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Consumption of Ion Exchange Resin Waste in Concrete

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ABSTRACT: ***This project deals with the investigation of strength property of concrete made by partial replacement of cement using ion exchange resin waste. Ion exchange resin waste is readily available at free of cost in various industries. We are using the cation exchange resin waste from water softening process. This waste material is collected from a local place in Chennai In recent years, ion exchange resin is used in concrete for corrosion resistant purpose. The percentage replacements of cement by using ion exchange resin waste are 10%, 20% and 30% by weight. The results indicate The selected concrete grade is M_{30} and water cement ratio is 0.45. Cubes and cylinders are casted with the specified replacement of cement by using ion exchange resin waste. The strength has been checked at 7 days, 14 days and 28 days curing for the specimens made with specified partial replacement of cement by using ion exchange resin waste. Cubes are subjected to compressive strength test and cylinders are subjected to split tensile strength test. It has been concluded that the reasonable strength of 31.76 N/mm^2 (Target strength of M_{20} grade concrete) may be attained in M_{30} grade mix ratio while adding ion exchange resin waste as 10% replacement of cement. So the optimum percentage of replacement of cement is 10% for both cubes and cylinders.***

Key words: Concrete, ION resin, Split tensile strength ,Compressive strength

I. INTRODUCTION

Concrete is a standout amongst the most widely utilized development material on the planet with an inexact of around two billion tons set overall for each year. It is alluring in numerous applications on account of its significant quality at a generally minimal effort. Cement can for the most part be created of locally accessible constituents and can be thrown into a wide assortment of basic arrangement and requires insignificant upkeep amid administration. Anyway natural concern is the discharge of CO2 related with bond fabricating and subsequently has brought strain to decrease the concrete utilization with the innovations and use of Admixtures. Here we use cation trade tar squander as an admixture. It will supplant the bond and after that sand incompletely in this task

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ION EXCHANGE PROCESS

The process removes all the ions present in the hard water are called as ion exchange process. The soft water produced by lime soda and zeolite processes,
does not contain hardness producing Ca^{2+} and Mg^{2+} ions, but it will contain other ions like Na^+, K^+, SO_4^{2-}, Cl^- etc., On the other hand demineralized water does not contain both anions and cations.
This process is carried out by using ion exchange resins, which are long chain, cross linked, insoluble organic polymers with a micro porous structure. The functional groups attached to the chains are responsible for the ion exchanging properties.

ION EXCHANGE RESIN

An **ion-exchange resin** or **ion-exchange polymer** is an insoluble matrix (or support structure) normally in the form of small (0.5-1 mm diameter) beads, usually white or yellowish, fabricated from an organic polymer substrate. The beads are typically porous, providing a high surface area.
There are two types of ion exchange resin,

1. Cation exchange resin
2. Anion exchange resin

Here we are using the spent cation exchange resin or cation exchange resin waste.

CATION EXCHANGE RESIN

Resins containing acidic functional groups (-COOH, -SO_3H**)** are capable of exchanging their H^+ ions with other cations of hard water. Cation exchange resin is represented as RH_2 Sulphonated coals and sulphonated polystyrene are the examples.

ION EXCHANGE RESIN WASTE

Ion exchange resin is an insoluble matrix normally in the form of small beads, usually white or yellowish, fabricated from an organic polymer substrate. Most commercial resins are made of polystyrene sulfonate. It is mixed with coolant water in industries to soften the water. When the capacity of resin becomes low, then it removed from the process shown in fig 1.
The removed resin is called as spent ion exchange resin or ion exchange resin waste. It is an abundant waste material comes from water softening process in an industry. It is readily available at free cost in various industries.
Here the **cation ion exchange resin waste is used**. While water softening, this resin absorbs ions of calcium, magnesium, sodium and potassium from the hard water.

Fig 1 Ion Exchange Resin Waste

ROLE OF CATION EXCHANGE RESIN WASTE IN CEMENT

It has been studied that due to the usage of ion exchange resin waste in concrete, it does not form any chemical reaction with cement. The physical adsorption only takes place between cement and ion exchange resin waste.

The ion exchange resin waste is physically bonded with cement due to the binding capacity of cement. This waste has ions of calcium and magnesium but these ions are well bonded by the resin so it does not cause any reaction with cement.

