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EXPERIMENTAL STUDY ON SELF HEALING RUBBERIZED POLYMER CONCRETE BY PARTIAL REPLACEMENT

Self Healing Mechanism, Rubberized Polymer Concrete

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Abstract : Study about Self-healing concrete and its strength parameters is very important criteria in recent concrete industry. The major problem in the application of concrete is crack formation which may be structural or non-structural. These cracks reduce the durability of the concrete. This is because concrete provides a convenient way to transport liquids and gases. Therefore, maintenance and repairs are inevitable. A variety of external methods can be used to repair the crack, but the solution is expensive, time consuming, and in some cases unattractive. If cracks occur in hard-to-reach places, they must be sealed without damaging the structure. Therefore, there is a need to develop concrete that can repair cracks without external maintenance. This self-healing property can be achieved in physical, chemical, or biological ways. This paper studies the strength parameters of self-healing concrete by combining with super absorbent polymer (SAP). Because SAP (sodium polyacrylate) is a chemical polymer that can be used as a self- healing agent, concrete can repair cracks without manual maintenance. Rubberized concrete is a concrete in which the scrap tire rubber is used as a partial replacement of coarse aggregate. It has been estimated that nearly 1000 million tires reach the end of their useful lives every year which imposes a serious problem to dispose of this huge bulk of waste rubber creating a threat to environment. To protect the environment from this problem researchers are consistently exploring to use this rubber as a source to replace the natural resources such as stone aggregates which will also address the growing demand of natural construction material. In this paper, we have prepared a self healing rubberized polymer concrete by partial replacement of materials and addition of SAP, fine aggregate is replaced by copper slag (20%), coarse aggregate is replaced by rubber aggregate (15%, 25%,35%) and cement is replaced by silica fume (5%, 10%, 15%). The SAP that is being added is Sodium polyacrylate, after the mix is prepared, we have to add this polymer (0.5%, 1%). Of the sodium polyacrylates, it is used as a self-curing agent of sodium polyacrylate having the formula [-CH_2-CH (COONa) -] Sodium polyacrylate consists of multiple pairs of acrylic compounds with positive and anionic charges that attract and bind water molecules, making sodium polyacrylate highly absorbent.

***Index Terms* - Self Healing Mechanism, Rubberized concrete, Polymer Concrete.**

I. INTRODUCTION:

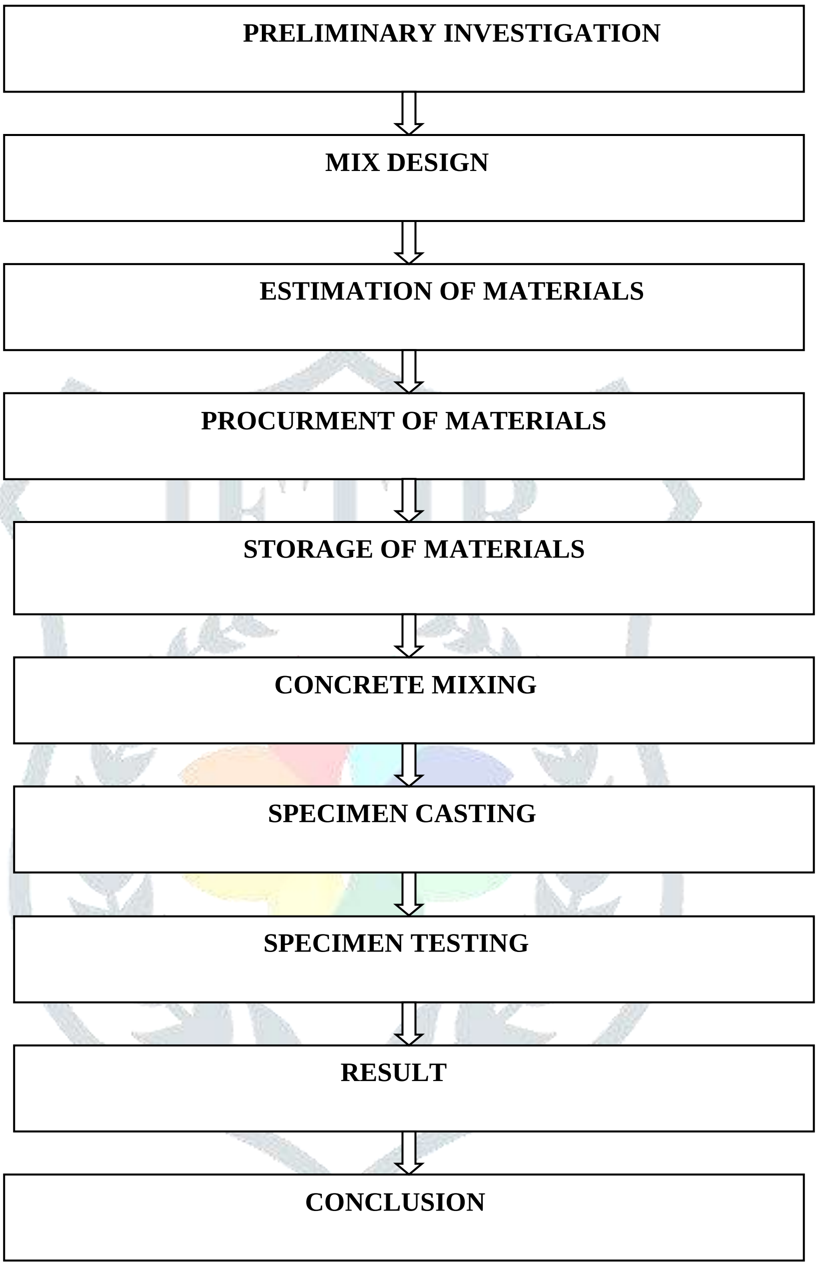
Concrete is the mixture of Cement, Coarse aggregate, Fine aggregate and Water. All the structural components area commonly made with concrete due to more amount compressive strength and durable. At the same time concrete weak in tensile strength. In that case all the structural members in tension members like beams, slabs are made compositely with Reinforced Steel Bars for the bearing of tension loads. In general, non-structural factors, such as structural loads or shrinkage, thermal effects, and physicochemical reactions, add to the cracks in concrete. Cracks may occur on the concrete surface and reach the rebar. This exacerbates the deterioration of the embedded rebar. This crack can cause leakage and affect water tightness. This is an important service life requirement for many structures, such as basements, retaining walls, reservoirs, dams, tunnels, pipes, and waste storage. A variety of external methods can be used to repair the crack, including manual repair with epoxy resin or polyurethane, and coating of the concrete surface by electrode position of the compound. These solutions are expensive, time-consuming, and in some cases unattractive. If a crack is found in hard-to- reach places, it cannot be repaired manually. Therefore, it is important to develop concrete that can heal and contain its own cracks.

