2 it can be observed that the chloride ion permeability of NRLMFRHPC increases with increase in W/B ratio, for all percentages of Steel fibers (0.0.0.5.0.75and 1.0) and for all percentages of rubber latex (0,0.25,0.5and 0.75). From Figure 1 & 2 it is observed that the chloride ion permeability value increases as W/.B ratio increases from 0.325 to 0.425. This shows that there is an increase of about 48.69% in permeability. Thus it can be concluded that the Chloride ion permeability value increases with increase in W/B ratio for all percentages of Steel Fibre and Rubber Latex mixes tried in the present investigation. The main reason for these phenomena is that the pores in the concrete increases with increase in water content which in turn increases the permeability. Hence it is recommended that while production of NRLMFRHPC mixes, low W/B ratio is preferred.

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B. Effect of Rubber Latex on chloride permeability

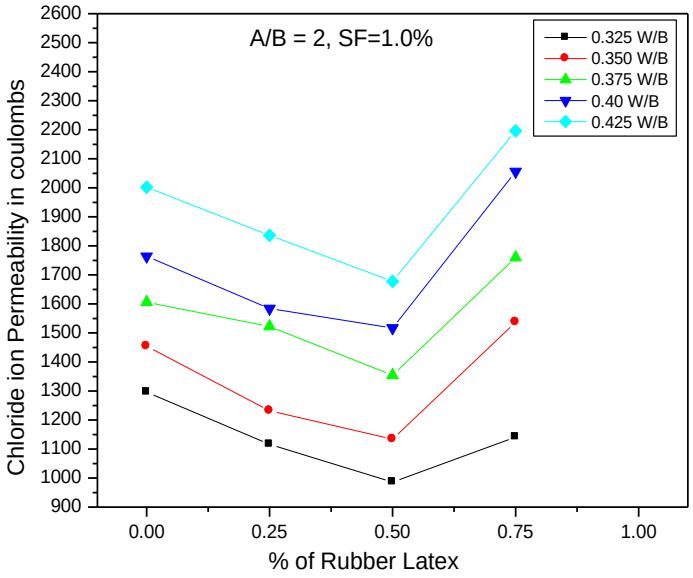

Fig. 3 Variation of Chloride ion permeability with dosage of rubber latex

The effect of dosage of NRL on Chloride Ion Permeability is presented in Fig.3
From the Figure 3, it can be observed that the chloride ion permeability of NRLMFR HPC mixes decreases with increase in percentage of rubber latex from 0 to 0.5%.. Further increase in Natural Rubber Latex increases the permeability. Thus it can be concluded that permeability decreases with increase in percentage of rubber latex upto 0.5% and further increase of Rubber Latex to 0.75% increases the permeability. From this investigation it is recommended to use 0.5% of rubber latex by wt of binder to get more durable concrete.

C. Effect of % of Steel Fiber on chloride permeability

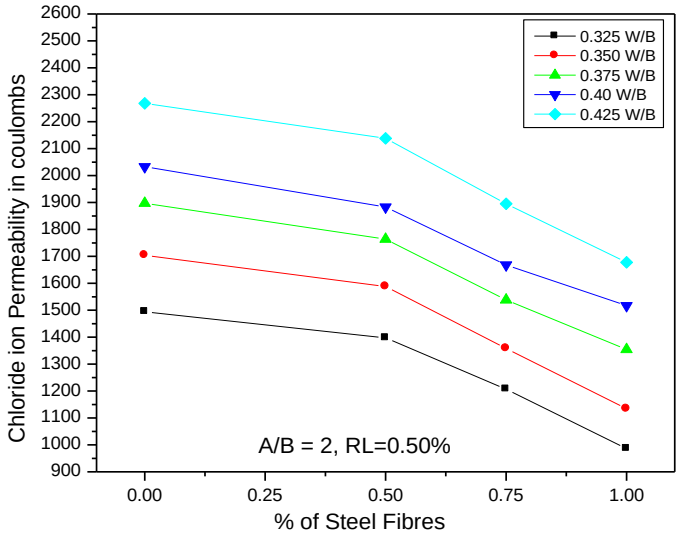

Fig. 4 Variation of Water Binder ratio with various percentage of Steel fibres

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From the Figure 4 it can be observed that the chloride ion permeability of NRLMFRHPC mixes decreases with increasing the percentage of steel fibers from 0 to 1.0%. The percentage decrease in ion chloride permeability value from 0.0 Steel fibre to 1.0% Steel fibre is observed as 30.40% for A/B=2.0, W/B 0.325 with 0.0% rubber latex. Hence it can be concluded that the permeability decreases with the increase in percentage of steel fiber. In this investigation the steel fiber is restricted to 1.0% in order to have better dispersion of steel fibers and to avoid balling of fibers.

VI. CONCLUSIONS

From the experimental work carried out and the analysis of the results following conclusions seem to be valid with respect to the utilization of Natural Rubber Latex and steel fibers in the production of NRLMFRHPC.

- The chloride ion permeability value increases with the increase of W/B ratio for NRLMFRHPC.
- The chloride ion permeability value decreases with the increase in the percentage of Rubber Latex from 0.0% to 0.5%. Further increase in percentage of NRL to 0.75% , the RCPT value increases. Thus it can be concluded that the permeability decreases with the increase in percentage of NRL upto 0.5% and further increase of NRL dosage, the permeability value increases. Hence it is recommended to use 0.5% of rubber latex by weight of binder to get more durable concrete
- The chloride ion permeability value of NRLMFRHPC Mixes decreases with increase in percentage of steel fibre. In this investigation the steel fibre is restricted to 1.0% in order to have better dispersion of fibres and avoid balling of fibres.

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