PRESENCE OF POSSIBLE CHEMICAL ELEMENTS

Polystyrene sulfonate, ions of calcium, magnesium, sodium and potassium. But this element does not show any chemical effect when mixed with cement in concrete.

DISPOSAL PROCESS OF CATION EXCHANGE RESIN WASTE

Currently they are disposing by just dropping it into waste pits near to the industries and as landfill in very rare cases. Hence the disposal of cation exchange wastes are collected by waste management limited and disposed as normal solid industrial waste (non hazardous).

HISTORY OF ION EXCHANGE RESIN MIXED WITH CONCRETE

The ion exchange resin is mixed with concrete for corrosion resistant purposes in marine environment. Because corrosion is mainly due to the presence of chloride ions from environment to the structures.

Particularly anion exchange resin is mixed with cement in RCC to prevent corrosion. Anion exchange resin has the capability of absorbing chloride ions and sulphate ions.

In pre-stressed concrete structures, to prevent corrosion of tendons the anion exchange resin is mixed with cement in certain proportions. It has been studied that concrete with polymers achieves good reasonable strength in compression and tension.

But these projects do not give result about strength property of concrete when the cement is partially replaced with cation exchange resin waste.

OBJECTIVE

1. The main objective of the project is to decrease the usage of cement in concrete by partially replacing cement using spent ion exchange resin.
2. To get the desired strength of concrete made with partial replacement of cement using spent cation exchange resin or cation exchange resin waste.
3. To reduce the cost of cement using in the concrete.
4. In order to control the emission of CO_2 from cement manufacturing process.

ADVANTAGES

1. Cement and sand can be replaced partially by using this waste in concrete and thereby reducing the cost of cement.
2. The time and money spending in disposing this waste material will be controlled.
3. Though it replaces cement, amount of cement usage will be reduced and thereby it decreases the CO_2 emission from cement manufacturing industries.
4. This waste material will have some value when it is mixed with concrete and so it makes profit to the industries.
5. It can be adapted to both RCC and PCC.

II. LITERATURE REVIEW

The literatures collected which are related to this topic. Generally the ion exchange resin is a type of organic polymer so we collected literatures of strength properties of polymer concrete. Also we collected literatures of ion exchange resin mixed with cement to get corrosion resistance in concrete.

SUMMARY

The above literature shows the corrosion resistance capacity of concrete mixed with ion exchange resin and strength properties of polymer concrete. From these literatures, we can know that the cement is partially replaced by resin or polymers and the resin has been used as an admixture in concrete particularly for corrosion resistance purpose.

So now we have an idea to determine the strength properties of concrete with partial replacement of cement by using ion exchange resin waste. Finally the compressive strength and tensile strength of concrete with partial replacement (10%, 20% and 30%) of cement by using ion exchange resin waste will be determined.

MATERIALS

CEMENT

Ordinary Portland cement used for casting concrete, this cement is the most widely used one in the construction industry in India. The grade of cement is 53 with specific gravity of 3.10. The initial setting time and final setting time were found to be 30 min to 600 min respectively. The density of cement was 1440kg/m^3

FINE AGGREGATE

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the requirements of IS: 383 : 1970. The river send is washed and screened, to eliminate deleterious materials and oversize particles. The Specific Gravity was 2.72 Water absorption is less then 1% and Bulk density of the coarse aggregate was 1625 kg/m^3

COARSE AGGREGATE

Hard granite broken stones of less than 20mm size were used as coarse aggregate. The Specific Gravity was 2.81 Water absorption is less then 1% and Bulk density of the coarse aggregate was 1582 kg/m^3.

WATER Potable water available in laboratory with pH value of not less than 6

ION EXCHANGE RESIN WASTE

Ion exchange resin was used to replace cement in casting the specimens. 10%, 20% and 30% of cement is replaced by the resin. The results of Specific Gravity, Bulk density, particle size and water absorption capacity of the resin were tested.

MIX DESIGN

Mix design is the process of selecting suitable ingredients of concrete and determining their relative proportion with the object of producing concrete of certain minimum strength and durability as economically as possible. The mix design is carried out to achieve specified age, workability of fresh concrete and durability requirements by using. The following data are required for mix proportioning of a particular grade of concrete.