II. OBJECTIVES:

This study is conducted to accomplish some predefined objectives like,

1. The cost of Physical repair will get reduced if Self-healing is achieved.
2. Find optimum percentage (%) of polymer.
3. Study mechanical properties (compressive & split tensile) of RPC with partial replacement.
4. Observe the self-healing mechanism.

III. Methodology:



Materials Required:

The following materials are required:

1.Ordinary Portland Cement
2.Coarse Aggregate
3. Fine Aggregate
4.Rubber aggregate
5. Silica Fume
6. Copper Slag
7. Sodium Polyacrylate

PROPERTIES OF THE MATERIAL:-

1. ORDINARY PORTLAND CEMENT

The chief chemical components of ordinary Portland cement are Calcium, Silica, Alumina and Iron. Approximate oxide composition limits are:

CaO	60-67%
SiO_2	17-25%
Al_2O_3	3-8%
Fe_2O_3	0.5-6%
Alkalis	0.3-1.2%
SO_3	2.0- 3.5%
MgO	0.5- 4.0%

Table 4.1 Approximate oxide composition limits

Fig 4.1 Ordinary Portland Cement

2. COARSE AGGREGATE

Construction aggregate, or simply aggregate, is a broad category of coarse- to medium-grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and roadside edge drains. Aggregates are also used as base material under foundations, roads, and railroads. In other words, aggregates are used as a stable foundation or road/rail base with predictable, uniform properties (e.g. tohelp prevent differential settling under the road or building), or as a low-cost extender that binds with more expensive cement or asphalt to form concrete.

Fig 4.2 Coarse aggregate

3. FINE AGGREGATE

Fine aggregate is the essential ingredient in concrete that consists of natural sand or crushed stone. The quality and fine aggregate density strongly influence the hardened properties of the concrete. The concrete or mortar mixture can be made more durable, stronger and cheaper if you made the selection of fine aggregate on basis of grading zone, particle shape and surface texture, abrasion, skid resistance, absorption and soil moisture. Aggregate is the granular material used to produce concrete or mortar and when the particles of the granular material are so fine that they pass through a 4.75mm sieve, it is called fine aggregate. It is widely used in the construction industry to increase the volume of concrete; thus, it is a cost saving material and you should know everything about the fine aggregate size, its density and grading zone to find the best material.

Fig 4.3 Fine aggregate

4. RUBBER AGGREGATE

Rubber is produced excessively worldwide every year. It cannot be discharge off easily in the environment as its decomposition takes much time and also produces environmental pollution. In such a case the reuse of rubber would be a better choice. In order to reuse rubber wastes, it was added to concrete as coarse aggregate and its different properties like compressive strength, Tensile strength, ductility etc. were investigated and compared with ordinary concrete. As a result, it was found that rubberized concrete is durable, less ductile, has greater crack resistance but has a low compressive strength when compared with ordinary concrete. The compressive strength of rubberized concrete can be increased by adding some amount of silica to it.

Fig 4.4 Rubber Aggregate

5. SILICA FUME

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume, also known as micro silica, is an amorphous polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150nm.

Fig 4.5 Silica fume

6. COPPER SLAG

Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular which are disposed of as waste or utilized.

Fig 4.6 Copper Slag

7. SODIUM POLYACRYLATE

Sodium polyacrylate, also known as water lock, is a sodium salt of polyacrylic acid with the chemical formula [$-CH_2-CH-$] and has broad applications in consumer products. This superabsorbent polymer has the ability to absorb 100 to 1000 times its mass in water. Sodium polyacrylate is an anionic polyelectrolyte with negatively charged carboxylic groups in the main chain. Sodium polyacrylate is a chemical polymer made up of chains of acrylate compounds.It contains sodium, which gives it the ability to absorb large amounts of water. Sodium polyacrylate is also classified as an anionic polyelectrolyte. When dissolved in water,it forms a thick and transparent solution due to the ionic interactions of the molecules. Sodium polyacrylate has many favorable mechanical properties. Some of these advantages include good mechanical stability, high heat resistance, and strong hydration. It has been used as an additive for food products including bread, juice, and ice cream.

Fig 4.7 Sodium Polyacrylate

IV. Mix Design followed:

MIX DESIGN for M25 [CONVENTIONAL CONCRETE], as per IS 10262:2009

MATERIAL	QUANTITY
Cement	448 Kg/m3
Fine Aggregate	748 Kg/m3
Coarse Aggregate	1298 Kg/m3
Water	192 Kg/m3
Water Cement Ratio	0.47
Ratio	1 : 1.41 : 2.87 (Cement : Fine Aggregate : Coarse Aggregate)

Table 5.1- M25 Conventional concrete

MIX DESIGN M25 [RUBBERIZED POLYMER CONCRETE], as per IS 10262:2009

Material	Quantity
Cement	328 Kg/m^3
Silica Fume	123 Kg/m^3
Fine Aggregate	600 Kg/m^3
Copper Slag	150 Kg/m^3
Coarse Aggregate	720 Kg/m^3
Rubber Aggregate	580 Kg/m^3
Super Absorbent Polymer (SAP)	1.885 Kg/m^3
Water	192 Kg/m^3
Water Cement ratio	0.47
Ratio	1 : 0.42 : 1.89 : 0.47 : 2.27 : 1.83 (Cement : S.F : F.A : C.S : C.A : R.A)

Table 5.2- M25 Rubberized polymer concrete

V. **Results and Discussions:**

Sl. No.	Cement (Kg)	Silica fume (Kg)	F.A (Kg)	Copper Slag (Kg)	C.A (Kg)	Rubber Aggregate (Kg)	Compressive strength (MPa)	
1	1.51 Kg	-	2.52 Kg	-	4.37 Kg	-	34.23	
2	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	28.77 SAP (0.5%)	29.55 SAP (1.0%)
3	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	20.91	21.5
4	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	12.09	12.35
5	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	29.97	30.8
6	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	18.73	19.2
7	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	23.67	24.28
8	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	25.92	26.5
9	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	10.59	10.89
10	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	15.09	15.7

Table 6.1 Compressive strength for 7 days

Sl. No.	Cement (Kg)	Silica fume (Kg)	F.A (Kg)	Copper Slag (Kg)	C.A (Kg)	Rubber Aggregate (Kg)	Compressive strength (MPa)	
1	1.51 Kg	-	2.52 Kg	-	4.37 Kg	-	45.64	
2	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	38.37 SAP (0.5%)	39.3 SAP (1.0%)
3	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	27.89	28.7
4	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	16.12	16.9
5	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	39.96	41.1
6	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	24.98	25.84
7	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	31.56	32.4
8	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	34.56	35.4
9	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	14.12	14.8
10	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	20.12	20.96

Table 6.2 Compressive strength for 28 days

Sl. No.	Cement (Kg)	Silica fume (Kg)	F. A (Kg)	Copper Slag (Kg)	C. A (Kg)	Rubber Aggregate (Kg)	Compressive strength (MPa)	
1	1.51 Kg	-	2.52 Kg	-	4.37 Kg	-	34.23	
2	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	28.77 SAP (0.5%)	29.55 SAP (1.0%)
3	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	20.91	21.5
4	1.44 Kg	5%(0.076)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	12.09	12.35
5	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	29.97	30.8
6	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	18.73	19.2
7	1.36 Kg	10%(0.151)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	23.67	24.28
8	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	4.15 Kg	5% (0.218)	25.92	26.5
9	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	3.71 Kg	15%(0.655)	10.59	10.89
10	1.29 Kg	15%(0.227)	2.01 Kg	20% (0.503)	3.27 Kg	25%(1.092)	15.09	15.7