Mix ratio = 1: 1.09 : 1.92
Water / cement ratio = 0.45.

EXPERIMENTAL INVESTIGATION

Production of good quality concrete requires meticulous care exercised at every stage of manufacture of concrete. It is interesting to note that the ingredients of bad concrete are the same.

If meticulous care is not exercised and good rules are not observed, the resultant concrete is going to be of bad quality. With the same material if intense care to exercise control at every stage it will in good concrete.

The various stages of manufacture of concrete are in this chapter. The test results of all the materials involved in this project are tabulated in this chapter.

Inference:

The properties are within the allowable limits.

CASTING OF TEST SPECIMENS and PREPARATION OF THE MOULD

The compressive strength of the concrete was determined by cubes of size 150mmx150mmx150mm. Split tensile strength of the concrete was determined by the cylinder of size 100mm diameter and 200mm height were prepared. And it is shown in fig 2 and the no of specimen casted were shown in table 1.

Fig 2Preparation of Mould

Table 1Casted specimen details

S.No	Ion Exchange Resin waste %	Cube	Cylinder
1	0	9	9
2	10	9	9
3	20	9	9
4	30	9	9

COMPRESSIVE STRENGTH TEST and SPLIT TENSILE STRENGTH TEST

Compressive test are made at recognized ages of the test specimens. Least three specimens, preferably from different batches shall be made for testing at each selected age. The cubes are placed in the compression testing machine in such manner that the load is applied to the opposite sides of the cube as cast. All are shown in table 2.

This test is carried out by placing cylindrical specimens (100 mm diameter and 200 mm height) horizontally between the loading surfaces of a compression testing machine and the load applied until failure of the cylinder, along the vertical diameter. It is estimated that the compressive stress is acting for about 1/6 depth and the remaining 5/6 depth is subjected to tension. The magnitude of tensile stress (acting in a direction perpendicular to

6.3.1 Comparison of average compressive strength

Table.2 Comparison of compressive strength

Ion Exchange Resin %	Average Compressive Strength (N/mm^2)	
	7 days	28 days
0	22.18	33.65
10	**19.53**	**31.76**
20	21.36	28.22
30	7.43	10.71

Inference

The strength of concrete slightly decreases at 10% replacement but it is the reasonable compressive strength of concrete and further any addition (20% and 30%) of ion exchange resin waste largely decreases the strength. So the acceptable replacement of cement is 10% for cubes.

Table 3 Comparison of average split tensile strength

Ion Exchange Resin %	Average Split Tensile Strength (N/mm^2)	
	7 days	28 days
0	2.66	3.48
10	**1.97**	**3.43**
20	1.09	1.67
30	0.68	1.21

Inference

The strength of concrete slightly decreases at 10% replacement but it is the reasonable tensile strength of concrete and further any addition (20% and 30%) of ion exchange resin waste largely decreases the strength. So the acceptable replacement of cement is 10% for cylinders.

III. CONCLUSION and DISCUSSION

1. The characteristic compressive strength of cube specimens made with 0%, 10%, 20% and 30% replacements are 33.65 N/mm^2, 31.76 N/mm^2, 28.22 N/mm^2 and 10.71 N/mm^2 respectively.
2. The characteristic tensile strength of cylinder specimens made with 0%, 10%, 20% and 30% replacements are 3.48 N/mm^2, 3.43 N/mm^2, 1.67 N/mm^2 and 1.21 N/mm^2 respectively.

3. The strength of concrete gradually decreases while adding ion exchange resin waste as partial replacement of cement. But it shows nominal strength up to 10% replacement of cement by using ion exchange resin waste.
4. It has been concluded that the reasonable strength of 31.76 N/mm^2 (Target strength of M_{30} grade concrete) may be attained in M_{30} grade mix ratio while adding ion exchange resin waste as 10% replacement of cement. So the optimum percentage of replacement of cement is 10% for both cubes and cylinders.
5. Thus a simple step to minimize the costs for construction with usage of ion exchange resin waste which is easily available at free of cost has been initiated.
6. An idea of saving the environmental pollution by cement production has also been stepped; being our main objective as Civil Engineers.

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