Table 6.3 Split tensile strength for 7 days

Sl. No.	Cement (Kg)	Silica fume (Kg)	F. A (Kg)	Copper Slag (Kg)	C. A (Kg)	Rubber Aggregate (Kg)	Split tensile strength (MPa)	
1	2.65 Kg	-	3.73 Kg	-	7.60Kg	-	1.53	
2	2.51 Kg	5% (0.14)	2.984 Kg	20% (0.746)	7.22 Kg	5% (0.38)	1.74 SAP (0.5%)	1.77 SAP (1.0%)
3	2.51Kg	5% (0.14)	2.984 Kg	20% (0.746)	6.46 Kg	15% (1.14)	1.67	1.69
4	2.51Kg	5% (0.14)	2.984 Kg	20% (0.746)	5.7 Kg	25% (1.90)	1.57	1.59
5	2.38Kg	10% (0.27)	2.984 Kg	20% (0.746)	7.22 Kg	5% (0.38)	1.68	1.70
6	2.38Kg	10% (0.27)	2.984 Kg	20% (0.746)	6.46 Kg	15% (1.14)	1.80	1.84
7	2.38Kg	10% (0.27)	2.984 Kg	20% (0.746)	5.7 Kg	25% (1.90)	1.68	1.70
8	2.25Kg	15% (0.40)	2.984 Kg	20% (0.746)	7.22 Kg	5% (0.38)	1.65	1.67
9	2.25 Kg	15% (0.40)	2.984 Kg	20% (0.746)	6.46 Kg	15% (1.14)	1.56	1.58
10	2.25 Kg	15% (0.40)	2.984 Kg	20% (0.746)	5.7 Kg	25% (1.90)	1.5	1.52

Table 6.4 Split tensile strength for 28 days

VI. Results and Discussions:

1. The optimum percentage of polymer is 1% at which higher strength is achieved
2. The Compressive Strength of the Rubberized Polymer Concrete made by replacement of materials and adding SAP (0.5%) is 40% lower than the Conventional Concrete.
3. The Split Tensile Strength of the Rubberized Polymer Concrete made by replacement of material and adding SAP (0.5%) is 30 % higher than conventional concrete.
4. It was found that the added SAP does not impact the tensile strength of concrete
5. The Self healing mechanism is checked.

REFERENCES:

1. Dr. A. Goplalan1, E. Arundhavapriya2, N. Mohanraj3, S. Abirami4, International Journal of Disaster Recovery and Buisness Continuity, Volume 11, No. 1 (2020), pp. 328-334

2. K.Durga Bhavani1, J.Naga Durga Sai2, “An Experimental Study on High Strength Bacteria Concrete with Partial Replacement of Coarse aggregate As Recycled Aggregates”,International Research JOURNAL of Engineering and Technology,Volume:06 issue:05 | May 2019 p-ISSN:2395-0072

3. 1K.Satishkumar, 2K.Anitha, International Journal of Pure and Applied Mathematics, Volume 116 No.14 2017, 25-30 , ISSN: 1311-8080.

4. M. Sivaranjani1, K. Ranjitha2, S. Premkumar3, “Study on the Properties of Concrete by using Super Absorbent Polymer”, International Journal for Research in Applied Science and Engineering Technology, Volume 5 Issue 111, March 2017, ISSN: 2321-9653.

5. Arn Mignon,1,2,† Didier Snoeck,1,† Peter Dubruel,2Sandra Van Vlierberghe,2and Nele De Belie1,*”Crack Mitigation in Concrete: Superabsorbent Polymers as Key to Success?” Materials (Basel). 2017 Mar; 10(3): 237

6. H. X. D. Lee, H. S. Wong*, N. R. Buenfeld, “Self-sealing of cracks in concrete using superabsorbent polymers”Cement & Concrete Research (2016), 79, 194-208

7. Arn Mignona.B, Didier Snoecka, “David Schaubroeckc, Nathalie Luickxd, Peter Dubruelb, Sandra Van Vlierbergheb, Nele De Beliee” (2015) pH-responsive superbsorbent polymers: a pathway to self healing of mortar, Vol.3, pp. 1381-5148.

8. Ghandhimathi,A1, Suji,D2, Elayarajah, B “Bacterial concrete; Development of concrete to increase the split tensile and compressive strength using Bacillus sphaericus”, International Journal of Applied Engineering Research, ISSN 0973- 4562 Volume 10, Number 3 (2015) pp. 7125-7132.

9. Parul Mangal, “An experimental Study on Rubberized Concrete by Using Waste Material with the Addition of Human Hair as Fiber”, International Journal for Research in Applied Science and Engineering Technology, Volume 3 Issue IX, September 2015, ISSN: 2321-9653